ANALYSIS OF COMMUNITY ENERGY AND EMISSION DATA TO UNDERSTAND PROGRESS TOWARD REACHING TARGETS

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Table of Contents

List of Figures

List of Tables

Executive Summary

This research analyzes the emission reduction progress of ten selected communities in the province of British Columbia (BC) by using the energy and solid waste data for local communities provided by the provincial government from 2007 to 2019 and transportation data provided by the Community Energy Association (CEA). This research aims to quantify their community Greenhouse gas (GHG) emission reduction targets and offers recommendations to strengthen the ability of local governments and supporting organizations to model energy & emissions effectively, contributing to enhancing the capacity of communities to meet their GHG reduction targets.

In summary, this research found that:

- By 2018, the City of Vancouver is progressing in reducing its GHG emissions compared to the 2007 baseline at a 12% reduction. This trend is similar to the progress announced by the City government at a 17% reduction in 2020.
- The City of Penticton, the City of Prince George, and the District of Squamish are increasing their community GHG emissions compared to the 2007 baseline at 15.5%, 16.6%, and 21.9%, respectively. This trend is similar to the progress announced in these cities' OCPs.
- There is an increasing trend of total GHG emissions in Resort Municipal of Whistler and the City of Kelowna compared to the 2007 baseline at 1.6% and 9.2%, respectively. However, this trend contradicts the decreasing emission announced in the communities' OCPs.
- In four communities that do not have fuel sale data, namely the City of Kamloops, the City of Rossland, the City of Nelson, and the City of Victoria, the total GHG emissions progress result is less confident; hence it is not shown in the progress assessment.

In the overall assessment in figure 1, the change in self-announced numbers presents the GHG emissions from communities' OCPs, and the change in this research is based on the dataset used in this research. The changes in GHG emissions found in this research are highlighted.

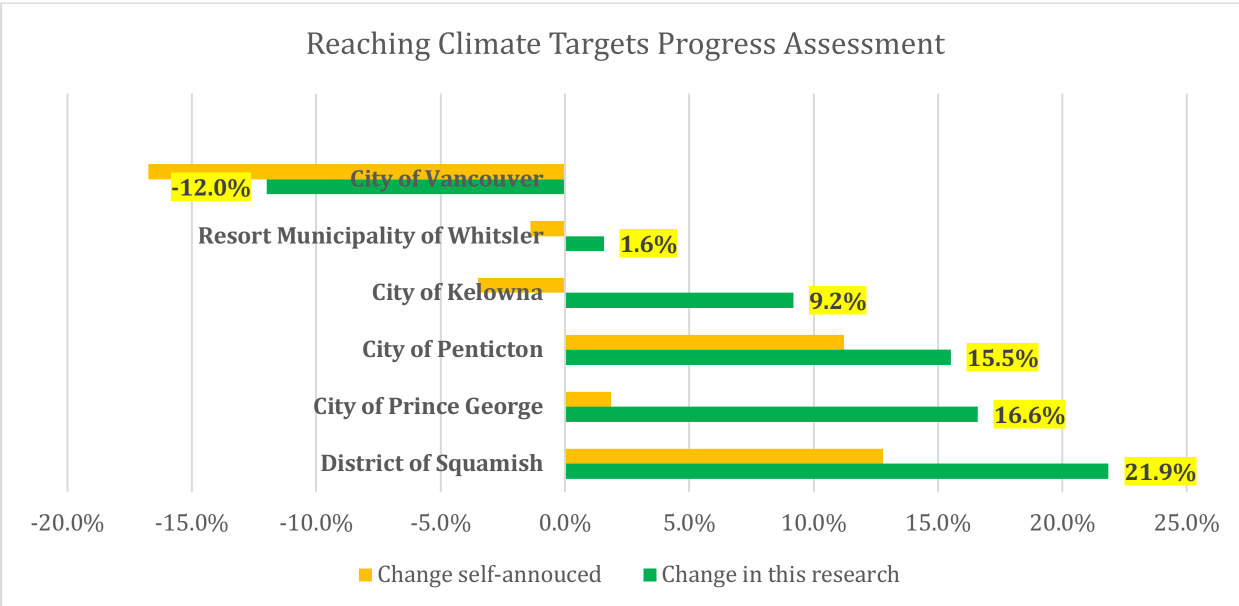

Figure 1: Overall progress of reaching GHG emission reduction targets

Next, the GHG emissions in building, waste, and transportation sectors are presented for all communities, helping to provide the rationale for the recommendation for the provincial government, local governments, third parties, and future research.

GHG emissions from energy used in buildings

Energy, including electricity and natural gas, used in two types of buildings: commercial and small-medium industries (CSMI) and residential buildings for ten communities is plotted and compared with each other and with BC average number. The GHG emissions are normalized based on population and heating degree days (HDD) to make a fair comparison.

In CSMI buildings, Prince George, Whistler, Kamloops, and Vancouver have had the highest emission per capita, respectively. Rossland has the lowest emission per capita in this segment. Compared to BC's data, only Squamish and Rossland consistently have lower GHG emissions per capita than the average BC over time (figure 2).

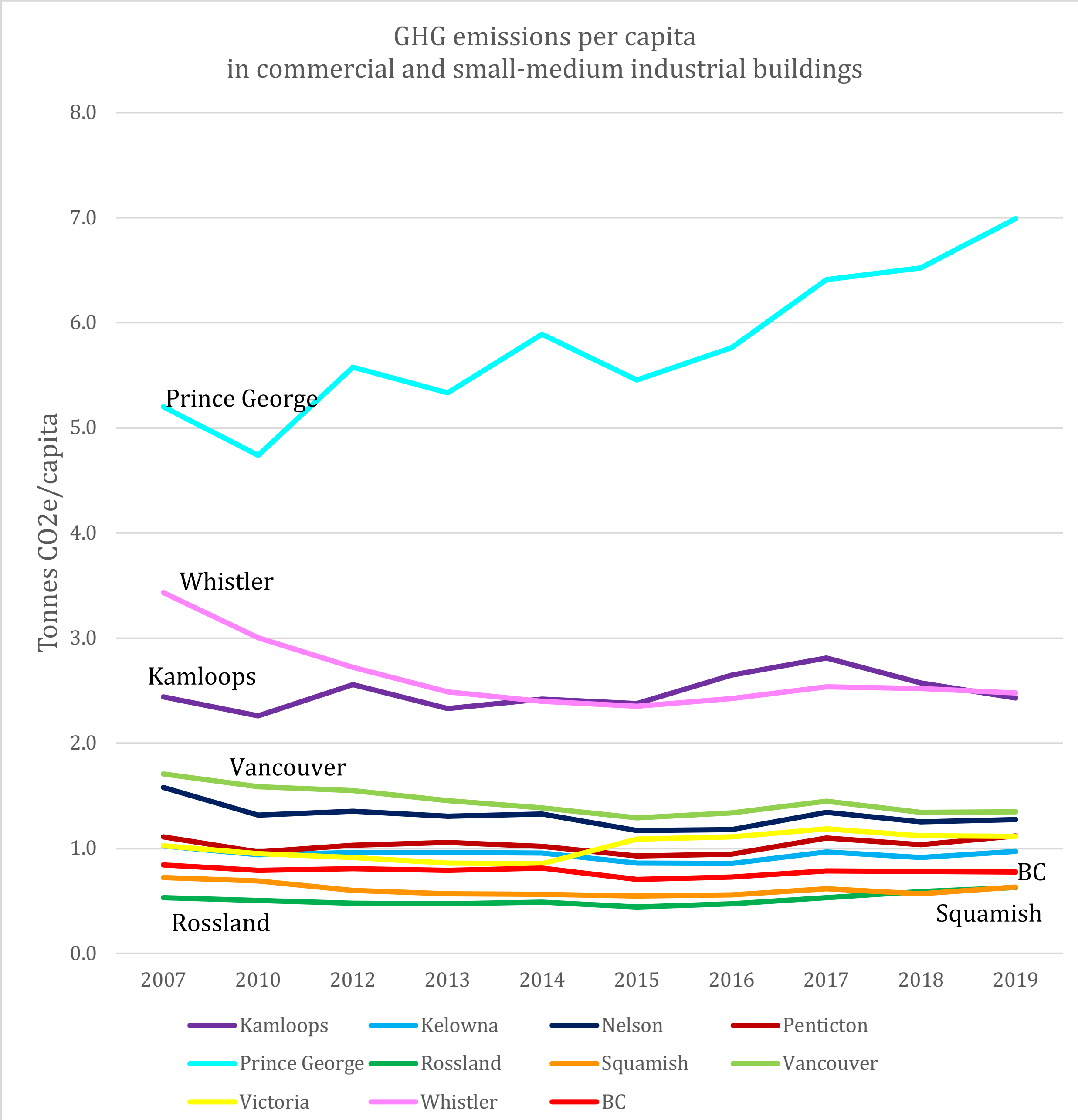

Figure 2: GHG emissions per capita in commercial and small-medium industrial buildings

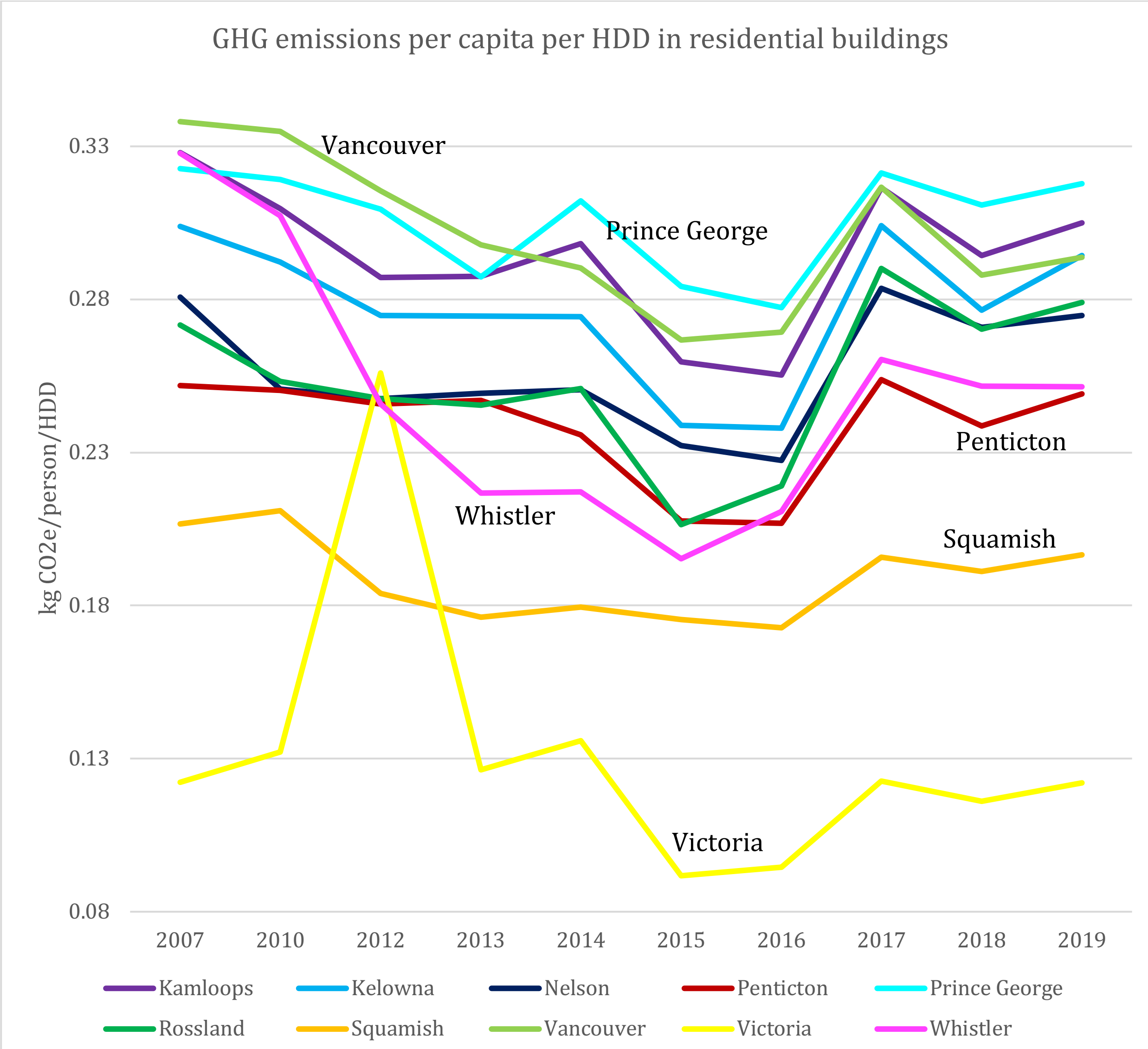

Figure 3: GHG emissions per capita per HDD in residential buildings

In residential buildings emissions per capita per HDD (figure 3), the general trend is downward until 2015-2016, with the most significant decline being witnessed in Whistler. Despite having a spike in 2012, Victoria is the city with the lowest emission per capita per HDD in residential buildings. The spike for all communities in 2017 is in partly due to the lowest average HDD.

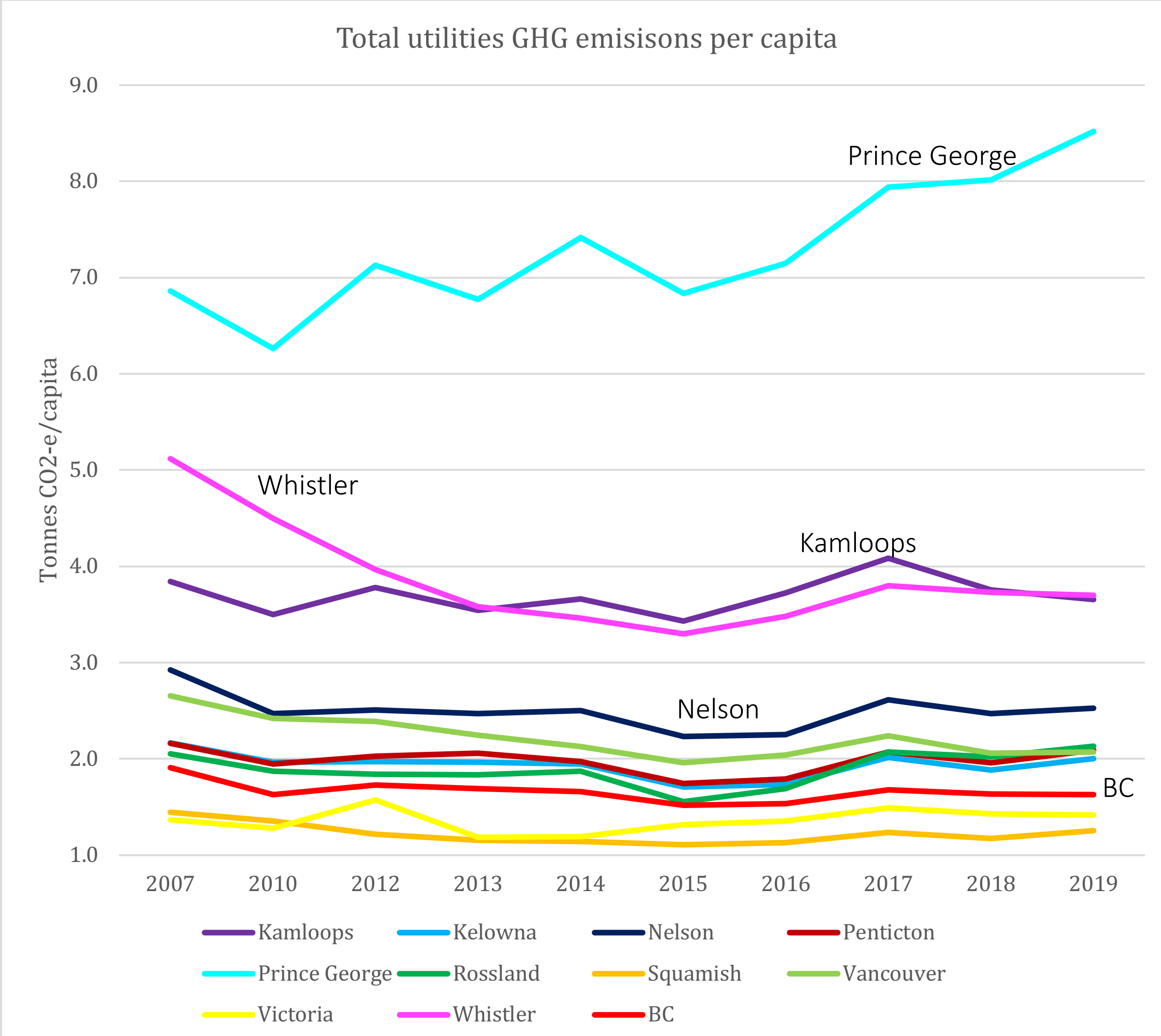

Figure 4: Total utilities GHG emissions per capita

In summary of both CSMI and residential buildings, the total GHG emission per capita for each city is presented in Figure 4. Prince George, Kamloops, and Whistler consistently stand in the top three cities with the highest emission per capita, with Prince George taking the lead over time. Only Victoria and Squamish have the building emission per capita lower than the BC average.

GHG emissions from waste

For all cities, GHG emissions from waste account for a smaller percentage of the overall community-wide emissions than utilities and transportation emissions. In 2017, the District of Squamish had the highest emission percentage from waste at 20%. The communities with the lowest share of waste in their total GHG emissions are Whistler, Vancouver, Nelson, and Kamloops, with less than 5%.

Figure 5 shows the total amount of CO2e from the waste emissions of all ten communities. In general, the GHG emissions from waste fall slightly over time. The city of Vancouver has the highest share, followed by Prince George, Kelowna, and Kamloops. For the nine years, the share of the waste emission of ten selected cities is very similar. However, in 2018, Prince George surpassed Vancouver to emit the highest amount of emission among ten cities.

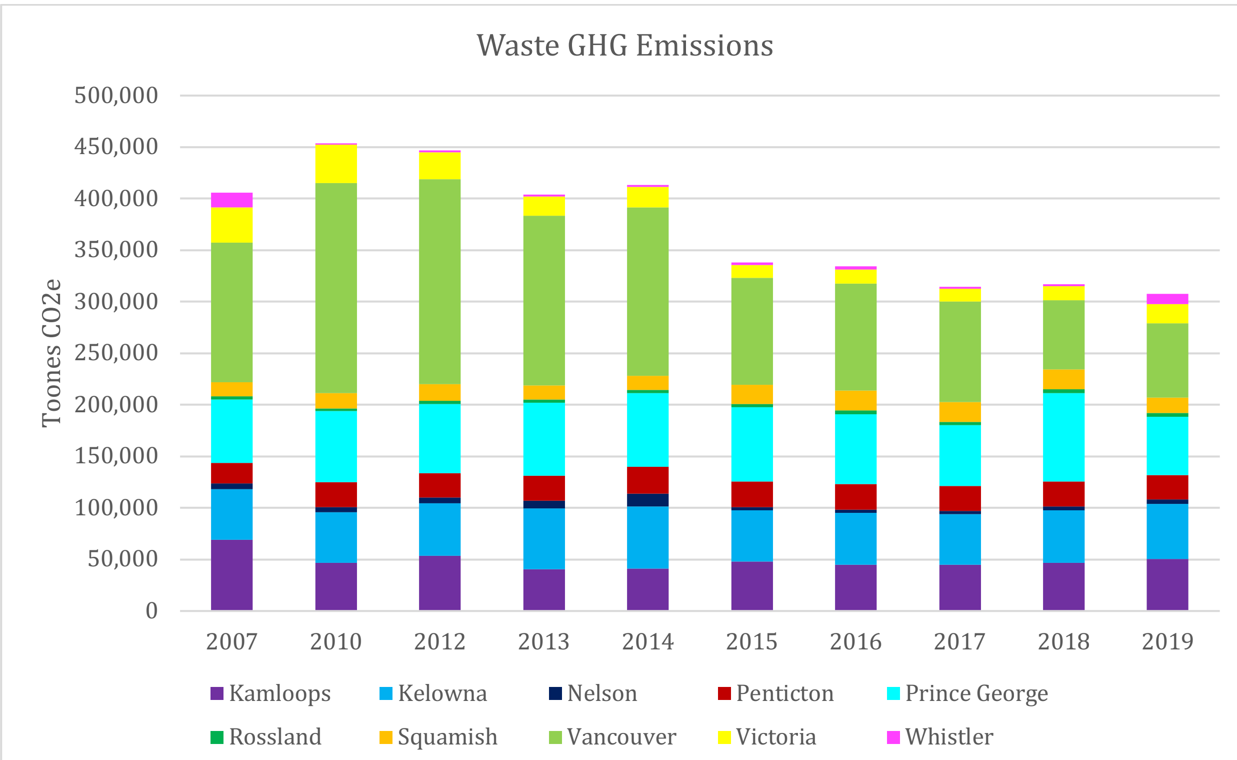

Figure 5: GHG emissions from waste

Notably, the emission from Whistler was relatively high in 2007 but reduced significantly and consistently years after. Since the 2005 closing of Whistler's municipal landfill, the municipality's solid waste has been shipped to Rabanco Landfill, Washington, USA. Although Whistler incurs the costs and emissions with sending the waste, its true amount and emissions have been moved to another place. In the original dataset, the provincial government warns the uncertainty of GHG emissions from solid waste disposal sent to Washington, the USA, due to the lack of historical data and difficulty of distributing emissions to each municipality that contributes to that landfill.

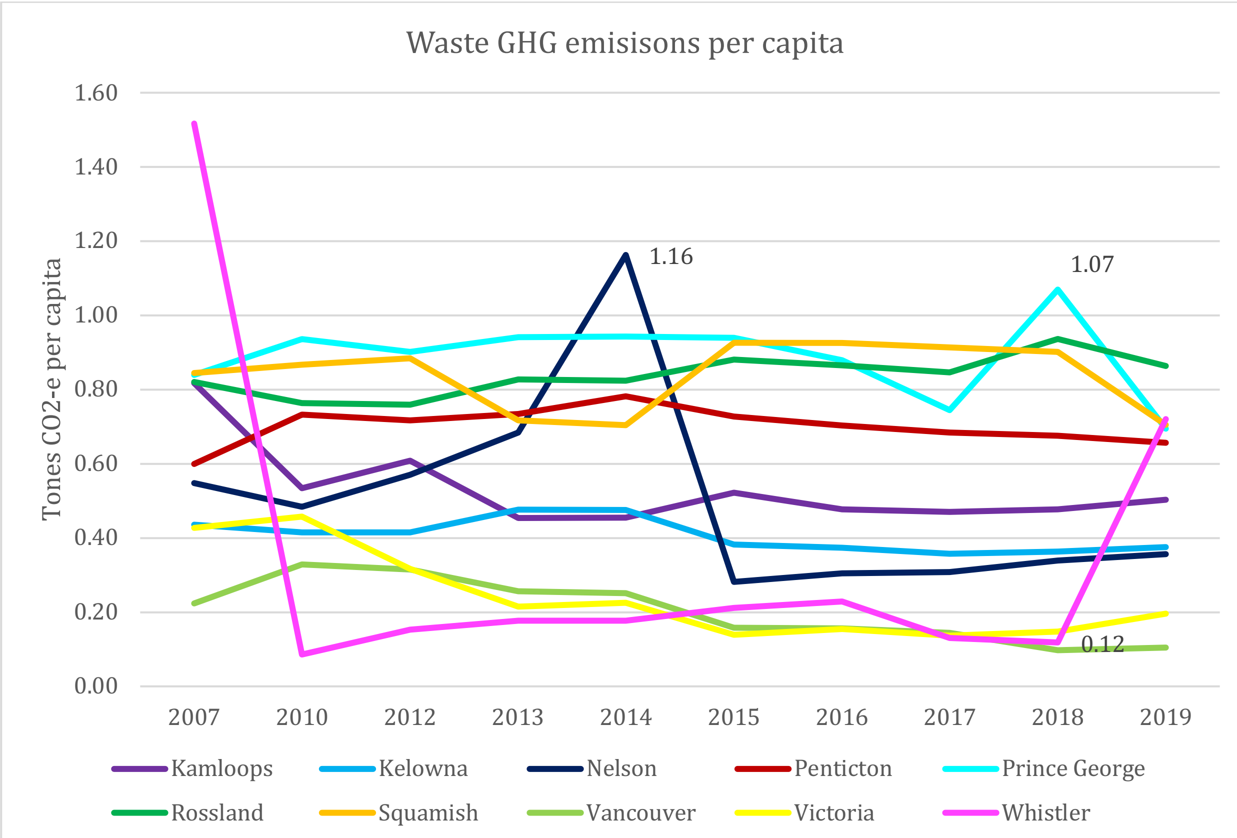

Figure 6: GHG emission per capita from waste sector

Figure 6 shows the GHG emission per capita in the waste sector for ten selected communities. Prince George consistently had the highest emission per capita from 2010 to 2015, then surpassed by Squamish in 2016 and 2017, reaching its peak at 1.07 tonnes of CO2e per person in 2018 before going down in 2019. Per capita waste emissions from Whistler increased sharply from 2018 to 2019 due to the reason explained above. Taking Whistler aside, Vancouver and Victoria saw a gradual decline in emission per capita over time and are two cities with the lowest emission per capita in the waste sector compared to other communities.

GHG emissions from transportation

The provided data of Metro Vancouver and Squamish-&-Whistler as regions are used to compare CO2e emission per capita among eight cities. Metro Vancouver consistently has the lowest emission per capita among all communities and is the only community with emissions per capita lower than BC average data. The metro region also has a steady decline, from 2.1 tonnes of CO2e per person in 2007 to 1.7 tonnes of CO2e per person in 2018 (figure 7).

Vernon and Squamish-&-Whistler alternatively have the highest emission per capita over this period. Since 2014, Vernon constantly is the most elevated position, ending with 4.8 tonnes CO2e per person in 2018, followed closely by Squamish-&-Whistler at 4.3 tonnes CO2e per person in the same year. For these two communities, no known factors other than weather and economy (e.g., visiting tourists) could be attributed to this fact.

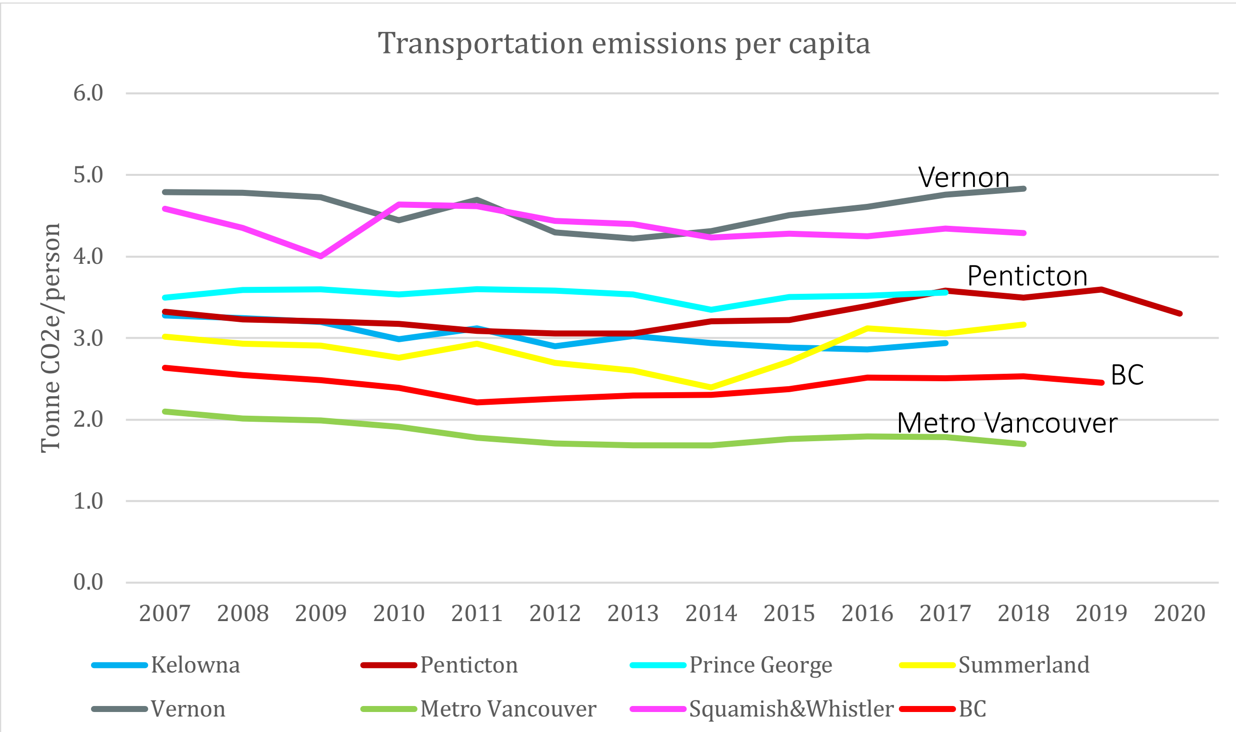

Figure 7: Transportation emission per capita

The data from Google Environmental Insights Explore (EIE) for transportation is available from 2018 to 2021 for four cities, namely the City of Kamloops, the City of Kelowna, the City of Prince George, and the City of Victoria. In general, the automobile is the primary transportation mode for four cities, with the highest in the City of Prince George at 98.7% and the lowest in Victoria at 82.7%, on a four-year average.

In the City of Victoria, the share of automobiles is the least among four cities but still the majority of transport modes, which increases over time at 73.8%, 84.9%, 85.1%, and 86.9% in 2018, 2019, 2020, and 2021 respectively. By 2020, cycling is growing from 2.7% in the previous year to 3.5%.

The standard bus and walking modes decrease slightly in 2020 and continue to fall in 2021. The data on using ferry boats is only available for 2018, at 14% 2018.

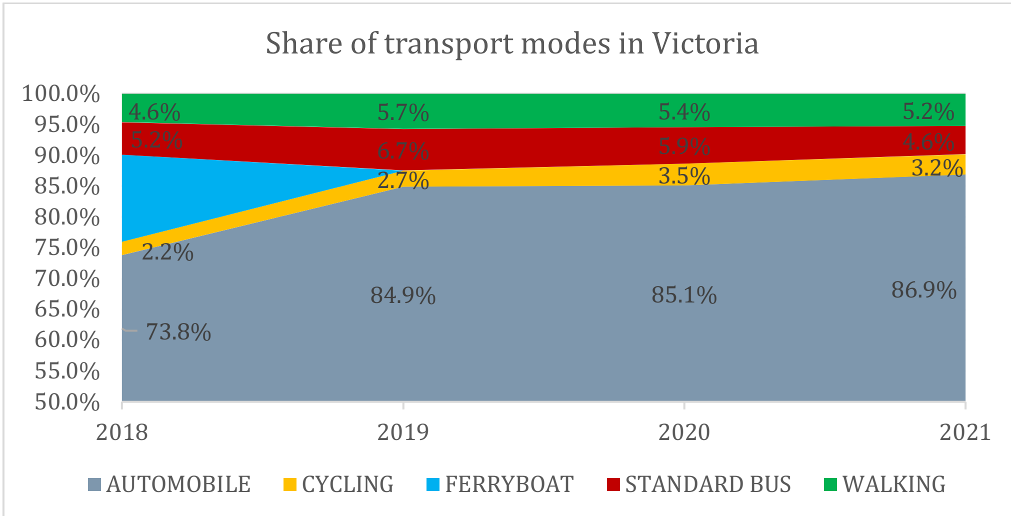

Figure 8: Share of transportation modes in Victoria

Google EIE data shows that the COVID-19 pandemic might positively affect the use of active transportation modes such as cycling. However, this effect is very modest and does not last in 2021 after the pandemic. The majority mode of transport is still automobile.

The detailed analysis provides recommendations for local government, provincial government, interested third parties, and future research.

For local government: More actions needed to speed up the progress to reach climate action targets

This research helps to confirm the progress of reducing GHG emissions in the City of Vancouver and the City of Kamloops, as shown in the previous section. It challenges the progress made by the other eight cities. This research, however, made clear that all ten cities need to speed up their actions and have interventions so that their bold climate targets can be met. They all need to work much, much harder on all these emissions sources, in specific:

- All of the efforts in utilities seem not to be sufficient to decarbonize the building sector. More resources need to be placed in a more efficient way in order to have a long-lasting impact on GHG emissions reduction in this sector.

- Transportation is a hard-to-abate sector. Different fuel types should be explored and deployed to drive down the GHG emissions in the transportation sector.

- Waste, though contributing a relatively small portion to the total emissions, still needs to be paid attention to, especially for communities that tip their waste in other jurisdictions.

- All in all, the City of Vancouver is a successful example for other communities to follow in reducing emission progress. The result of emissions reduction from the City of Vancouver is remarkable in all three concerned sectors. Nevertheless, the City still needs to speed up its actions to be able to achieve its bold climate action targets.

Recommendation for provincial government:

Keeping data collection: The ongoing effort to keep data collected and published is of the most importance. It is understandably a long, complicated, and costly process involving a wide range of agencies, but keeping the momentum going will immensely support the evaluation of the climate action commitments of the local and provincial governments. However, there are three aspects that the provincial government can do to improve the dataset's quality.

- **Broadening monitored sectors focusing on transportation data:** Currently, except for the dataset from 2007, 2010, and 2012 that have the transportation emission data, the data set from 2011 to 2019 only covers utilities and waste data. The lack of up-to-date transportation data challenges comprehending the complete picture of total emissions for each local jurisdiction and the province. Later, the effort can be made to track emissions for other economic sectors such as agriculture.

- **Set up a feedback system:** Anyone who found any data problem can send the notice for the next releasing time to improve data qualification. For example, by doing this research, the author found some mistakes regarding emission data, i.e., emission data is inaccurate concerning the number of electricity consumption.

- **Shorten the time to release data:** The current lagging time is two years for collecting and controlling the data quality before publishing it. However, for this year, it is until July 2022 that the data 2019 is published. This delayed time poses a difficulty for assessing climate action progress and hinders timely intervention action.

Support local governments

- **Liaise with local governments:** The provincial government can liaise with local governments to better understand the data provided by utilities and then improve the data quality.

- **Provide more resources for local government:** Using the City of Vancouver as the model and provide resources for other communities to learn from the City of Vancouver.

The recommendation for the interested third parties, including think tanks, academia, non-for-profit organization, and the like, is to embrace the opportunity this dataset can bring. In the effort to combat climate change, it is essential to monitor the action to be able to provide appropriate intervention if needed. Equally important is the ability to predict GHG emissions to inform policymakers on the potential strategy.

Recommendation for future research

In future research, it is necessary to follow up with a more standard methodology and up-to-date transportation data. The provincial government does not provide transportation data in the CEEI data set after 2012. Therefore, it is hard to quantify the actual GHG emissions from this sector. At the beginning of this research, the author planned to use the raw data from the Insurance Corporation of British Columbia, but the change of insurance policy created multiple registration records, which made it challenging. Standard vehicle kilometer traveled data is also needed to quantify GHG emissions. The author recommends that there should be separated research on transportation emissions concerning the broad and complexity of the topic.

Google EIE data is also a good resource for identifying the progress of increasing active transportation modes such as cycling and walking compared to automobiles. This data source can, in part, help to determine the effectiveness of active transportation plans. To the author's knowledge, few organizations in Canada are cooperating with the Google EIE team. Future research can consider reaching out to those organizations to see if the Google EIE team could expand the jurisdictions in their dataset and further explore the data they provide.

Concerning regional districts like Vancouver and Squamish, the next research could also try to identify the relationship between the decline in residential emissions and densification in the building sector. In other words, an increasing proportion of apartment and condo units compared to single-family homes affect GHG emissions from residential buildings.

Last but not least, among over 200 communities in BC, this research only focuses on the ten selected communities. Future research can expand the scope of this research to include more communities. Ideally, there should be an online progress evaluation tool to support the local and provincial governments in monitoring their GHG emissions reduction in real-time.

DETAILED REPORT

Introduction

The Government of Canada has been doing an outstanding job in monitoring greenhouse gas (GHG) emissions across the country. The Province of British Columbia (BC) has also tracked the energy, transportation, and solid waste data for each community from 2007 to the present. Despite this effort, little work has been done to analyze the progress of each local community and quantify the community GHG emission reduction targets to be able to understand the successes and challenges of achieving their emissions reduction efforts.

It is vital to have a clear picture of progress for each community so that adequate and effective intervention can be considered on time. With this motivation, this research will try to answer the following questions:

1. How have communities in BC been progressing in energy use and emissions reductions versus their targets?

2. What are the trends within and between communities on energy and emissions, and how have these trends been helping or hindering progress toward reaching targets?

3. What factors contribute to these trends, and hence to the success or failure of communities in meeting emissions reduction targets?

4. What actions have communities taken (e.g., home energy retrofit initiatives, electric vehicle charging initiatives), and how can the results be identified in the data?

Based on the answers to these questions, the research will seek to provide recommendations to strengthen the ability of local governments and supporting organizations to model energy & emissions effectively. The research will suggest key areas to focus on so that it helps to strengthen the ability of communities to meet GHG reduction targets. And lastly, the research will help to inform ongoing tracking and reporting processes that will feed into future data collection, including identifying supporting progress indicators.

Background

This section provides a zoom-in view of federal and provincial governments' commitments to reduce GHG emissions. Commitments are shown in different key strategies and plans. More detailed information on the selected key strategy is provided in Appendix A.

Canadian Federal Government Commitments

Canada's 2030 Emissions Reduction Plan: Clean Air, Strong Economy (3/2022)

The plan[1] is to serve the need of Canadians for clean air, good jobs, a healthy environment, and a strong economy. This plan provides a sector-by-sector approach reaching the climate target of cutting emissions by 40 percent below 2005 levels by 2030.

Figure 9 below shows different commitments in the past as compared to the 2030 Emissions Reduction Plan, which aims to reduce the total GHG emissions of Canada to 443 million tonnes CO_2e. This is 40% less than the 2005 GHG emission level at 741 Mt CO_2e[2]. In order to reach this target, the pathway to 2030 shows the role of each economic sector, in which transportation, oil and gas, heavy industry, and buildings will need to play a significant role.

Figure 10 shows the breakdown of the CAD 9.1 billion investment pledges by the federal government to cut pollution and grow the economy. The majority of the investment is earmarked for accelerating the adoption of electric vehicles and climate action by communities, at CAD 2.9 billion and CAD 2.2 billion, respectively.

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[1] https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html

[2] CO_2e (also written as carbon dioxide equivalent, CO2 equivalent or CO2eq) is a metric measure that is used to compare emissions from various greenhouse gases on the basis of their Global Warming Potential by converting amounts of other gases to the equivalent amount of CO2.

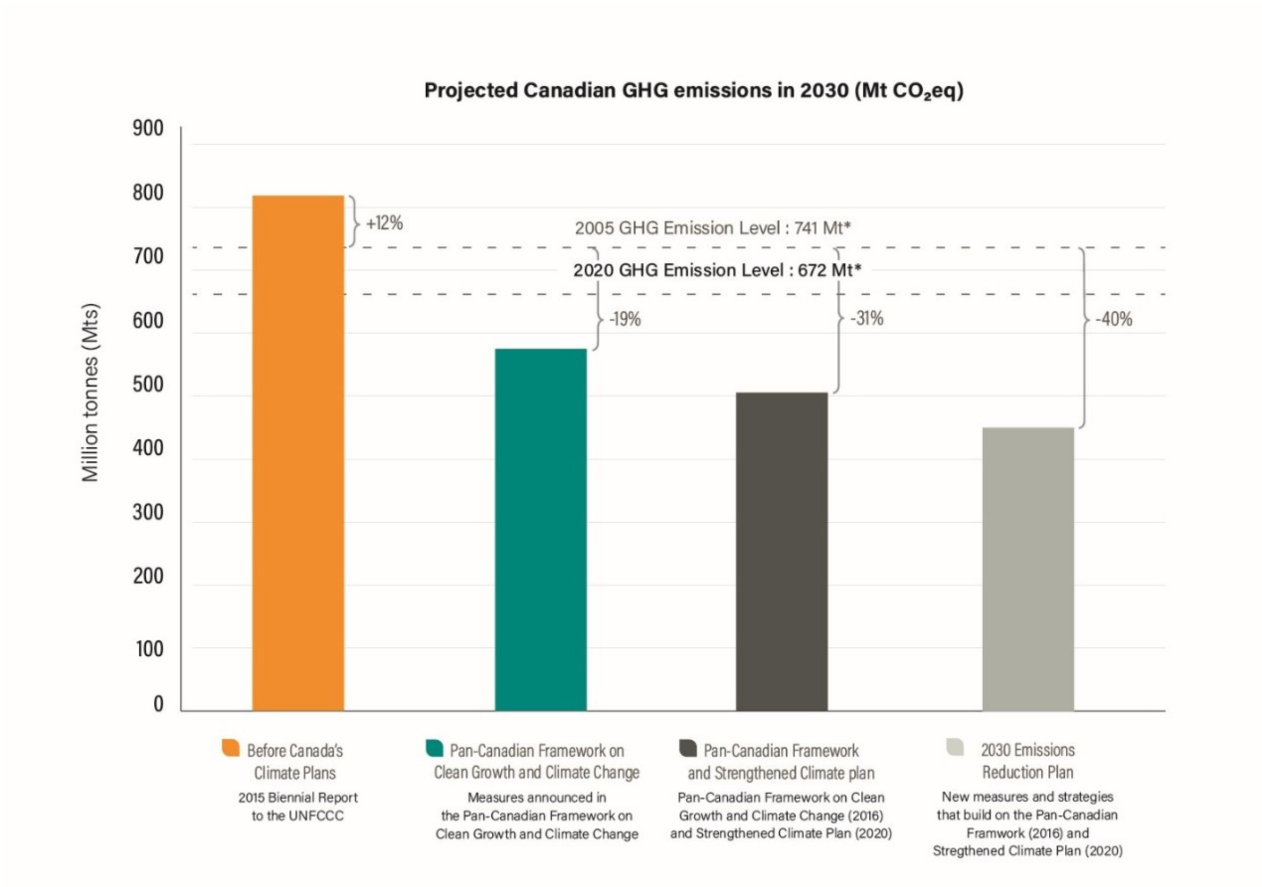

Figure 9: Projected Canadian GHG Emissions in 2030 (Canada's 2030 Emissions Reduction Plan)

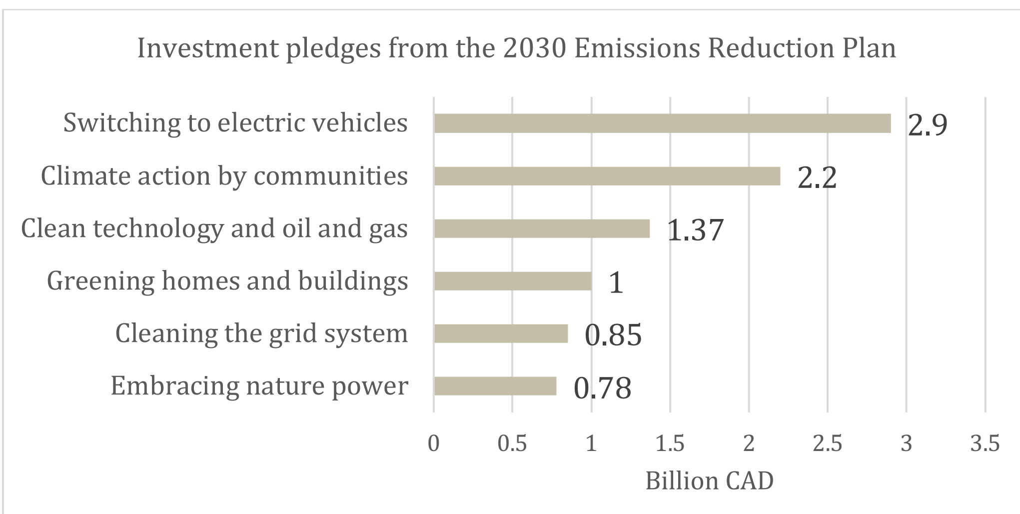

Figure 10: Investment pledges for the 2030 Emissions Reduction Plan

A Healthy Environment and A Healthy Economy (12/2016)

This federal plan[3] is to build a better future with a healthier economy and environment. It will make life more affordable for households, make Canadian communities more livable, and focus on workers and their careers in a more robust and cleaner economy. It has five pillars, including:

1. Cutting energy waste
2. Transportation and power
3. Pollution isn't free
4. Clean industrial advantage
5. Healthier families and resilient communities

National Adaptation Strategy

The first Canada National Adaptation Strategy[4] has been developing since December 2020 and is planned to be released by the end of 2022. There are five expert advisory tables since the first working phase focusing on:

1. Health and Wellbeing
2. Resilient Natural and Built Infrastructure
3. Thriving Natural Environment
4. Strong and Resilient Economy
5. Disaster Resilience and Security.

Pan-Canadian Framework on Clean Growth and Climate Change (8/2017)

This plan[5] was developed with the provinces and territories and in consultation with Indigenous people in order to meet the country's emissions reduction targets, grow the economy, and build resilience to a changing climate. The Pan-Canadian framework has four main pillars:

1. Pricing carbon pollution
2. Complementary climate actions
3. Adapt and build resilience

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[3] https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf

[4] https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/national-adaptation-strategy.html

[5] https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

4. Clean technology, innovation, and jobs

Canadian Net-Zero Emissions Accountability Act (Net-Zero by 2050) (6/2021)

To avert the impacts of climate change, the Government of Canada is committed to achieving net-zero emissions by 2050. The Canadian Net-Zero Emissions Accountability Act[6], which became law on June 29, 2021, enshrines in legislation Canada's commitment to achieving net-zero emissions by 2050. The Act ensures transparency and accountability as the government works to deliver on its targets. The Act requires public participation and independent advice to guide the Government of Canada's efforts.

British Columbia Government Commitments

BC is committed to reducing greenhouse gas emissions by 16% below 2007 levels by 2025, 40% by 2030, 60% by 2040, and 80% by 2050. To do this, CleanBC is the plan designed for a cleaner, better future with a low-carbon economy that creates opportunities for all people.

CleanBC Plan (2018)

CleanBC Plan includes a wide range of actions to reduce emissions, build a cleaner economy and prepare for the impacts of climate change. Launched in late 2018, CleanBC is helping improve how people get around, heat homes, and power industry. It includes groundbreaking policies that are leading the way forward on climate change. For example, under CleanBC, BC was the first jurisdiction in the world to make it law that all new car and truck sales would be zero-emission vehicles by 2040[7]. Since then, the highest uptake in electric vehicle purchases on the continent has

[6] https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050/canadian-net-zero-emissions-accountability-act.html

[7] https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

been witnessed. In total, CleanBC aims to reduce 18.9 Mt of provincial GHG in 2030, which accounts for 74% of the target reduction placed in legislation (25.4 Mt GHG from a 2007 baseline).

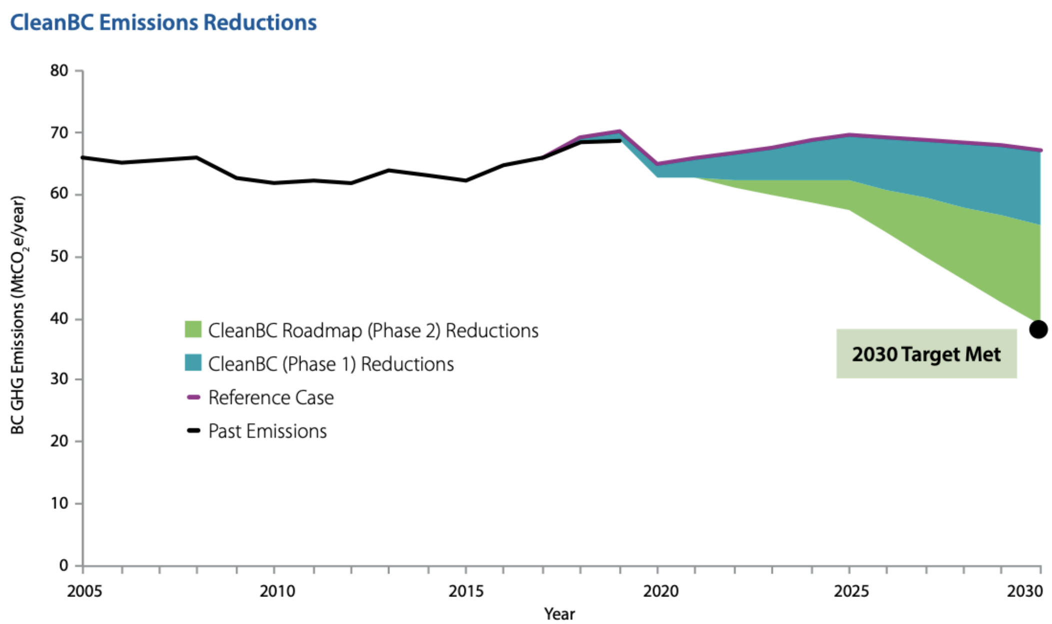


Figure 11: CleanBC Emissions Reductions (CleanBC Plan)

CleanBC Roadmap to 2030 (10/2021)

The CleanBC Roadmap to 2030[8] is the plan to achieve 100% of the emissions target. It includes a range of accelerated and expanded actions across eight pathways:

1. Low Carbon Energy
2. Transportation
3. Buildings
4. Communities
5. Industry, including Oil and Gas
6. Forest Bioeconomy
7. Agriculture, Aquaculture, and Fisheries
8. Negative Emissions Technologies

In the Roadmap to 2030, all economic sectors are expected to move up in the market readiness curve, in which electricity leads the way to be the most mature sector with low carbon technology, followed by transportation, buildings, and low carbon energy in the deployment states.

[8] https://cleanbc.gov.bc.ca

Figure 12: Progress of different sectors in BC (CleanBC Roadmap to 2030)

Local government collaboration

The BC provincial government has supported local governments in reducing GHG emissions and adapting to a changing climate. The provincial government, through CleanBC, also enacted laws and regulations, including the Climate Change Accountability Act, Carbon Tax Act, Greenhouse Gas Industrial Reporting and Control Act, and Clean Energy Act. These laws and regulations require local governments to commit to reducing emissions and transitioning to a low-carbon economy. In Bill 27 – 2008[9], Section 877 requires that "*An official community plan must include targets for the reduction of GHG emissions in the area covered by the plan, and policies and actions of the local government proposed with respect to achieving those targets*".

[9] https://www.bclaws.gov.bc.ca/civix/document/id/lc/billsprevious/4th38th:gov27-1

For more than a decade, local governments in BC have shown climate leadership through signing the Climate Action Charter, fulfilling commitments like tracing, reporting, and reducing emissions, and implementing climate action in their jurisdictions. The Charter was launched in 2007. Since then, almost every local government in BC—187 of 190 municipalities, regional districts, and the Islands Trust—has signed the Charter.

Resources provided by the BC provincial government to local governments include:

- Local Government Climate Action Program (LGCAP) to replace Climate Action Revenue Incentive Program (CARIP).

- CleanBC Communities Fund.

- Community Climate Funding Guide.

- Resources and actions for local governments.

More information on BC provincial strategy and support is provided in Appendix B.

BC'S NET-ZERO COMMITMENT

Like our current emission reduction targets, BC's commitment to a net-zero future will be backed by legislation. We'll engage with Indigenous communities, local governments, businesses, industry, and others in 2022 to ensure the legislation is consistent with the targets and the paths to reach them.

Research purpose

Project scope

There are over two hundred communities in BC. Within the framework of sustainability scholar, a decision has been made between the scholar and the mentor at Community Energy Association (CEA) to focus on ten communities. Three sectors have been selected, namely buildings, transportation, and waste, to assess community-wide emissions.

To select ten communities in BC, a set of criteria has been considered:

- Local communities' climate action targets
- Communities that have official community plans
- Diversified profiles (population, geographic distribution)
- Potential interests of local communities in this research's result

Based on this set of criteria, ten communities have been selected for further research (Table 2). For the ease of showing data in a graph/figure, the name of the communities might be shortened, for example City of Kamloops is shortened to Kamloops.

Table 1: Ten selected communities

No.	Name of communities
1	City of Kamloops
2	City of Kelowna
3	City of Nelson
4	City of Penticton
5	City of Prince George
6	City of Rossland
7	District of Squamish
8	City of Vancouver
9	City of Victoria

10	Resort Municipality of Whistler

Research method

Desk research on the Official Community Plan, Climate Change Plan, and other relevant local strategies to create a framework in which local effort toward reducing GHG emissions can be quantified. Progress data was collected based on publicly available data and data provided by CEA when necessary. Data aggregation and visualization were created using Microsoft Excel and Tableau.

Key datasets and their GHG emissions methodology calculations are summarized as follows.

Provincial greenhouse gas emissions inventory

BC Provincial Inventory[10] reports the GHG emissions in the province's legislated emissions reduction targets. The Climate Action Secretariat prepares and publishes the Provincial Inventory annually, with up to a two-year delay to allow time to assemble the information. The 1990-2019 Provincial Inventory was posted in October 2021 and had emissions data in three categories: activities, economic sectors, and gases. In addition to the aggregated GHG emissions of the whole province, utility energy data and landfill waste data focused on the community level are made available from 2007 to 2018. In the most updated version in July 2022, the provincial inventory of utilities and waste for each local jurisdiction is updated until 2019.

Within this research, utility energy and landfill waste data are used to determine the progress of reaching climate action targets, while the provincial GHG data is used to benchmark local communities' performance. It is worth noting that the most updated dataset comes at the final stage of this research, so the author tried to update as much as possible.

Provincial community energy and emissions inventory (CEEI)

The Province of BC made a series of standard assumptions in the creation of the CEEI[11] data and provided energy and emissions data at the community level to support local governments in

[10] https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory

[11] https://www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei

meeting local Climate Action Charter commitments. The dataset includes the years 2007, 2010, and 2012.

This research does not use the data from CEEI due to the updated data from the provincial GHG emissions inventory (mentioned in the previous part). However, the methodology used in the CEEI dataset is consistent with the Greenhouse Gas Protocol[12], with later data collection also based on the CEEI method. The CEEI method is mentioned in the following sections in three selected sectors.

Buildings

Data source

Provincial GHG emissions inventory as mentioned above. Data for five fuel types is collected, including:

- Electricity
- Natural gas
- Piped propane
- Delivered propane
- Wood
- Heating oil

Electricity, natural gas, and piped propane consumed within a local government boundary are included where confidentiality rights permit. And heating oil, delivered propane, and wood are estimated. For the major utilities (BC Hydro, Fortis BC Gas and Electric, Pacific Northern Gas), data is provided for 2007, 2010, 2012-2018. No data for the other utilities and wood/oil/propane estimates is available for 2013.In this research, the following actions are made to be able to process the dataset:

- ⇨ Electricity data from Nelson and Penticton are not provided in 2013; therefore, the average data of consumption and emissions from 2012 and 2014 are used to estimate for 2013.
- ⇨ Whistler was not connected to natural gas between 2007 and 2009; therefore propane emissions are used for Whistler in 2007.

[12] World Resources Institute and the World Business Council for Sustainable Development. The Greenhouse Gas Protocol; A Corporate Accounting and Reporting Standard. Revised Edition.

⇨ No analysis was made for wood, oil, and propane emissions because: "Wood/Oil/Propane data was only calculated for 2007. Future years have only been adjusted for weather. These estimates (including 2007) should be considered approximate and used with caution."

Heating Degree Days (HDD)

HDDs give an indication of the amount of space heating (e.g., from a gas boiler/furnace, electric baseboard heating, or fireplace) that may be required to maintain comfortable conditions inside a building during cooler months. When the daily average temperature is colder than the threshold temperature, HDDs are accumulated. 17℃ or 18℃ are commonly used as the threshold temperature. HDD data for the moderate emission scenario is collected from Climate Atlas[13]. (Moderate emission scenario is the representative concentration pathway 4.5, which assumes the Earth's radiative forcing will be increased by 4.5 W/m2 by 2100).

Calculation method (CEEI method)

Electricity and natural gas consumption data is obtained from energy utilities. The calculation for GHG emissions in buildings is:

Energy consumption *x* emission factor/coefficient *x* Global Warming Potential = CO_2e.

Emission factors

The provincial GHG emissions inventory uses the emission factors provided by energy utilities. For the electricity emission factors, data of three entities, namely BC Hydro, FortisBC, and Nelson Electricity, is used and averaged for three years. These emissions decreased over the timeframe between 2007 to 2017 as depicted in the below figure.

[13] https://climateatlas.ca/map/canada/hdd_2060_85#

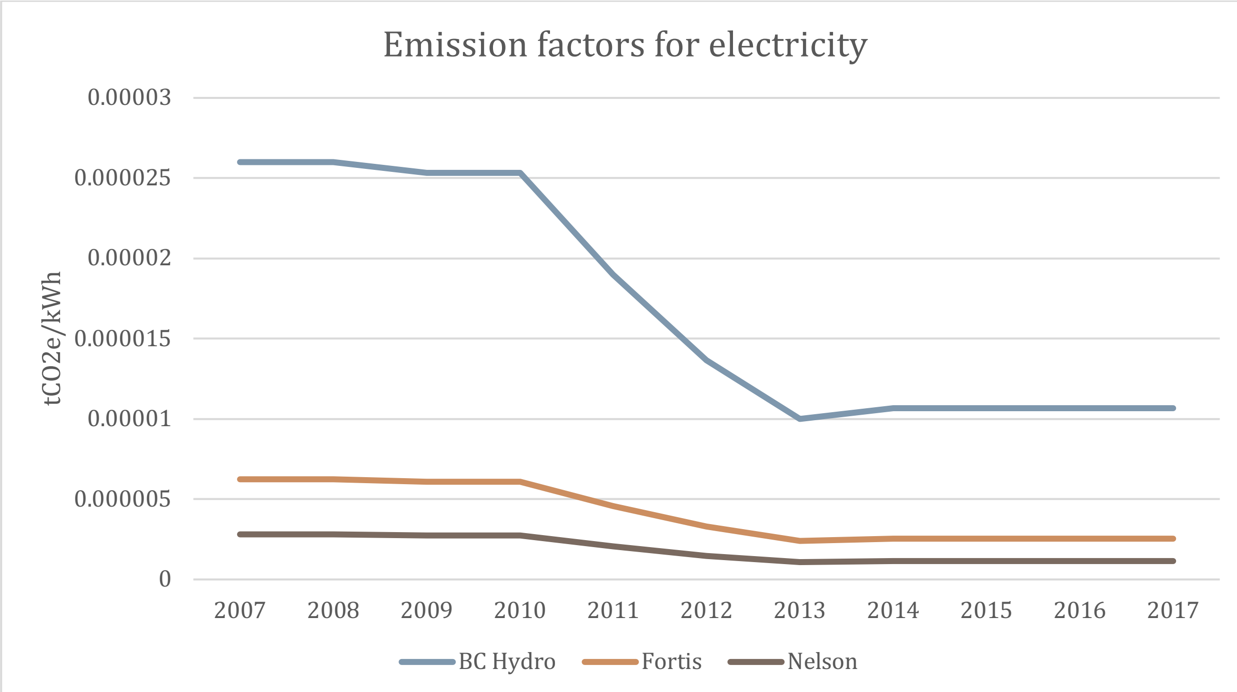


Figure 13: Emission factors used in building sector

Unlike electricity emission factors, the natural gas emission factor is unchanged at 0.0499 tCO2e/GJ over time.

Waste

Data source

Provincial GHG emissions inventory as mentioned above.

Calculation method

The waste in place (WIP) method using first-order decay equation for calculating GHG emissions from landfills is chosen in CEEI method because of its consistency and accuracy. This method accounts for the GHGs actually emitted in the current year, which are a result of waste disposed of in previous years.

$$E_Y = \sum_{i=1}^{N} \sum_{j=1}^{10} k L_o \left(\frac{M_i}{10}\right) e^{\left[-k\left(N-i+\frac{j-1}{10}\right)\right]}$$

Where:

- E_Y *is the methane emission* $(m^3\ CH_4)$ from the landfill in year Y, the year for which the calculations are made.
- M_i is the mass of the MSW disposed in year i (in tonnes).
- j is the time increment in 1/10th years.
- N is the number of years that MSW disposal is accounted for.
- k is the decay rate (per year).
- L_0 is the methane generation potential of MSW ($\frac{m^3\ CH_4}{tonne} MSW$)

Then the conversion of methane to CO_2-equivalent uses this equation:

$$GHG_{CO2e,mass} = GHG_{CH4,volume} * 0.6785 \frac{kg\ CH_4}{m^3 CH_4} * 25 * 0.001$$

Where:

- $GHG_{CO2e,mass}$ is emissions reported as CO_{2e} in units of mass (tonnes)
- $GHG_{CH4,volume}$ is emissions reported as CH_4 in units of volume (m^3)
- 0.6785 is the density of methane at standard temperature and pressure
- 25 is the global warming potential of CH_4
- 0.001 is the conversion factor from kilograms to tonnes.

Transportation

Data source

Fuel sale data in GHG emissions is provided by CEA. CEA has provided the fuel sale data for eight cities, of which six cities are within the scope of this research. In the remaining four cities (Kamloops, Nelson, Rossland, and Victoria), local governments' reports will be used to collect the most up-to-date data.

Google Environment Insights Explorer

In 2018, Google founded the Environmental Insights Explorer (EIE)[14] with the aim of providing baseline data to support the process of setting and finding reduction opportunities.

[14] https://insights.sustainability.google

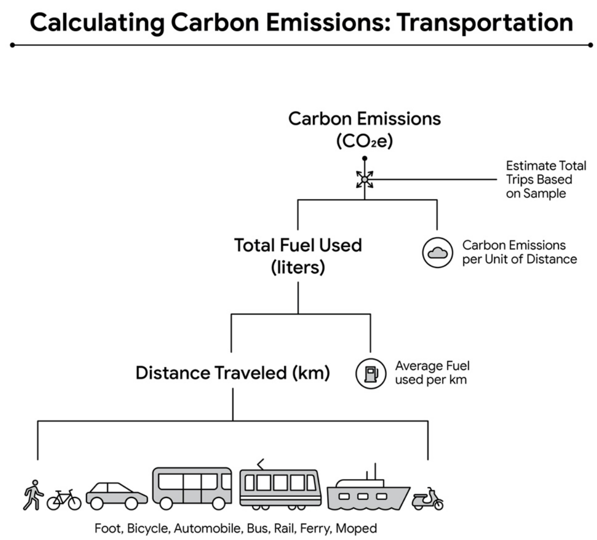


Figure 14: Google EIE's methodology for transportation emissions calculation

For ten selected communities in this project, only four cities are represented within the EIE data, namely Victoria, Kelowna, Kamloops, and Prince George, from 2018 until 2021. The results of EIE data will be used as an additional reference for the fuel sale data.

Population

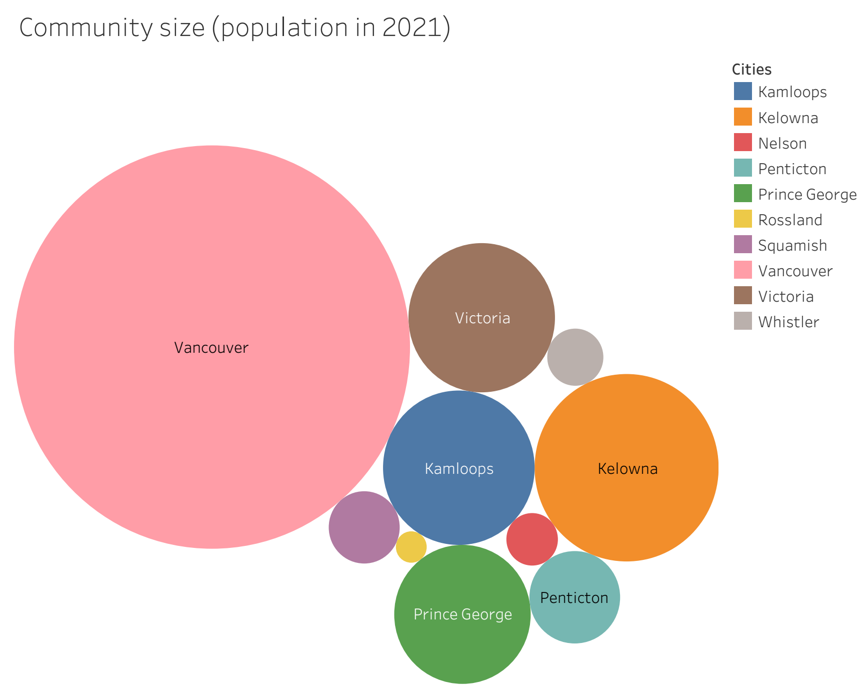
Population estimates for sub-provincial areas are collected from BC Statistics[15]. The population of each selected community will be used to calculate emissions per capita.

[15] https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-estimates

Results and discussion

Overview of ten selected communities

Ten communities are selected based on the criteria of their climate action plans, geographical distribution, and population representation. Figure 15 below shows the size of each city based on the population in 2021. The City of Vancouver has the highest number of residents, with 572,225 people. Rossland has the lowest population of 3,794 people.



Cities	POP 2021
Vancouver	572,225
Kelowna	100,976
Kamloops	80,716
Victoria	77,821
Prince George	75,405
Penticton	32,402
Squamish	14,765
Nelson	9,755
Whistler	9,364
Rossland	3,794

Figure 15: Community size based on population in 2021

Whistler and Squamish saw the most fluctuation in population numbers over time among the ten cities. Especially from 2018 to 2019, Whistler saw its population rise by 8%, the highest among all the communities. In the following years until 2021, however, Whistler population change dramatically decreased, reaching the lowest negative percent in 2020-2021. Squamish also witnessed the fluctuation in the population change. The district had a negative value for population growth in 2018-2019; however, the trend was reversed in the following years.

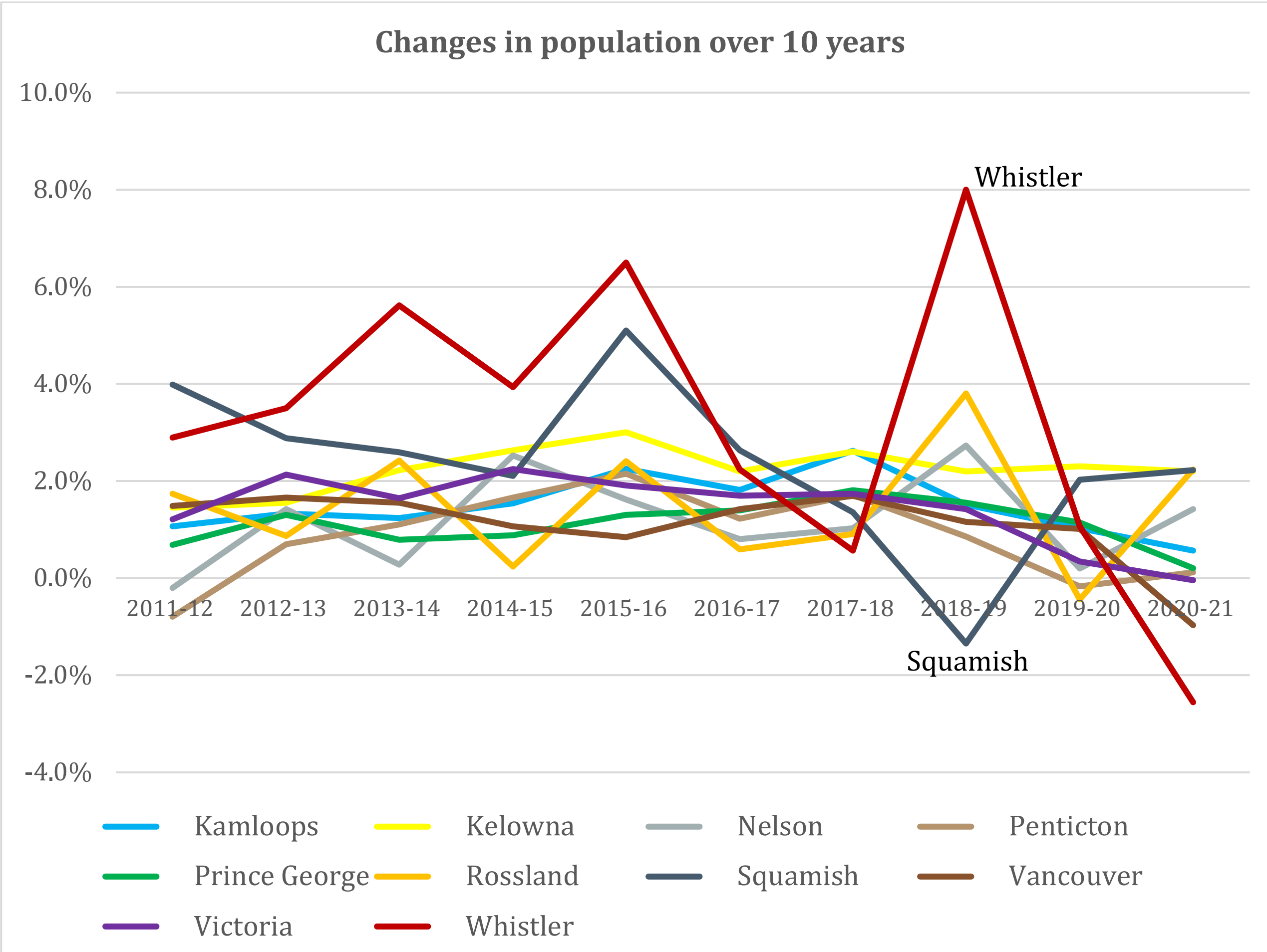


Figure 16: Change in population over time

All ten selected communities have GHG emission reduction targets (Table 2). Four communities, namely Nelson, Penticton, Squamish, and Vancouver, have Net-Zero targets in 2050. The six remaining cities have set their targets to have an 80% GHG emissions reduction in 2050 and Whistler has a further target of a 90% reduction in 2060, compared to the 2007 baseline.

Table 2 also provides a snapshot of the emission profile at the community-wide[16] level. The data from Table 2 is collected from Official Community Plans (OCPs) and other strategic papers

[16] Community-wide emissions refer to community-wide energy use. It consists of transportation, buildings, and waste as the focus areas. (CEA)

published by local governments. Notably, except for the City of Vancouver and Victoria, where the primary source of emissions is from the building sector, the primary source is transportation in the other eight communities. The column denoted change contains information from publicly released information (such as OCP, monitoring reports, etc.) and is named self-announced change in the summary section of this report.

As compared to the baseline GHG emissions, five cities have reduced emissions, including Kamloops, Kelowna, Vancouver, Victoria, and Whistler. The City of Vancouver is leading the emission reduction pathway, with emissions in 2020 being 17% less than the 2007 baseline, which the result in 2020 could be partly due to the impact of the COVID pandemic. The City of Rossland has seen almost no increase in emissions as compared to the 2007 level. And the remaining four cities, including Nelson, Penticton, Prince George, and Squamish, have seen their emissions increase compared to the 2007 level.

Table 3 provides overview policy papers, including plans and strategies each local community adopts. In a situation where a community does not have a specific strategy, it does not mean they do not have any work plan for that topic. All OCPs are comprehensive, placing sustainability as their development's core pillar. The City of Vancouver does not have an OCP, but the Greenest City 2020 Action Plan serves as the OCP with a sustainability vision. Notably, all selected cities have climate action plans and adopted the BC Energy Step Code for their building sector.

The last column of Table 3 presents the status of corporate emissions[17] (local government emissions) in the most updated Climate Action Revenue Incentive Progam (CARIP) reports. Five local governments have carbon neutral status, including Nelson, Penticton, Squamish, Vancouver, and Whistler. It is worth mentioning that although these local governments may have made some progress in reducing actual corporate emissions, they will have mainly achieved this status through purchasing offsets. The five remaining governments have their status of accelerating progress on charter commitment. The status in the CARIP report means local government's effort in reducing their corporate activity emissions.

[17] Corporate emissions refer to municipal facilities and operations. It can have detailed energy information with more emphasis on immediate actions and can anchor community-wide projects. However, corporate emissions account for a very small portion of the community-wide emissions. (CEA)

Table 2: Overview emission reduction targets and a snapshot on the result (self-announced results)

Cities	Emission reduction target (Community-wide) *					Emission profile (snapshot)**						
	2020-2025	2030-2033	2040	2050	2060	Building	Transportation	Waste	Year	tCO2e	2007 (tCO2e)	Self-announced emissions reduction
City of Kamloops		30%		80%		29%	66%	5%	2017	565,000	612,000	-7.7%
City of Kelowna	4%	25%		80%		36%	55%	9%	2012	642,000	665,234	-3.5%
City of Nelson		75%	100%	100%		37%	59%	4%	2018	79,102	71,200	11.1%
City of Penticton		40%		100%		37%	54%	9%	2019	250,000	224,761	11.2%
City of Prince George	5%	12%	50%	80%		38%	52%	10%	2017	550,000	540,000	1.9%
City of Rossland		40%	60%	80%		33%	55%	12%	2020	25,000	24,970	0.1%
District of Squamish***		45%		100%		27%	53%	20%	2017	97,000	86,000	12.8%
City of Vancouver****		50%		100%		56%	39%	4%	2020	2,335,000	2,805,000	-16.7%
City of Victoria		50%		80%		50%	40%	10%	2017	369,609	399,146	-7.4%
Resort Municipality of Whistler	33%			80%	90%	38%	60%	2%	2019	131,166	133,019	-1.4%

*100% means net zero

** Due to rounding, number does not add up to 100%

*** District of Squamish has set baseline year is 2010

**** City of Vancouver aims to be carbon neutral before 2050

Table 3: Key plan and strategy to realize GHG emission reduction commitments

Cities	Official Community Plan	Climate Action Plan	Sustainability Plan	Electric Vehicle Strategy	Sustainable Transportation Plan	BC Energy Step Code adoption	CARIP 2018 & 2019
City of Kamloops	Yes	Yes	Yes	Yes	Yes	Yes	Accelerating progress on charter commitments
City of Kelowna	Yes	Yes	No	Yes	Yes	Yes	Accelerating progress on charter commitments
City of Nelson	Yes	Yes	Yes	No	Yes	Yes	Carbon Neutral
City of Penticton	Yes	Yes	Yes	No	Yes	Yes	Carbon Neutral
City of Prince George	Yes	Yes	Yes	Yes	Yes	Yes	Accelerating progress on charter commitments
City of Rossland	Yes	Yes	Yes	No	Yes	Yes	Accelerating progress on charter commitments
District of Squamish	Yes	Yes	No	No	Yes	Yes	Carbon Neutral
City of Vancouver	No	Yes	Yes	Yes	Yes	Yes	Carbon Neutral
City of Victoria	Yes	Yes	No	Yes	Yes	Yes	Accelerating progress on charter commitments
Resort Municipality of Whistler	Yes	Yes	Yes	Yes	Yes	Yes	Carbon Neutral

Although in the utility data, FortisBC Gas and Fortis Electric include large industrial customers within commercial and small-medium industries (CSMI), the emissions from related operations of these facilities will not be reported in the community energy emission. However, their closeness to a city or community will subsequently affect the lifestyle and energy consumption of residents and offices who might work or supply those facilities. According to the BC industrial facility's greenhouse gas emissions[18], the table below shows the number of industrial facilities in the regional district to which the selected communities belong. The total tonnes of CO2e is the sum of those facility-reported emissions. The District of Squamish and the City of Vancouver have the most significant number of industrial facilities in their regions, followed by the City of Kamloops and the City of Prince George.

Table 4: Industrial facilities with their emissions

NAME OF CITY	NUMBER OF INDUSTRIAL FACILITIES IN REGIONAL DISTRICT	TOTAL T CO2-E (2018)
City of Kamloops	9	1,774,522
City of Nelson	1	1,330,736
City of Kelowna	5	478,095
City of Penticton		
City of Prince George	5	661,485
City of Rossland	3	357,745
District of Squamish	24	2,776,651
City of Vancouver		
City of Victoria	1	15,368
Resort Municipality of Whistler	0	0

[18] https://www2.gov.bc.ca/gov/content/environment/climate-change/data/industrial-facility-ghg

Buildings

This section presents the overall electricity consumption per capita and natural gas consumption per capita for ten selected communities in the building sector. The detailed emission profile of each community will be provided later.

Per each fuel type, one city with the highest number is taken out in a separate graph so that the remaining cities' data will be readable. Figure 17 shows Whistler's remarkably decreasing trend of electricity per capita, starting from 41,712 kWh/person in 2007 down to 26,197 kWh/person in 2019. This significant reduction is believed to be due to Whistler's late connection to natural gas. There would have been more use of electricity for heating and hot water in the community, but then with the availability of cheap natural gas, they would have seen a shift towards that fuel, and hence a declining use of electricity. However, despite significantly reducing over time, Whistler's electricity consumption per capita is still the highest among the ten cities.

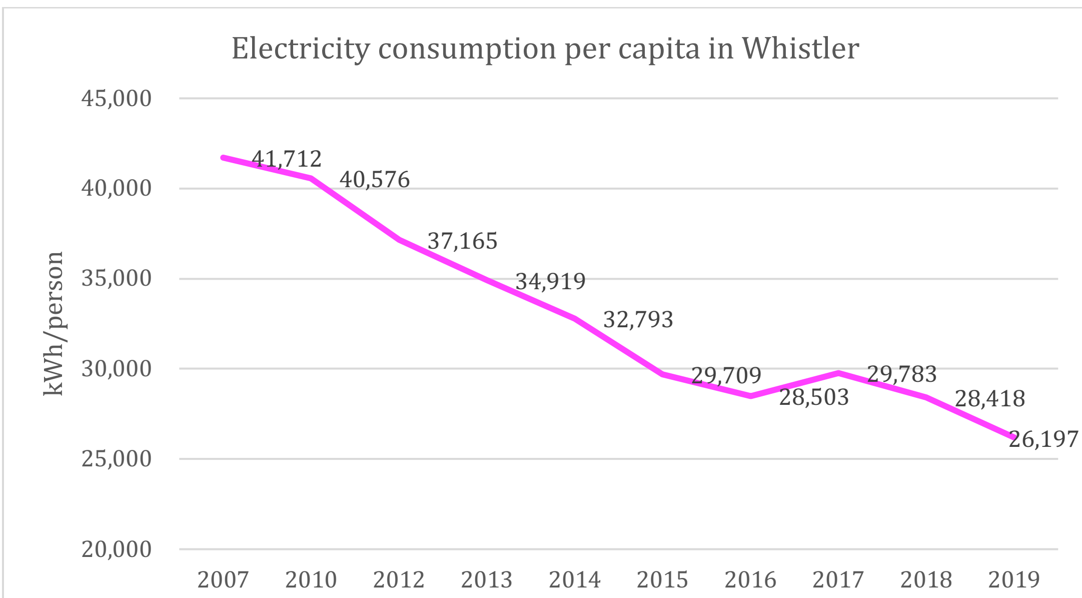


Figure 17: Electricity consumption per capita in Whistler

Figure 18 illustrates the remaining nine cities. The remaining nine cities generally have their electricity used per capita within 6,000 kWh to 11,000 kWh/person over time. Only Kelowna's number increased above this range and up to 13,094 kWh/person and 12,510 kWh/person in 2014 and 2015, respectively. Rossland has the lowest electricity consumption per capita in the same period, followed by Vancouver and Kamloops. To put it in perspective, BC's average number for electricity consumption per capita is 11,800 kWh/person. Electricity consumption per capita is 14,600 kWh/person for Canada.

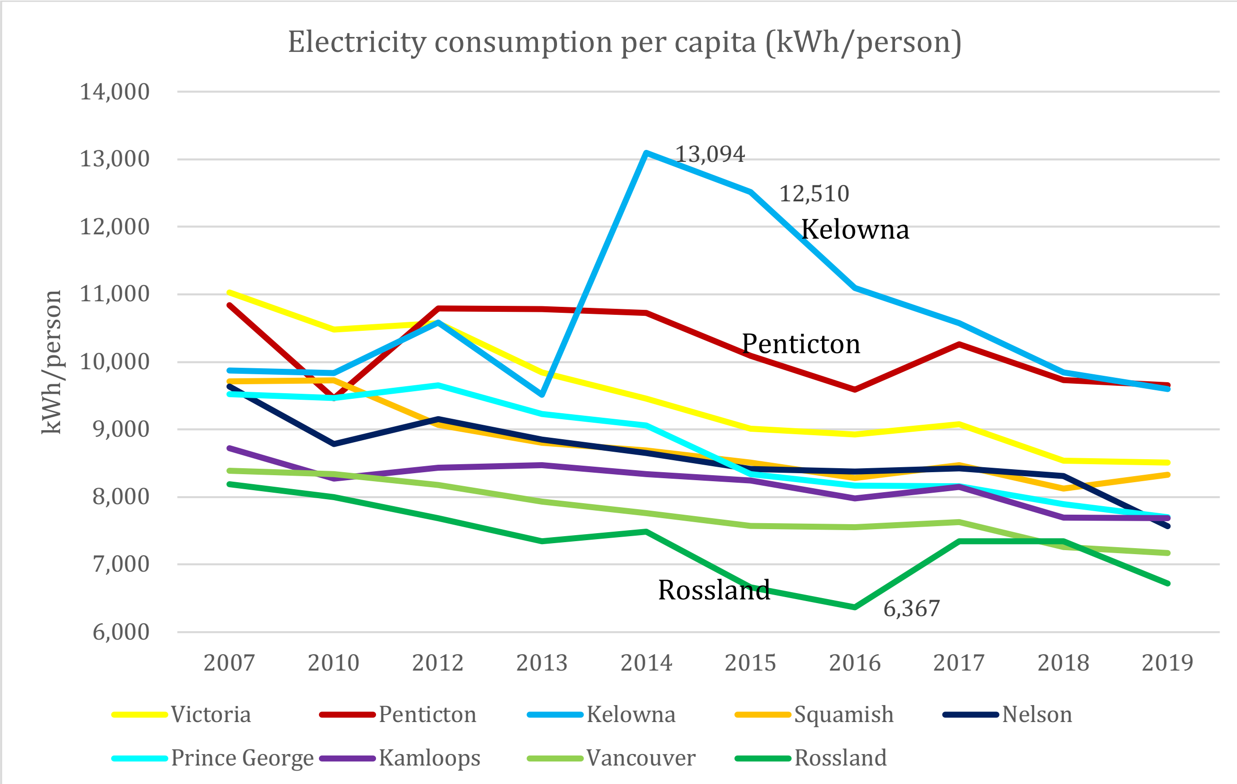


Figure 18: Electricity consumption per capita

Regarding natural gas consumption per capita, Prince George has its highest data among ten cities, and the data fluctuates but gradually increases over time. The lowest consumption was in 2010 at 121 GJ/person, while in the most recent year in 2019, it reached 169 GJ/person.

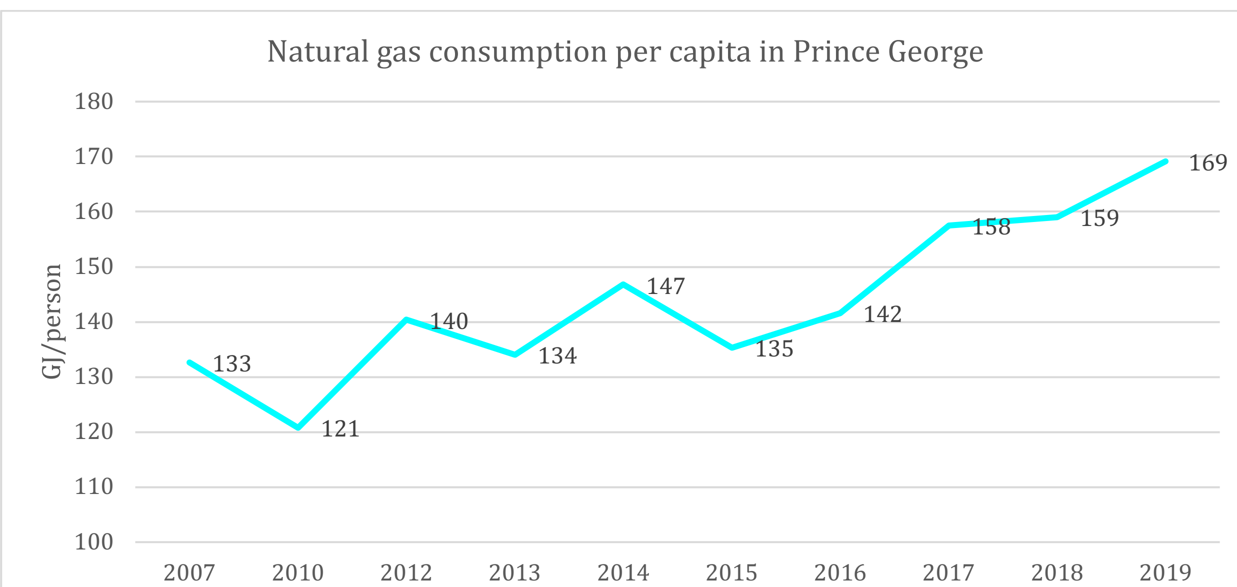


Figure 19: Natural gas consumption per capita in Prince George

Figure 20 below shows the natural gas consumption per capita for the remaining nine cities. Whistler had the highest number at 81 GJ/person in 2007, but Kamloops surpassed it in 2011. Since then, these two cities have their numbers highest among nine cities, fluctuating within the range of 60 to 80 GJ/person. Consistently, Squamish has the lowest number at just over 20 GJ/person over time, followed closely by Victoria. The remaining five cities have data between 30 to 50 GJ/person. In reference, BC's average number for natural gas per household is 90 GJ/household per year.

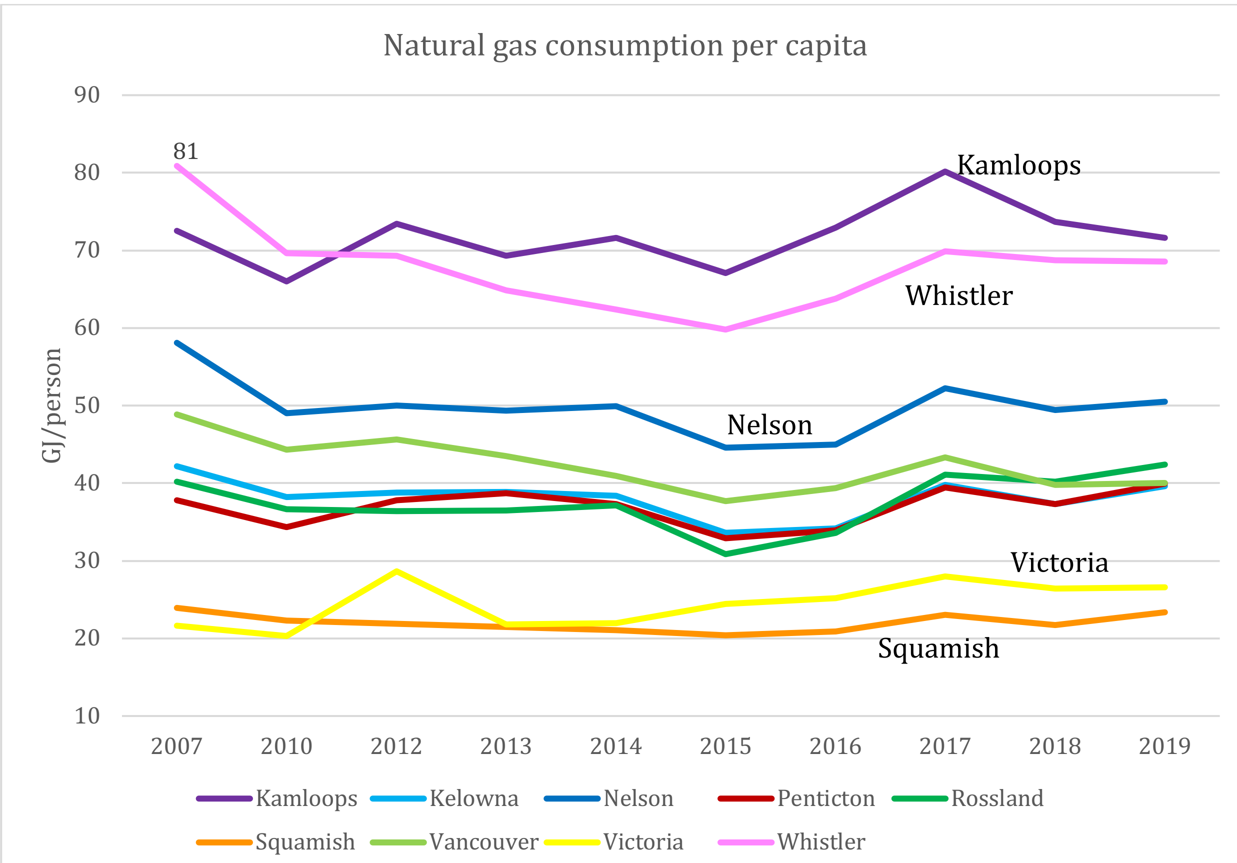


Figure 20: Natural gas consumption per capita

Note: Whistler used propane for residential buildings in 2007.

With regard to emissions in CSMI and residential buildings, the emission per capita indicator (for both fuel types) is used to normalize the emissions and compare between cities. In CSMI buildings, Prince George, Whistler, Kamloops, and Vancouver have had the highest emission per capita, respectively (Figure 21). Rossland has the lowest emission per capita in this segment. The BC data is included to show the average performance benchmark for all cities. Compared to BC's data, only

Squamish and Rossland consistently have lower GHG emissions per capita than the average BC over time.

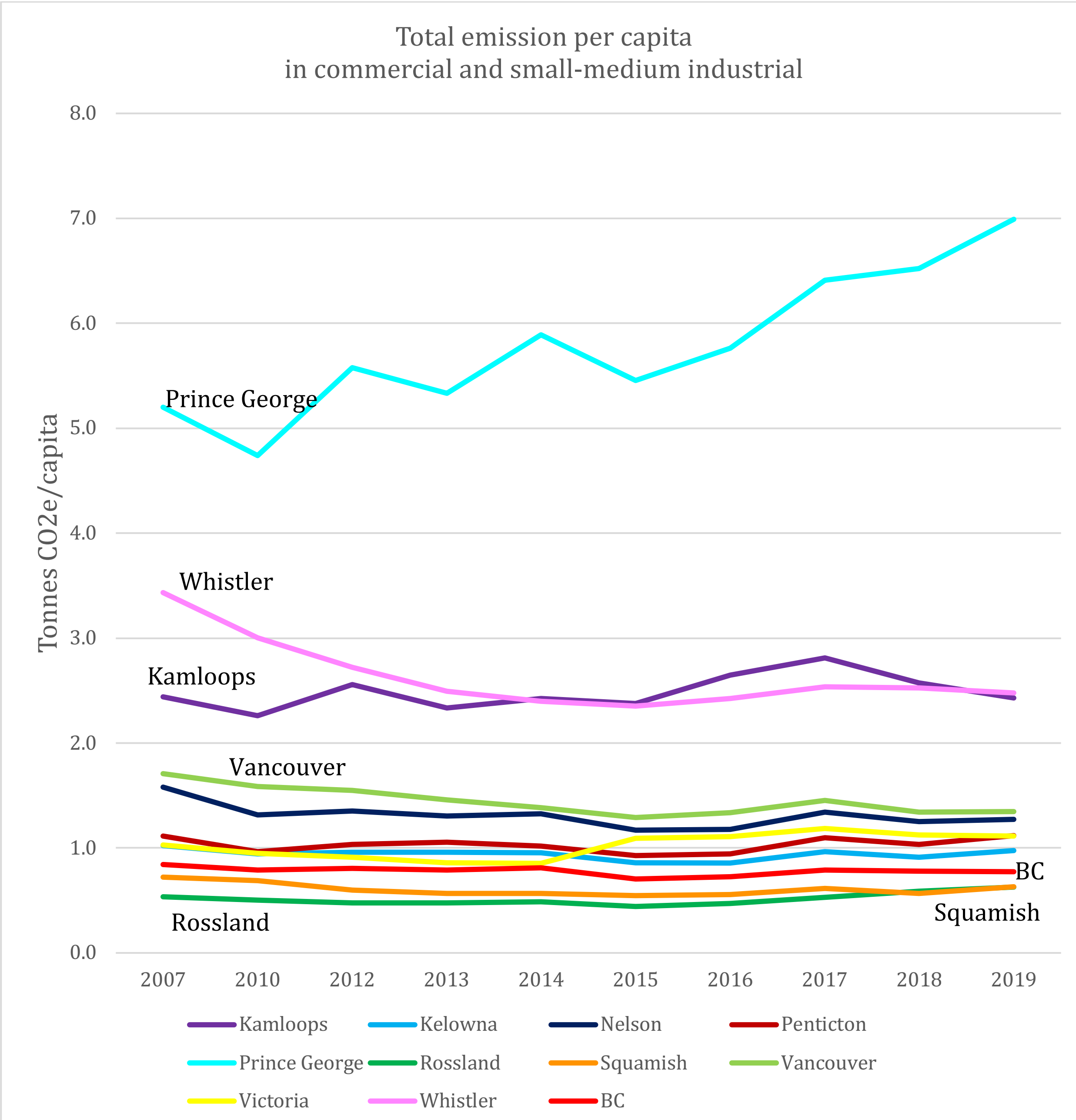


Figure 21: Emission per capita in commercial and small-medium industrial

In Figure 21, as mentioned above, FortisBC includes large industrial customers in CSMI; therefore, the emission per capita is relatively high. And except for Prince George with a steadily increasing trend, Kamloops with a moderately growing direction of emission per capita, and Victoria with a leap from 2014 to 2015, other cities stay constant over time.

Concerning residential buildings, three cities have their building emission per capita lower than BC data Vancouver, Squamish, and Victoria. Notably, Whistler's residential building emissions have decreased significantly from 2007 to 2015. This trend is partly due to the impact of connecting to the natural gas pipeline and stopping using propane.

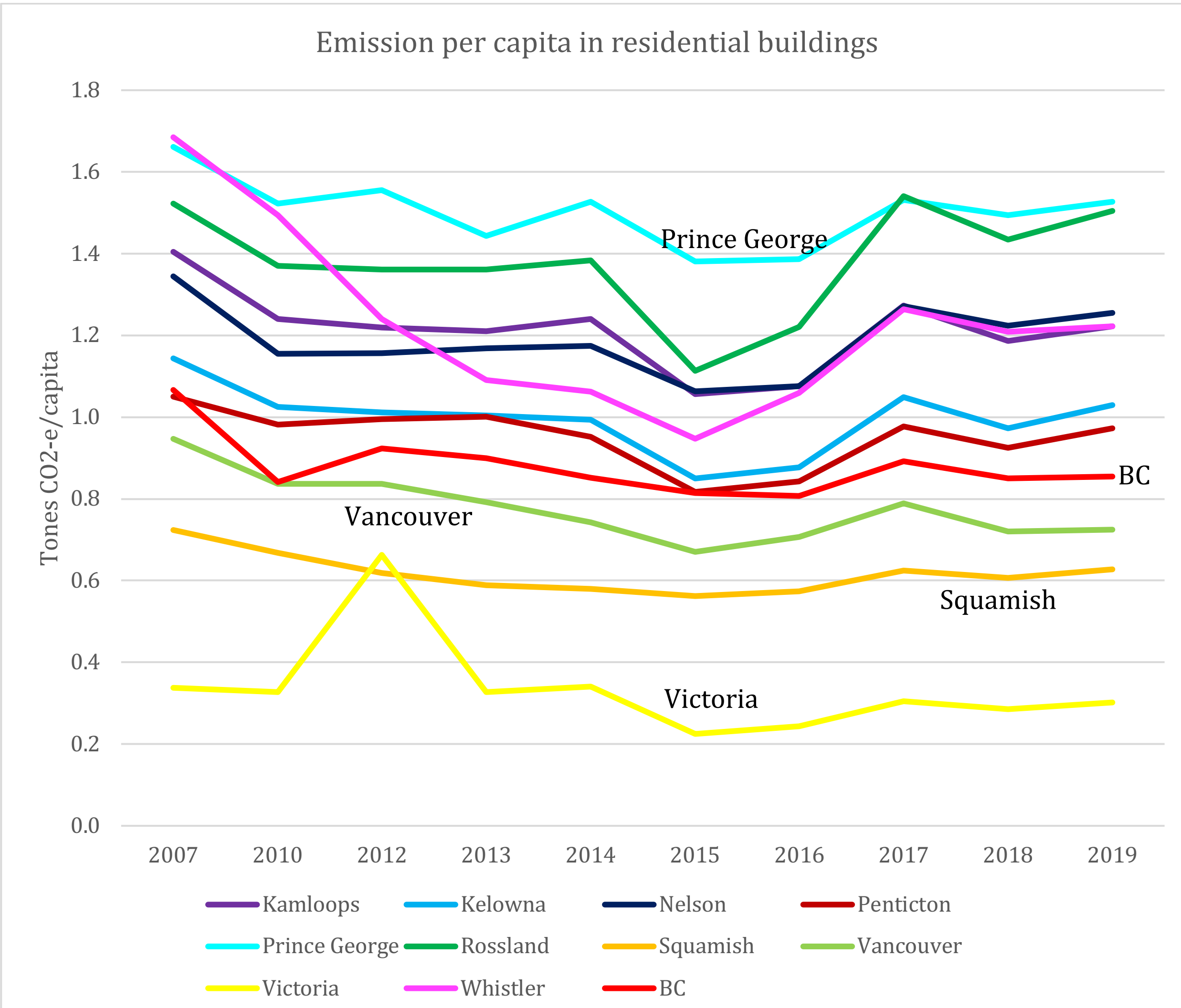


Figure 22: Emission per capita in residential buildings

To better understand the impact of cold weather on energy consumption and its GHG emissions, the below figure 23 generates emissions per capita per HDD.

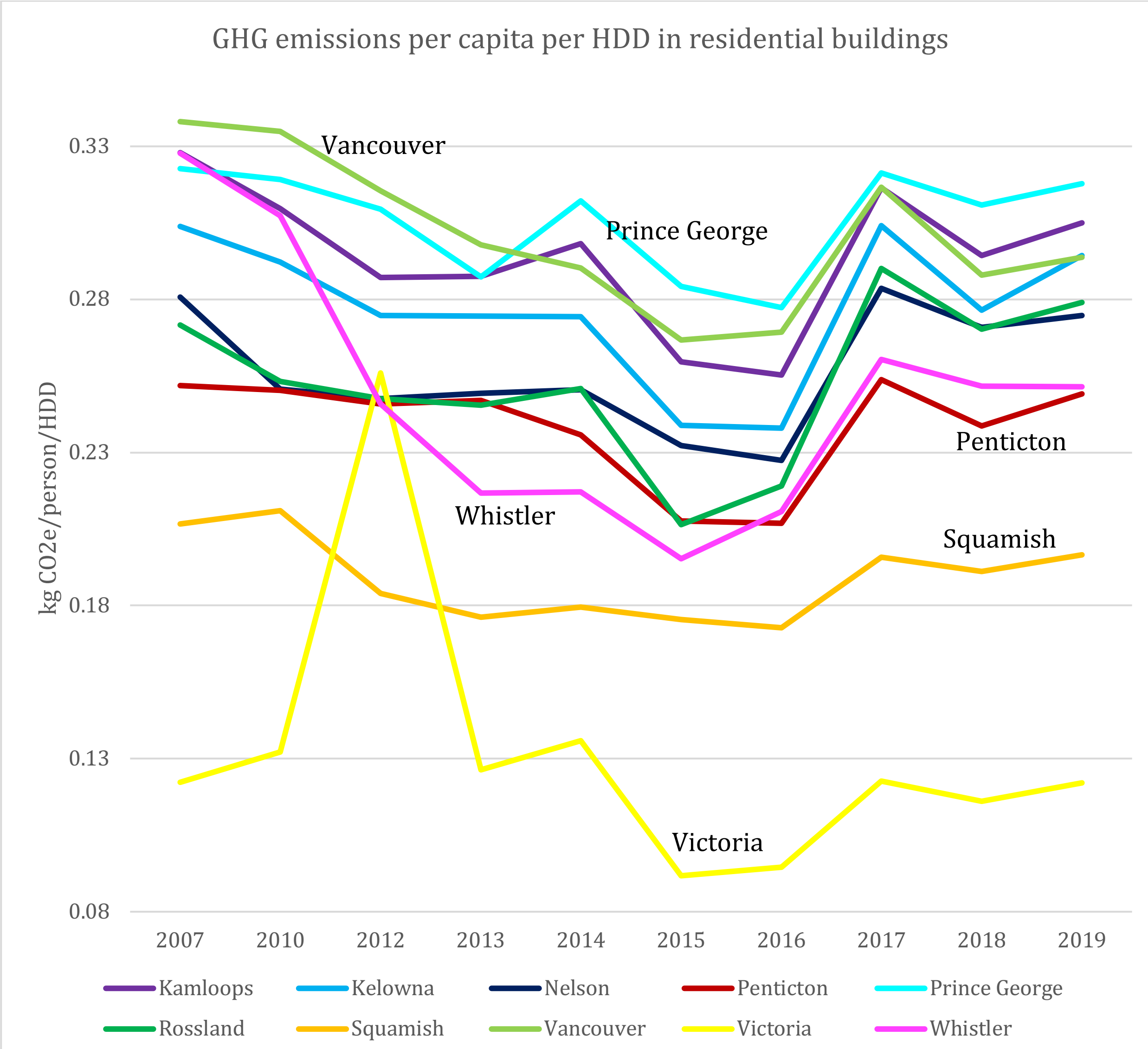


Figure 23: GHG emissions per capita per HDD in residential buildings

In residential buildings emissions per capita per HDD, the general trend was downward until 2015/2016, then rose again in 2017. The year 2017 has the lowest HDD on average, which increases gradually in 2018 and 2019. Whistler witnessed the most significant decline over time. Despite having a spike in 2012, Victoria is the city with the lowest emission per capita per HDD in residential buildings.

In summary of both CSMI and residential buildings, the total GHG emission per capita for each city is presented in Figure 24. Prince George, Kamloops, and Whistler consistently stand in the top three cities with the highest emission per capita, with Prince George taking the lead over time. Only Victoria and Squamish have the building emission per capita lower than the BC average.

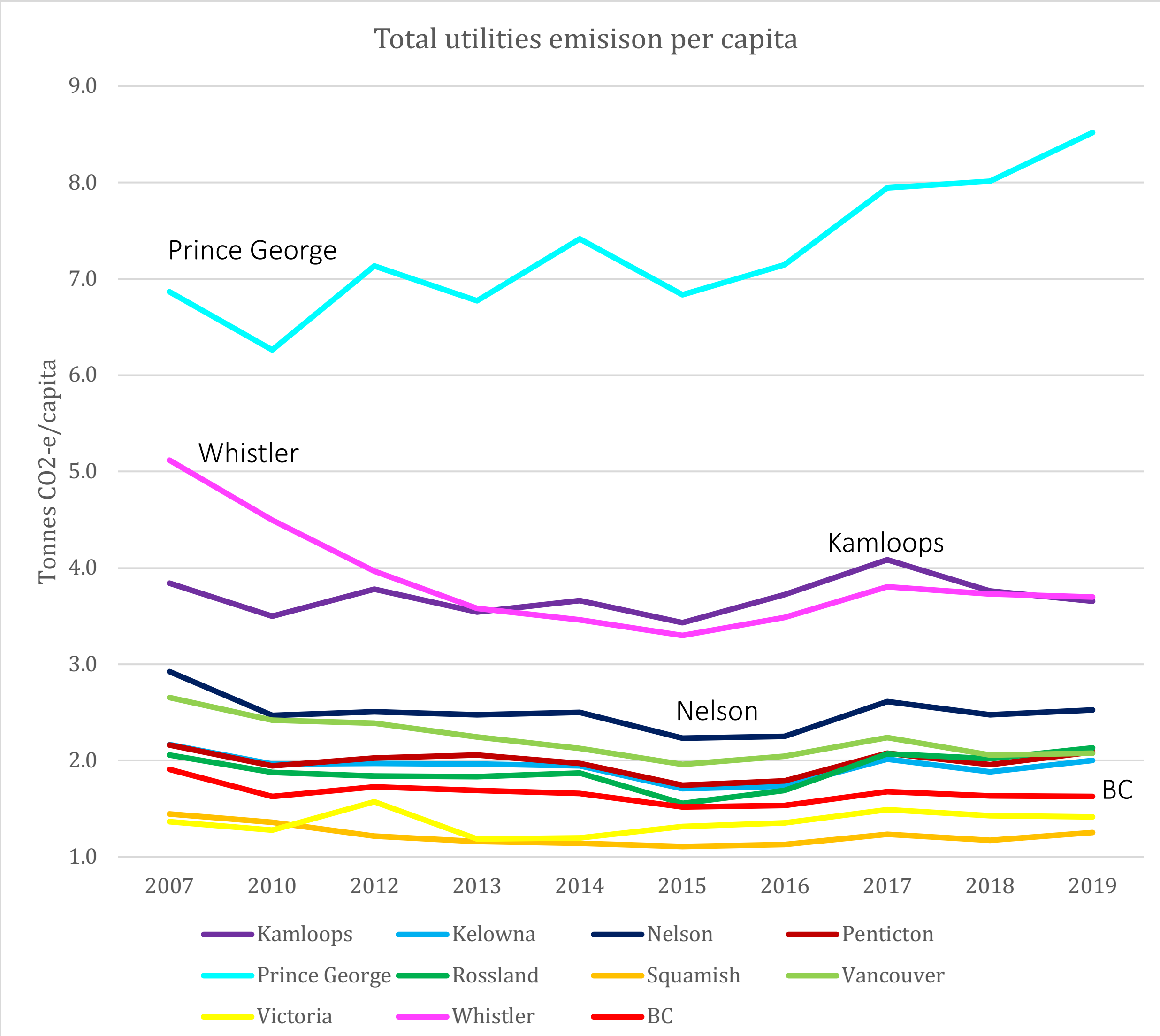


Figure 24: Total utilities emission per capita

In the next section, each community's GHG emissions in the building sector will be presented in detail. GHG emissions trends will be forecasted based on the historical data and measurements the community has adopted.

Note: the building dataset does not contain data from 2008, 2009, and 2011. However, when using Tableau for the below visualizations, Tableau automatically connects the missing years to show the trend of data more clearly.

City of Kelowna

In the building emission picture of the City of Kelowna, two trends are opposite for electricity and natural gas. For both CSMI and residential buildings, the GHG emissions from using electricity decreased significantly over time, especially between 2010 and 2013. At the same time, GHG emission from using natural gas shows trends upward but not as steep as for electricity.

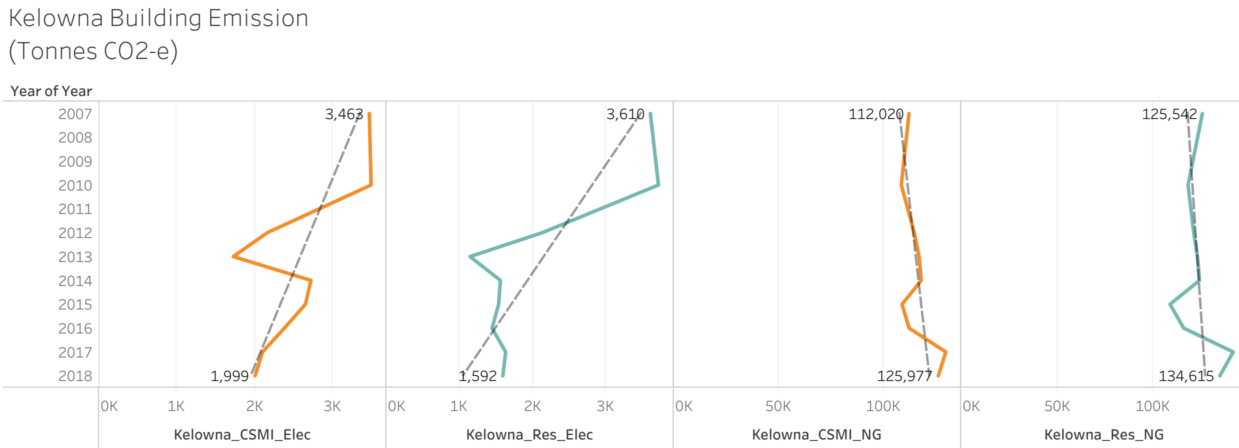


Figure 25: Kelowna building emission

Nevertheless, with consideration of the decreasing emission factor for electricity, the positive correlation between electricity consumption and the emitted emission is questionable because of the decreasing emission factors. Figure 26 below attempts to find the answer to this concern.

Clearly, the opposite trends are observed between the two variables. In essence, electricity consumption is increasing in both types of buildings while emission is decreasing over time.

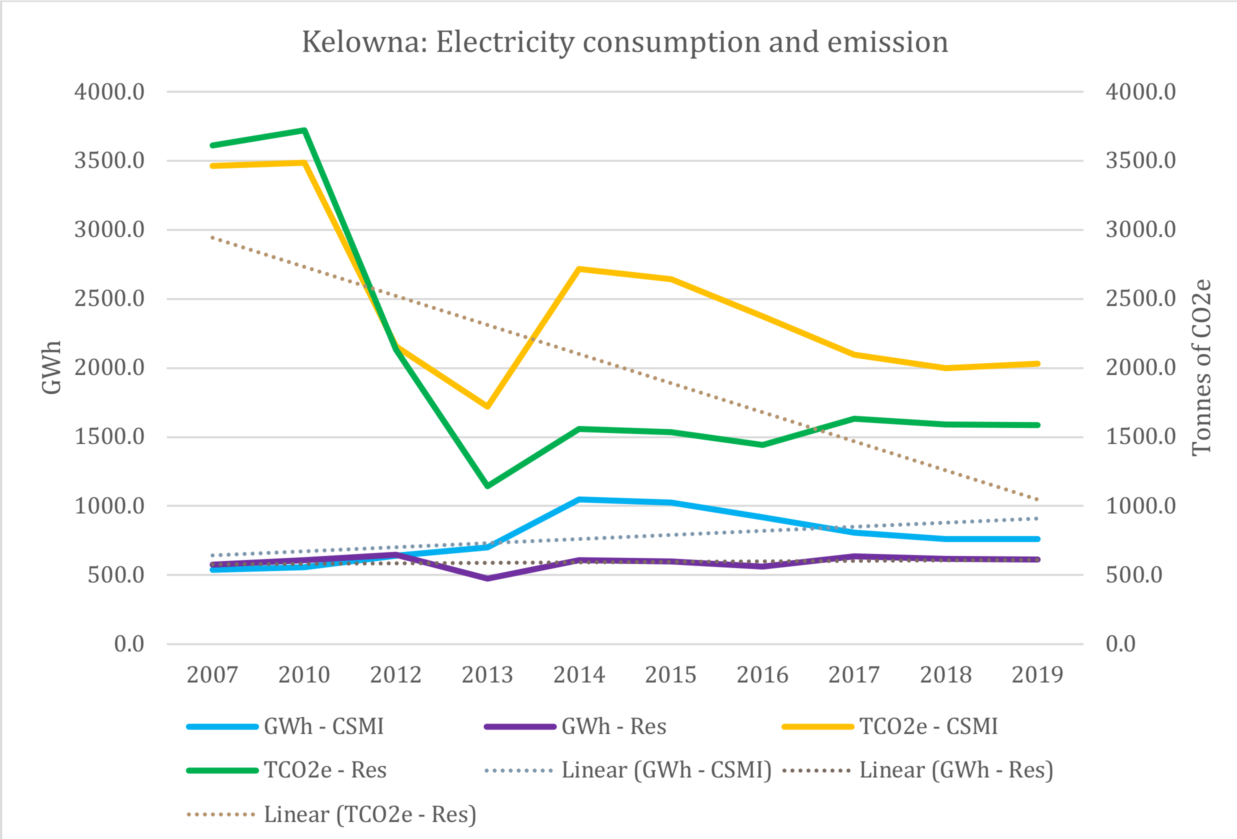


Figure 26: Kelowna electricity consumption and emission

The City of Kelowna adopted the BC Energy Step Code in April 2017 and has a rebate program from both the city and FortisBC to offer a $325 building permit rebate for residential buildings with the transition to Step 3 and beyond. There is not yet an assessment of the impact of the program on the total GHG emissions in the building sector.

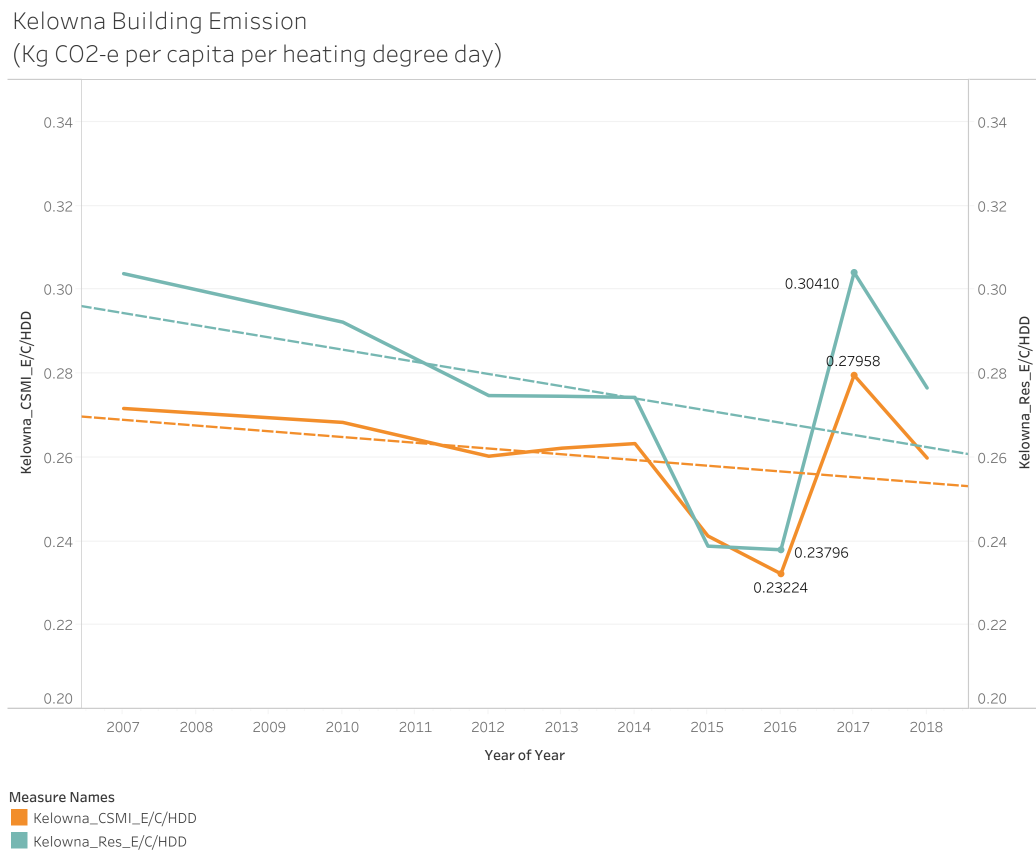


Figure 27: Kelowna building emission per capita per HDD

On average, Kelowna has 3,606 HDDs per year. Figure 27 shows the comparison of emission per capita per HDD in CSMI and residential buildings. Overall, the downward trends can be seen in both cases, with its lowest points in 2015-2016. In other words, buildings are producing fewer GHG emissions when accounting for cold weather. From 2007 to 2018, the emission per capita per heating degree days in residential buildings is higher than that in CSMI, but residential buildings are making quicker progress. The fact that 72% of dwellings are single-detached houses and 81% of household size is less than three persons per household[19] might contribute to the cause. The peak in 2017 for both types of buildings could be due to the impact of the extreme weather year with record floods, followed by the hottest and driest July and August[20].

[19] Statcan website/Kelowna

[20] https://www.kelowna.ca/sites/files/1/ff-climate.pdf

City of Kamloops

In the City of Kamloops, the total emissions from electricity are significantly lower than that of natural gas in both CSMI and residential buildings. Emission from electricity consumption is going down for both types of buildings. Emissions from using natural gas are increasing significantly in CSMI buildings while almost unchanged in residential buildings.

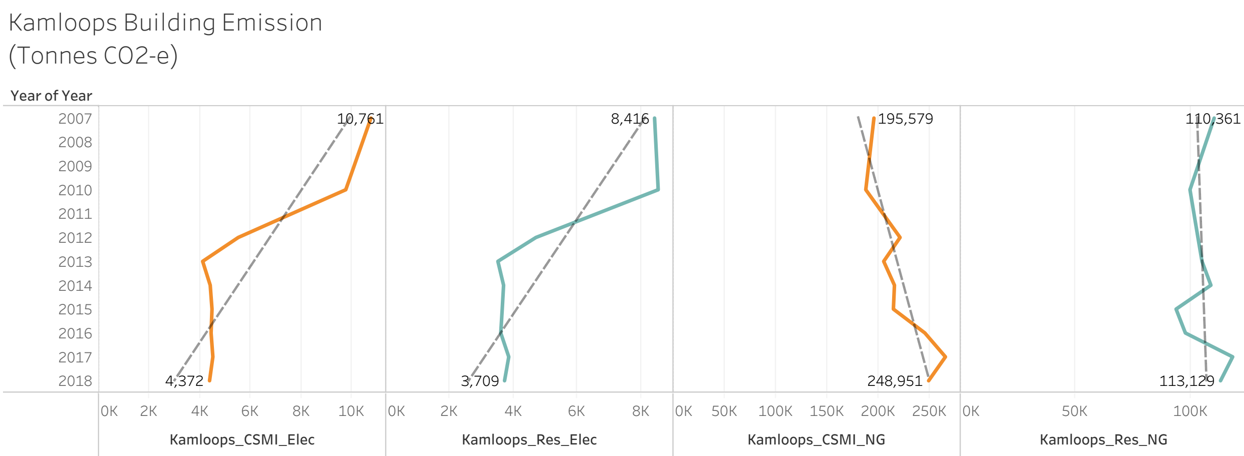


Figure 28: Kamloops building emissions

Because of the electricity sector's emission factors, the graph below compares electricity consumption with the released emission. The significant downward trend from 2010 to 2013 can't be translated into the reduction of electricity consumption but contributed to the emission factors used. Both CSMI and residential buildings in Kamloops have almost no change in their electricity consumption.

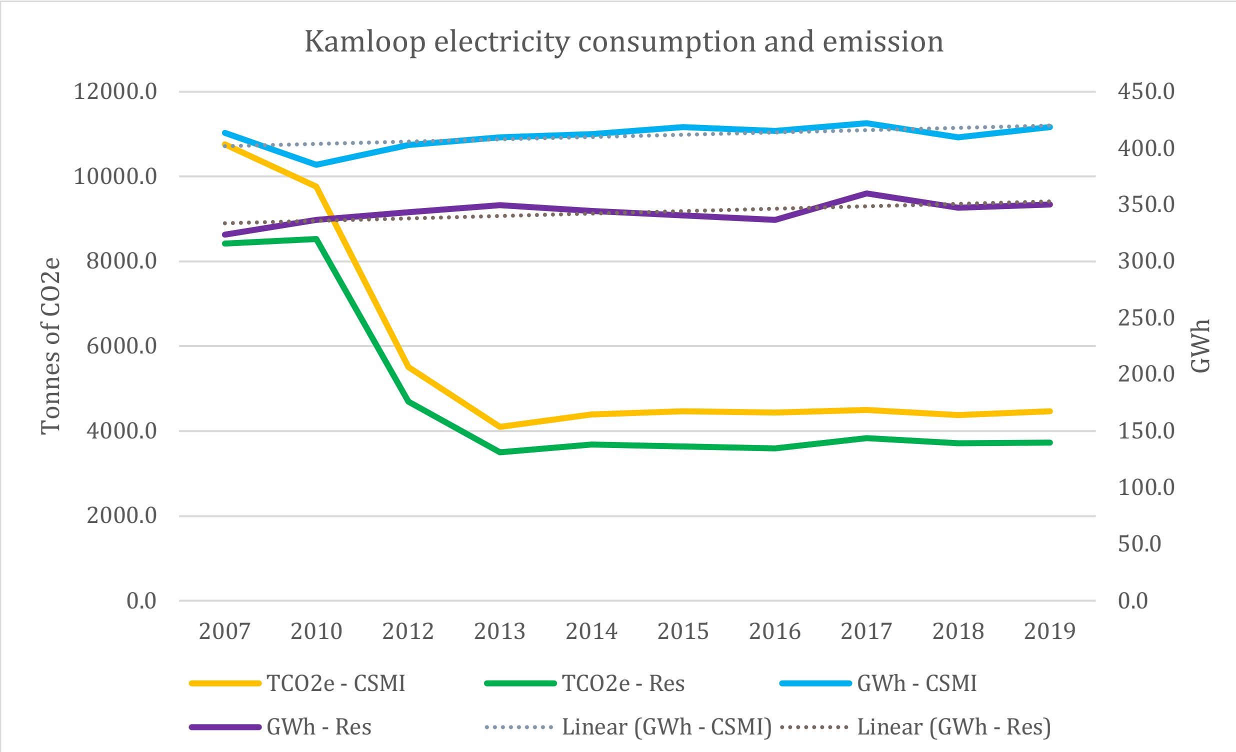


Figure 29: Kamloops electricity consumption and emission

In June 2018, the city started developing an Energy Step Code implementation strategy. In addition, a number of activities have been implemented to increase the energy efficiency of residents' homes in the city of Kamloops. And according to Statistics Canada, in Kamloops, the majority of the private house has more than two persons per household. So, this effort is expected to continue the trend from 2017 to 2018 in residential buildings.

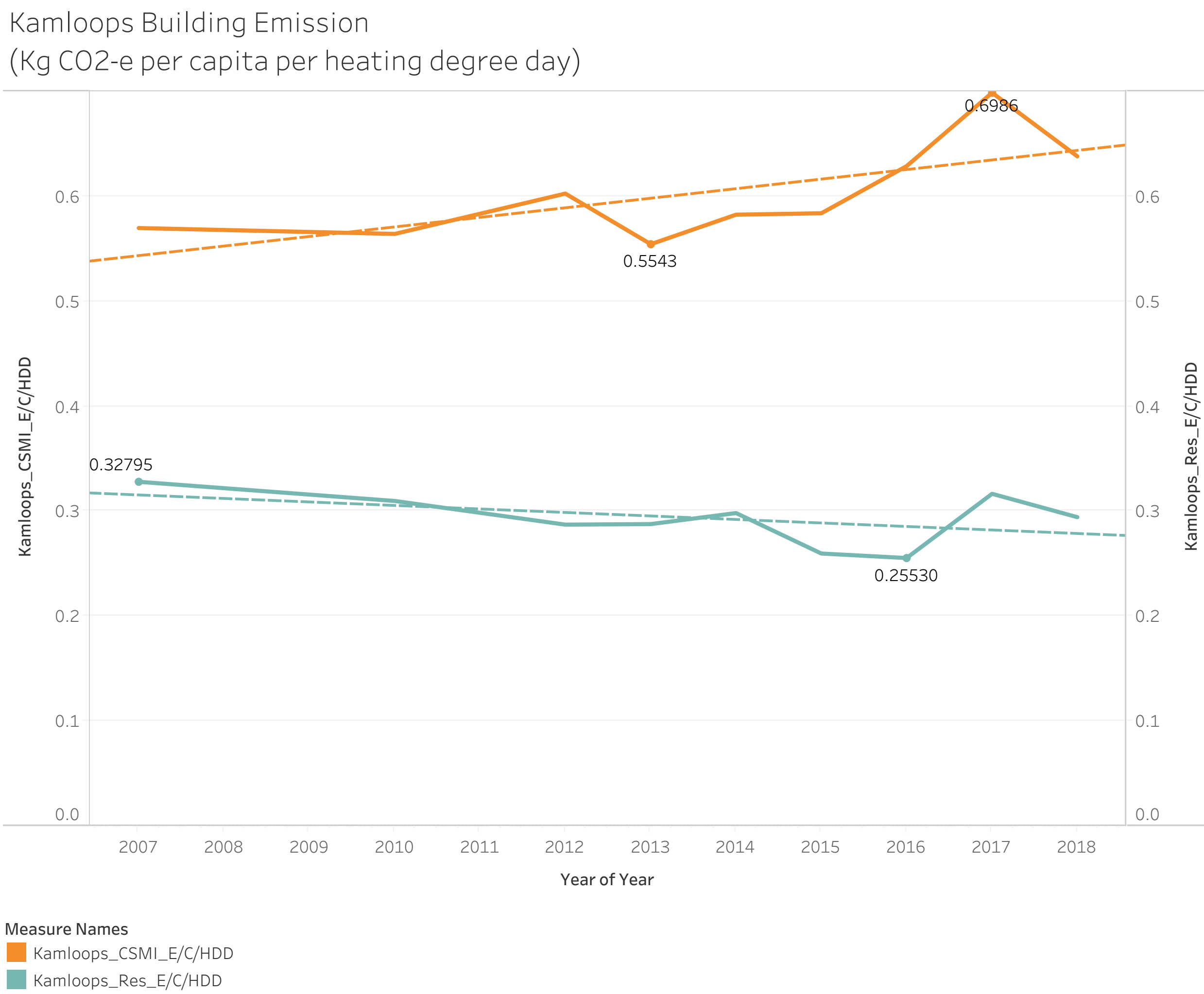


Figure 30: Kamloops building emission per capital per HDD

Average HDDs for this period in Kamloops are 4,138 days. Figure 30 shows the contrast trends of emission per capita per HDD in CSMI versus residential buildings. While the direction of emission in CSMI increases over time, the reverse trend is true for residential buildings. At the highest point in 2017, CSMI had 0.69 tonnes of CO2e per capita per HDD, while at its peak point in 2007, residential buildings had only 0.33 tonnes of CO2-e per capita per HDD. The increase in emissions in CSMI buildings is presumably due to increased consumption in the industry.

City of Nelson

The City of Nelson has the lowest energy consumption in the building sector. Therefore the total emission is also small compared with other cities. In the general trend, the emission from electricity consumption steadily decreases over time for both CSMI and residential buildings. A similar but less significant trend for natural gas emission in CSMI, while the opposite direction in the same period is witnessed for residential buildings.

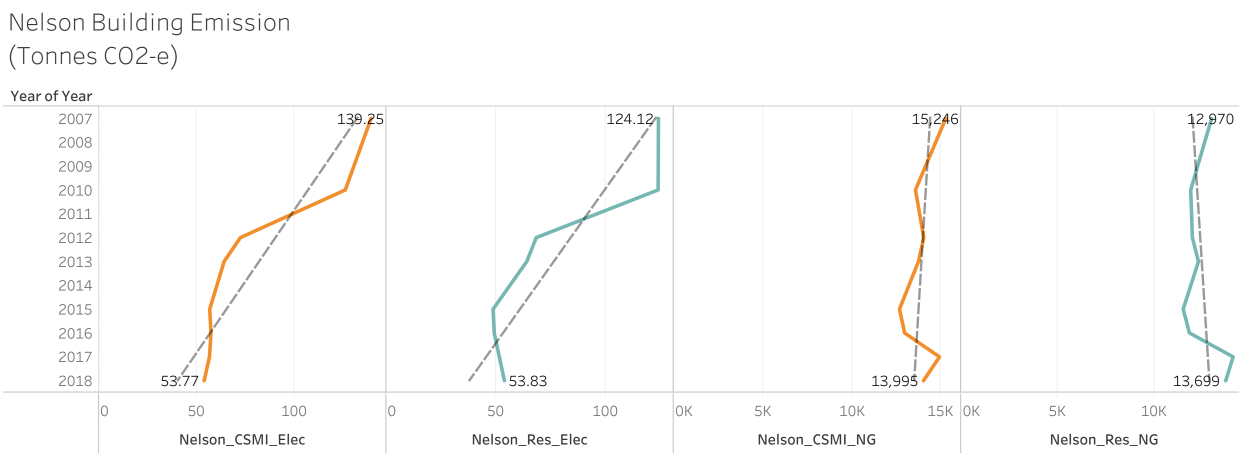


Figure 31: Nelson building emissions

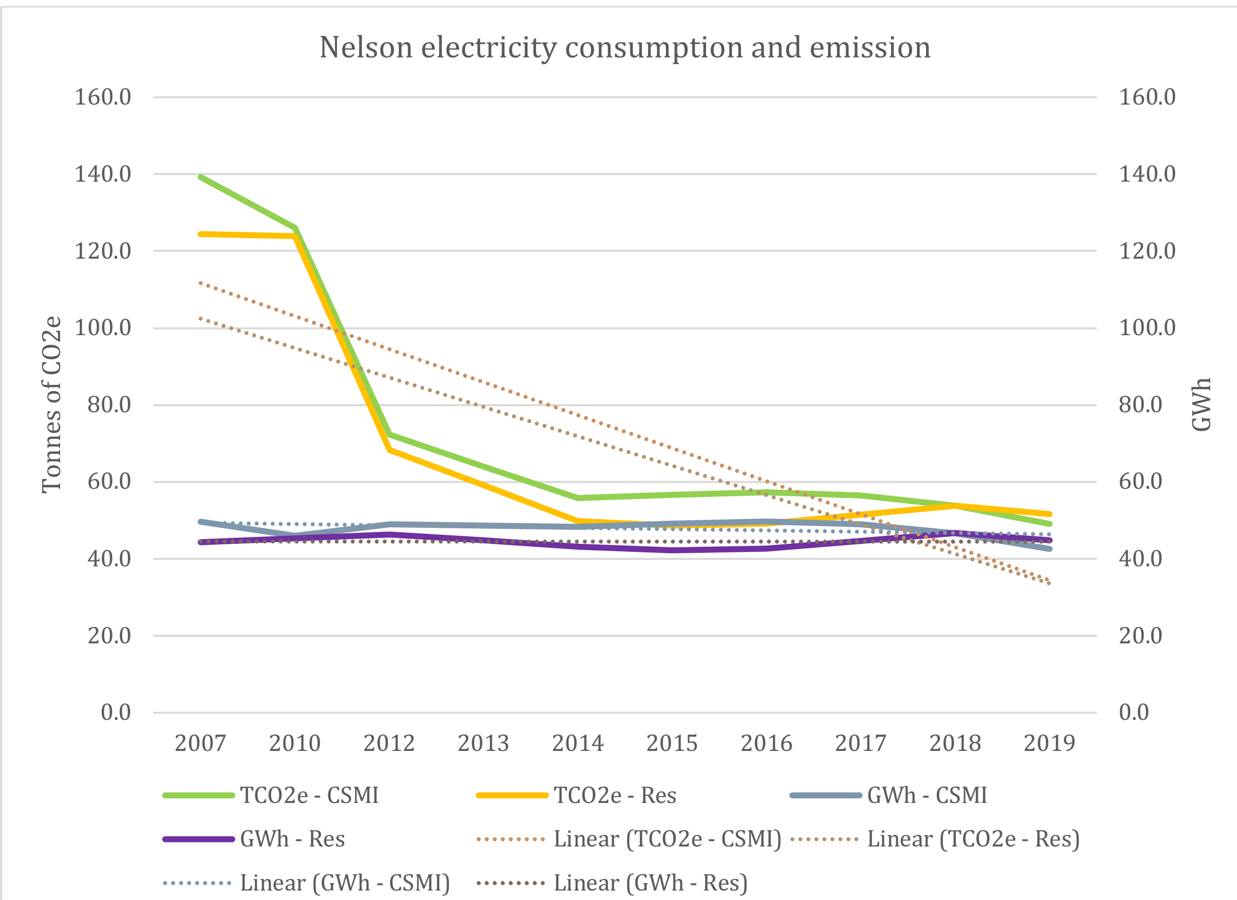


Figure 32: Nelson electricity consumption and emission

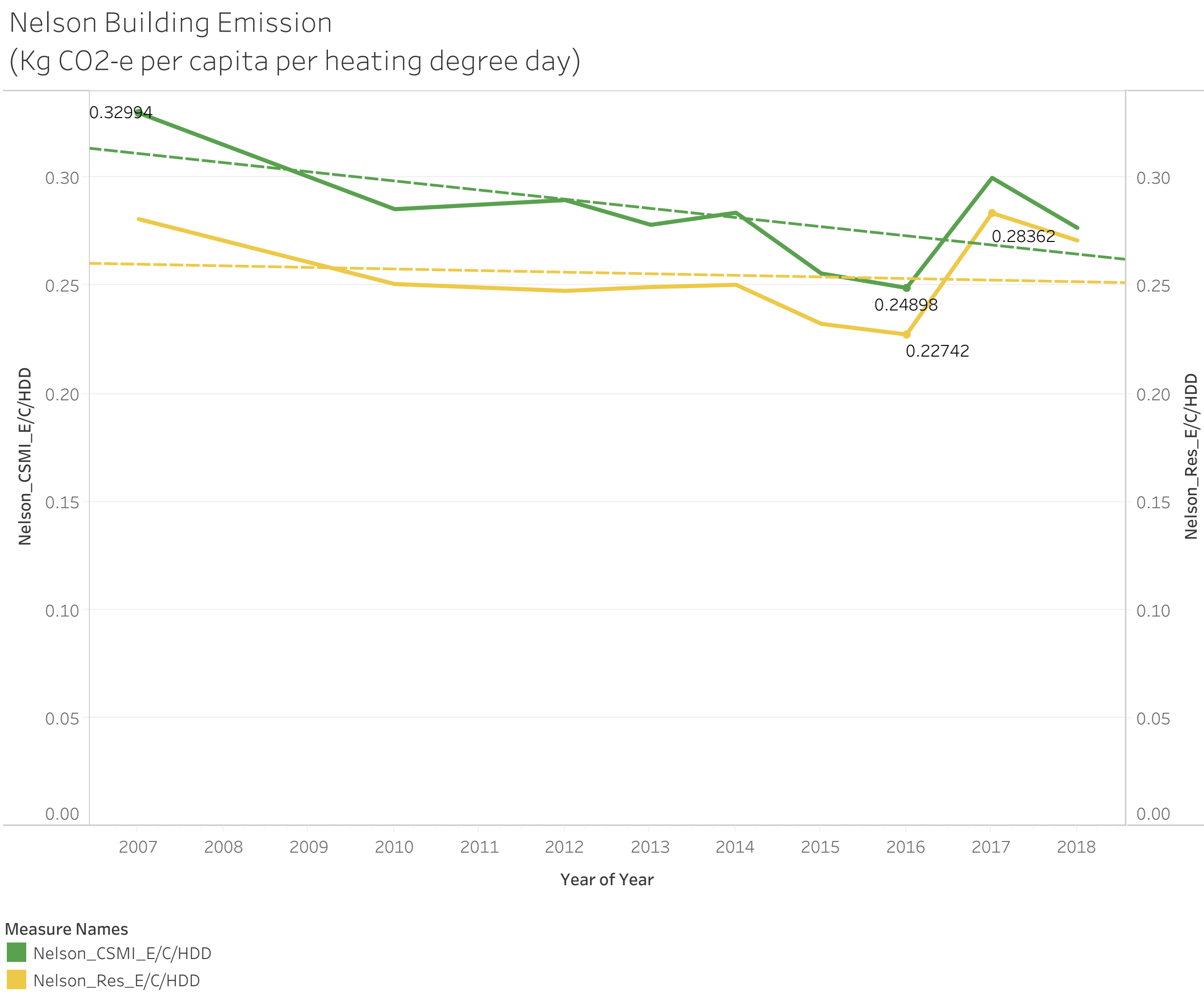


Figure 33: Nelson building emission per capita per HDD

Nelson has the longest energy-saving campaign in BC (EcoSave energy retrofit program) from April 2012 to the present, which applies to residential buildings. However, the program does not seem to have had a strong effect on community energy use and emissions, as is displayed by the stable trend lines of electricity consumption and the emission per capita per HDD in residential buildings, as shown in Figure 33 above.

City of Penticton

From 2007 to 2018, there were two clear opposite trends of emissions from electricity and natural gas usage in Penticton (Figure 34). Emissions from electricity for CSMI and residential buildings account for a very small fraction of those from natural gas. However, electricity emission shows a steady downward trend, while natural gas emission shows a gradual upward trend.

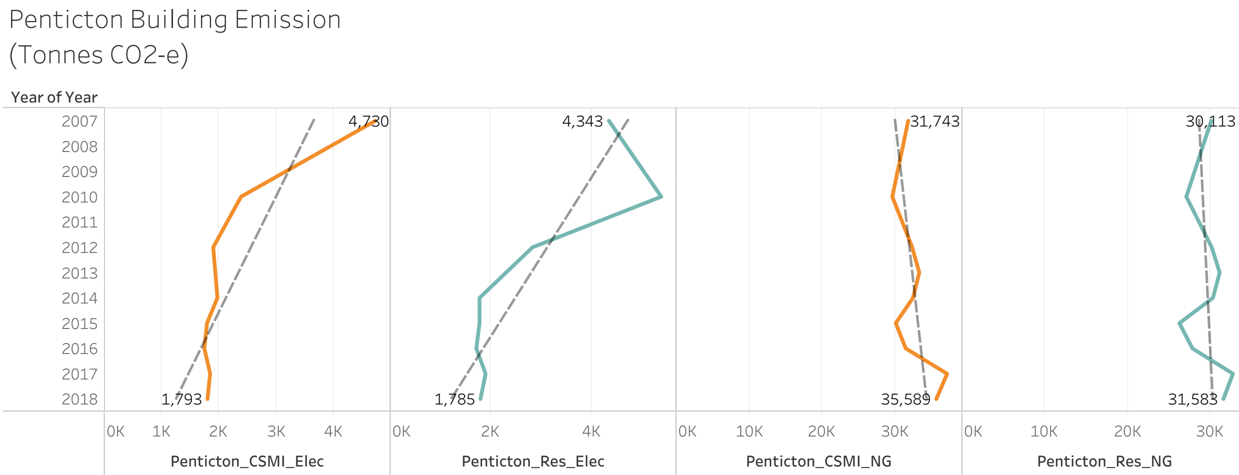


Figure 34: Penticton building emission

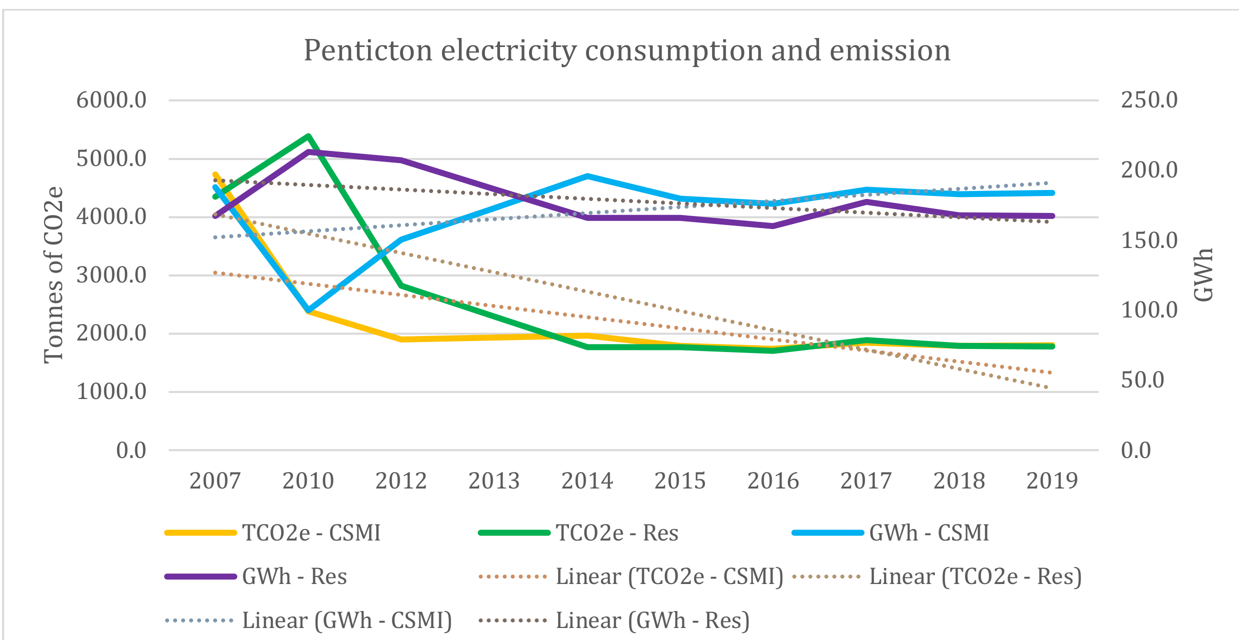


Figure 35: Penticton electricity consumption and emission

Concerning electricity consumption, figure 35 illustrates a peak in residential buildings and a drop in CSMI in 2010. After that, lines collate, and CSMI surpassed residential buildings in 2013 with regard to electricity consumption. Since then, the trends for both building types have remained stable.

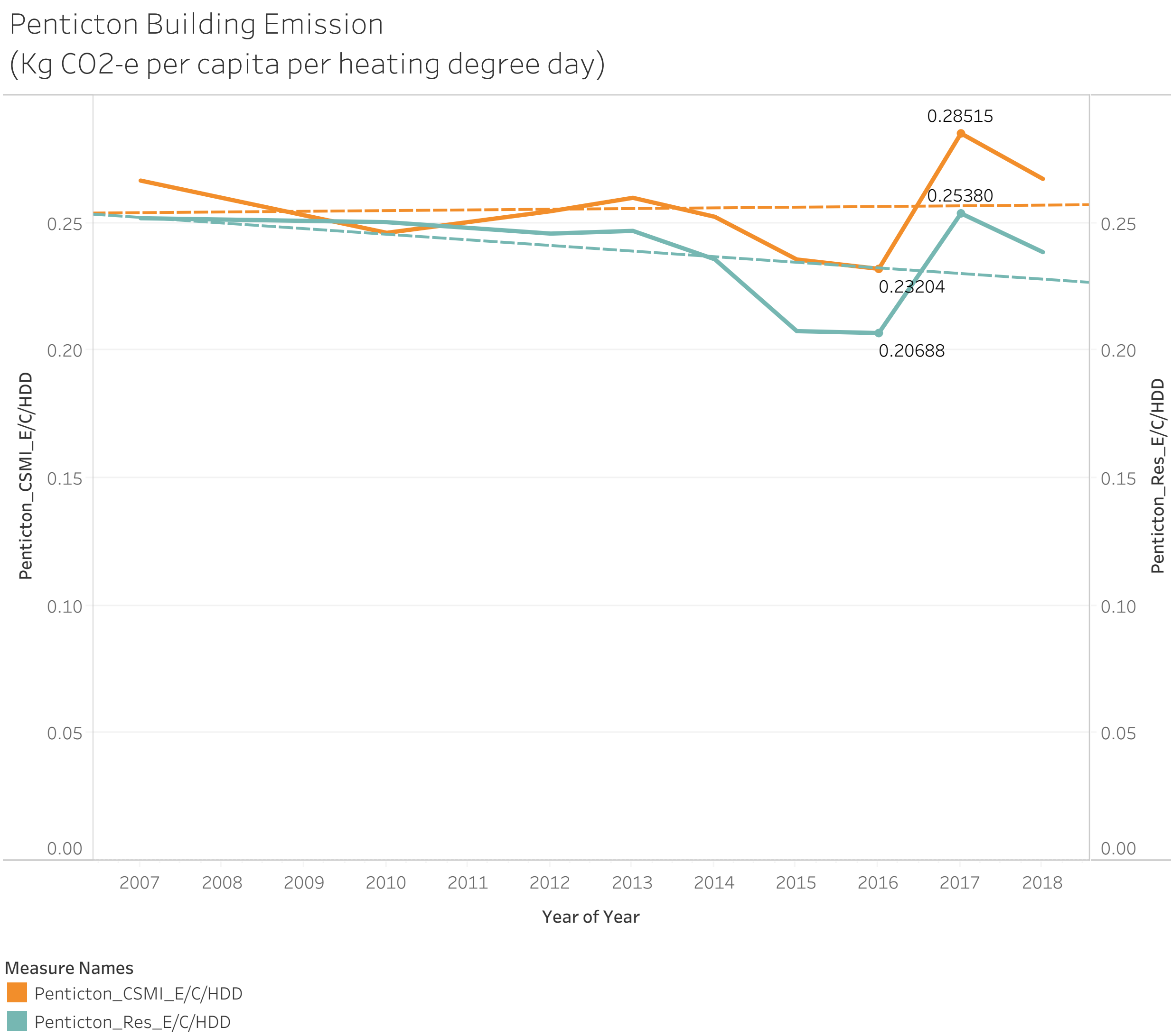


Figure 36: Penticton building emission per capita per HDD

On average, Penticton has 3,996 HDDs, and Figure 36 depicts two trends for the emission per capita per HDD for CSMI and residential buildings. At its highest point in 2017, CSMI has emission per capita per HDD at 0.285 tonnes of CO2e, while residential buildings have it at 0.232 tonnes of CO2e. Based on the trends shown in the figure, more action should be taken in the CSMI sector to lower its emission.

According to Statistic Canada, in 2016, of the population of 33,761 people, there were 15,740 private dwellings occupied by usual residents. Within this number, 65.3% of the structural type of dwelling relates to residential houses (instead of buildings or apartments). Notably, 75% of these dwellings were occupied by households with 1 and 2 persons. This information confirms that the residential buildings perform better than CSMI in emission reduction.

Penticton has adopted BC Energy Step Code and even goes ahead of the province-mandatory compliance for part 9 residential buildings with a minimum of achieving step 3 and for part 3 complex commercial buildings with step 1. The city also offers existing homes with its Home Energy Loan Program (HELP) for eligible energy-efficiency upgrades with a maximum loan amount is $10,000, to be repaid over ten years on the Monthly Electric Utility bill. The City of Penticton HELP program will run until Dec. 31, 2022. Although not many homes have taken part in this program to date (CEA).

City of Prince George

The building emissions in the City of Prince George have three different trends: A steep fall is observed in electricity usage in both CSMI and residential buildings; A steady rise is witnessed in the use of natural gas in CSMI; and almost no change in the usage of natural gas in residential buildings.

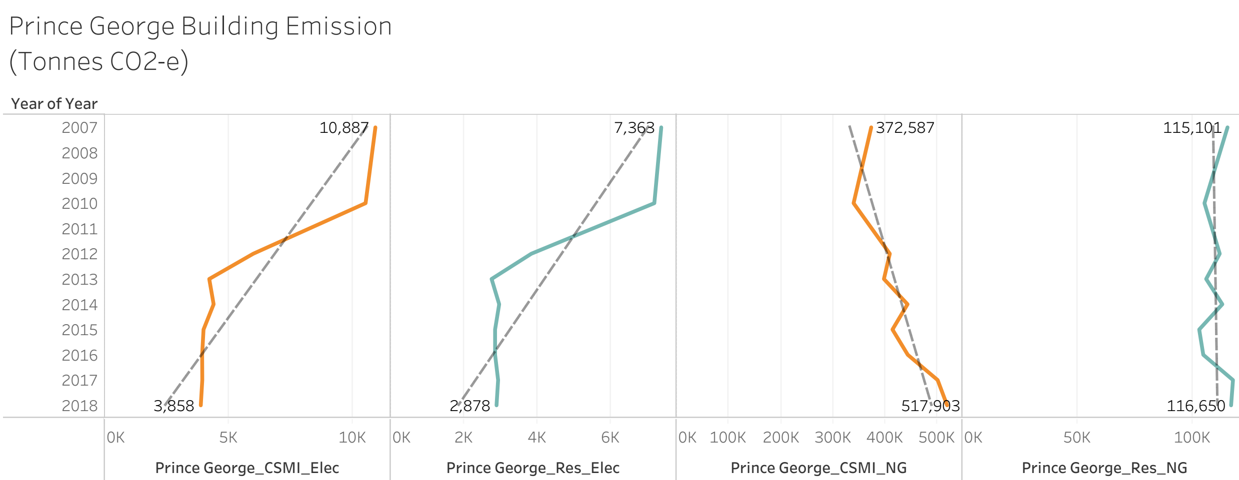


Figure 37: Prince George building emission

Figure 38 below illustrates the actual consumption of electricity in both types of buildings and their GHG emissions. While a slightly decline can be seen the use of electricity in CSMI building, there is no change in that of residential building.

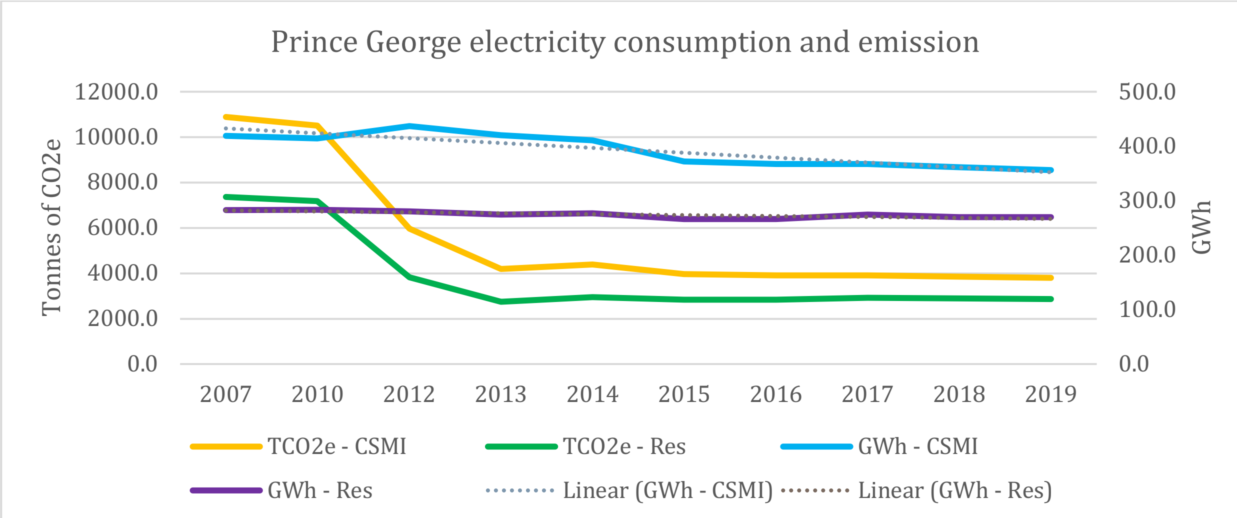


Figure 38: Prince George electricity consumption and emission

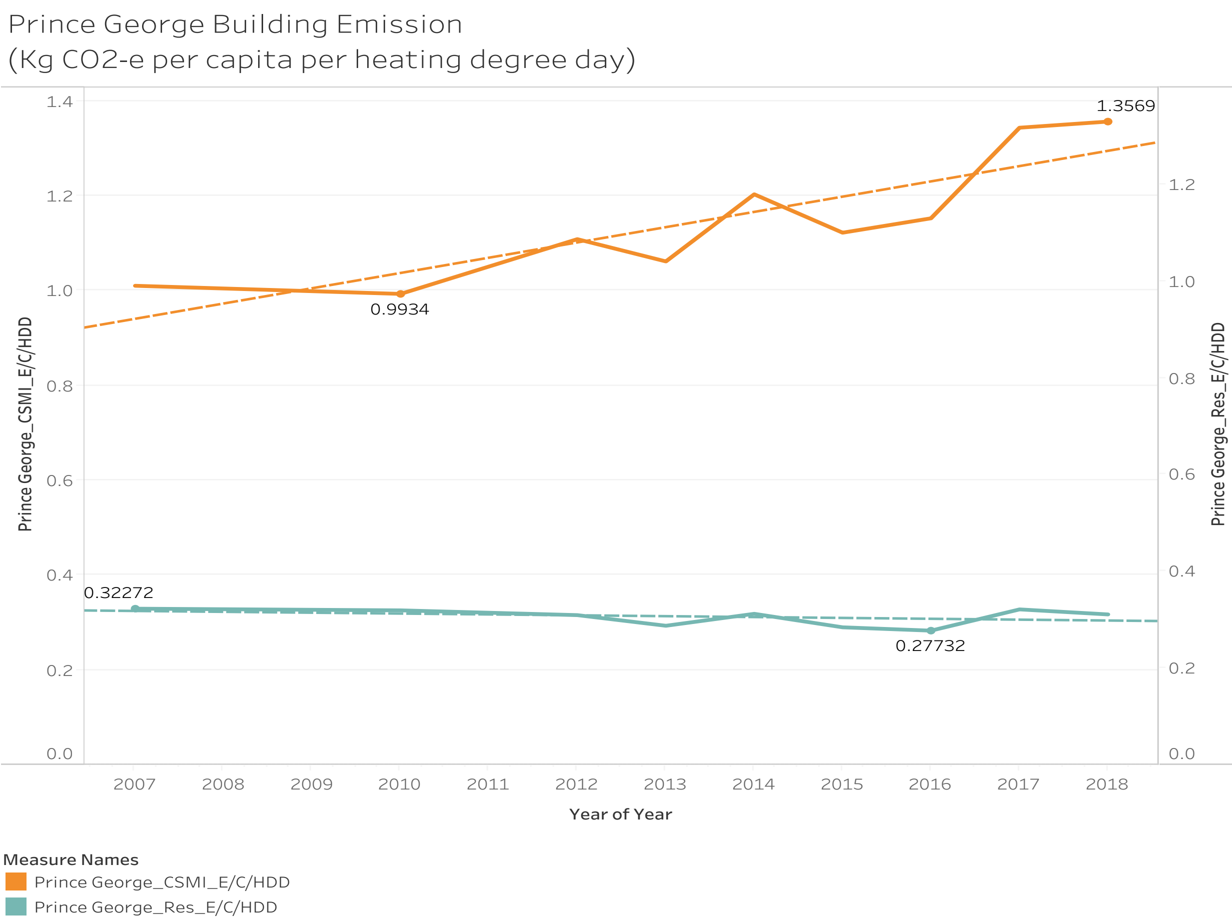


Figure 39: Prince George building emission per capita per HDD

Because of the steady increase in the use of natural gas in the CSMI building, Figure 39 shows the difference between emission per capita per HDD in CSMI and residential buildings. Prince George has higher industrial activities, which would increase the CSMI emissions/capita/HDD compared to other locations. Recently, the City of Prince George announced that from September 1, 2022, all Part 3 and Part 9 buildings must comply with Step 1.

City of Rossland

The City of Rossland is different from other communities assessed in that the total emissions in residential buildings for electricity and natural gas are significantly higher than that of the CSMI buildings. Taking natural gas emissions, in 2018, the emission from residential buildings was 5,648 tonnes of CO2e, while it was 2,303 tonnes of CO2e from CSMI buildings. Both buildings saw a sharp drop in natural gas emissions in 2015.

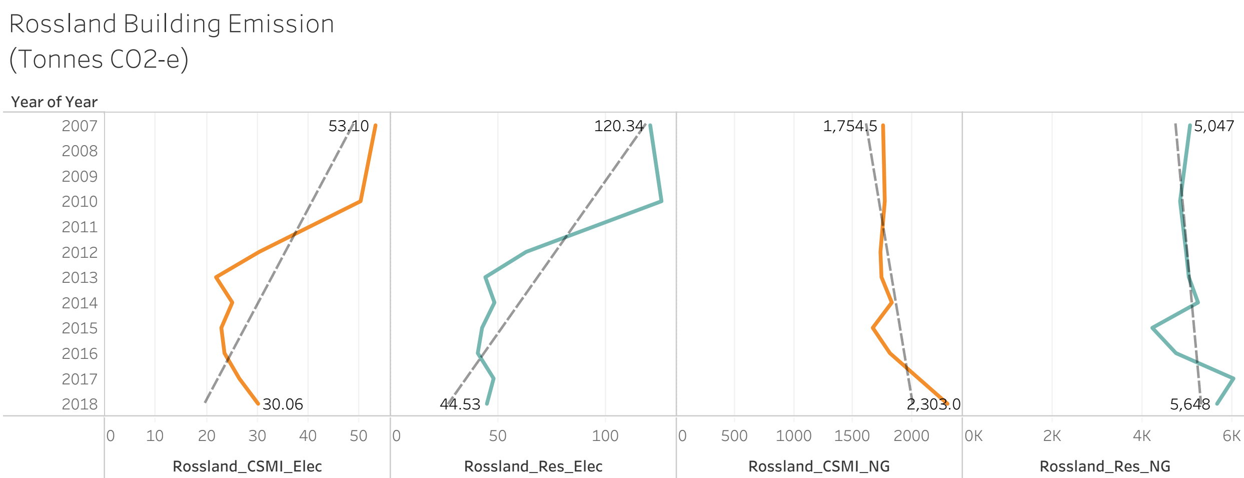


Figure 40: Rossland building emission

Looking closely at the electricity consumption and its emission, the electricity consumption in the residential buildings is higher than that of the CSMI building. But the trend of electricity use in residential buildings is gradually declining while that trend for CSMI is slightly increasing in the same period.

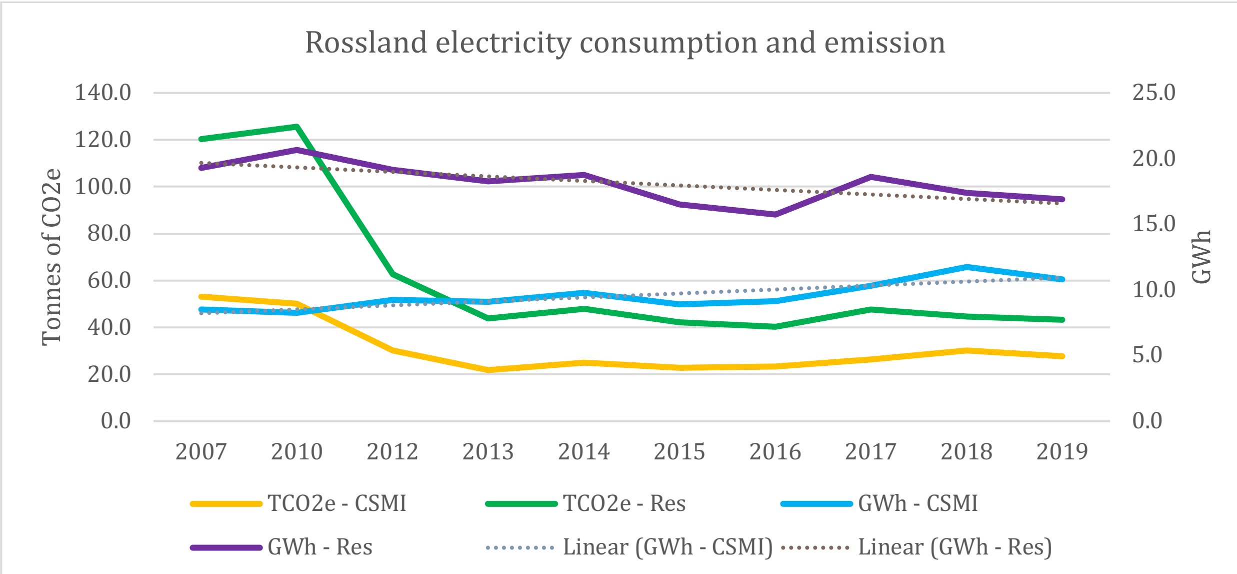


Figure 41: Rossland electricity consumption and emission

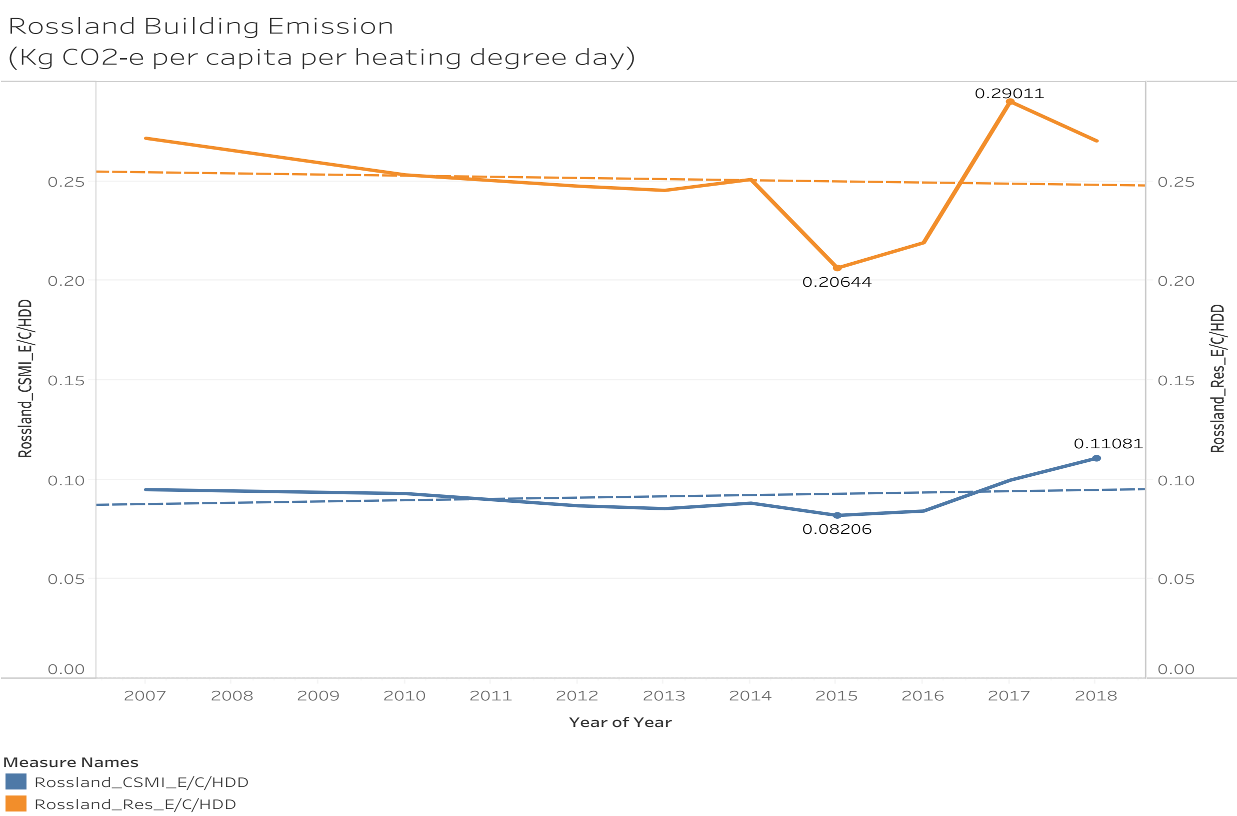


Figure 42: Rossland building emission per capita per HDD

Rossland had a program called “Rossland Energy Diet” from August 2011 to March 2012. It may have been the single most effective energy retrofit program to date, at least in terms of the number of homes that participated (about 1/4 of the homes in Rossland)[21]. It is hard to see this impact on the current graphs of emission data. And after this program, there seems not to have a similar scale program for the commercial building sector in Rossland.

City of Squamish

Overall, GHG emissions from natural gas are higher than electricity consumption in the City of Squamish. GHG emissions from natural gas use also show an upward trend for both CSMI and residential buildings. The reversed direction is observed for emissions from electricity usage.

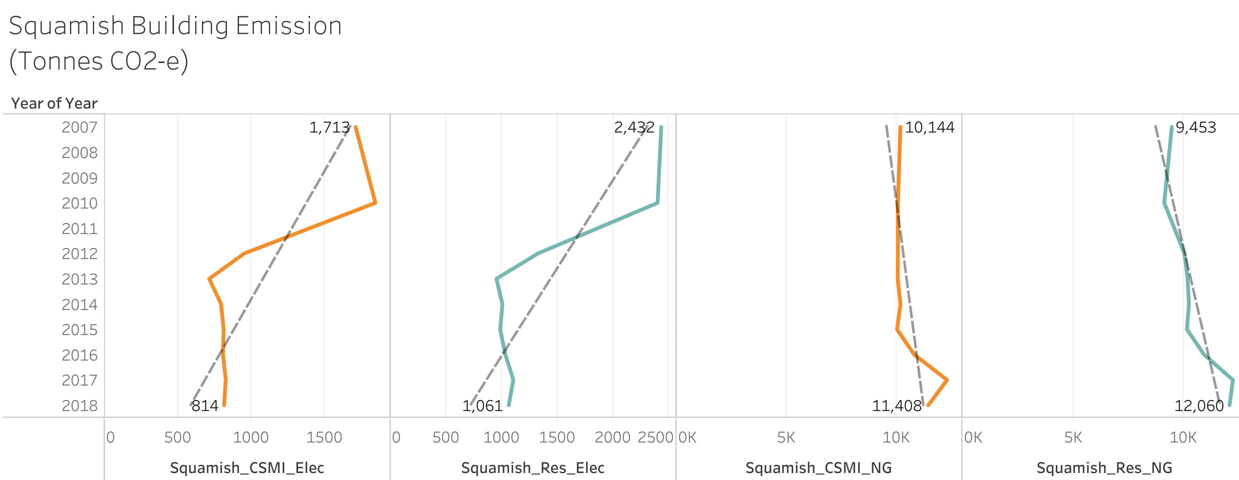


Figure 43: Squamish building emission

Figure 44 details the electricity consumption and emission for both types of buildings, in which the usage of electricity in CSMI is between 60 to 80 GWh per year, while residential buildings use less than 100 GWh per year. The amount of electricity used is relatively stable for both types of

[21] CEA

buildings. However, the emission trendlines are falling significantly because of the change in emission factors.

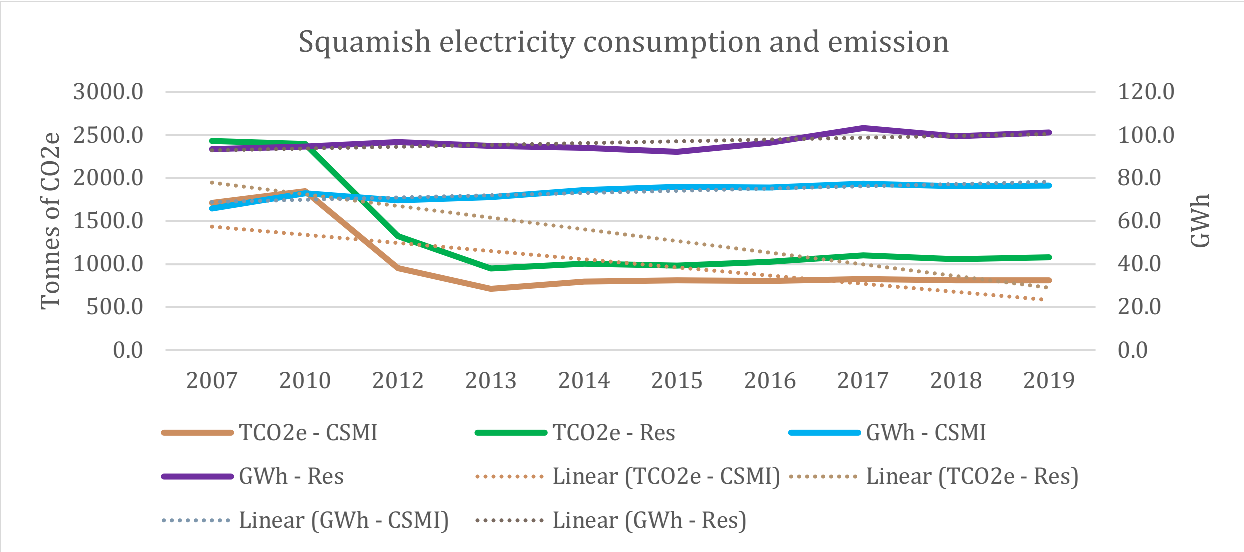


Figure 44: Squamish electricity consumption and emission

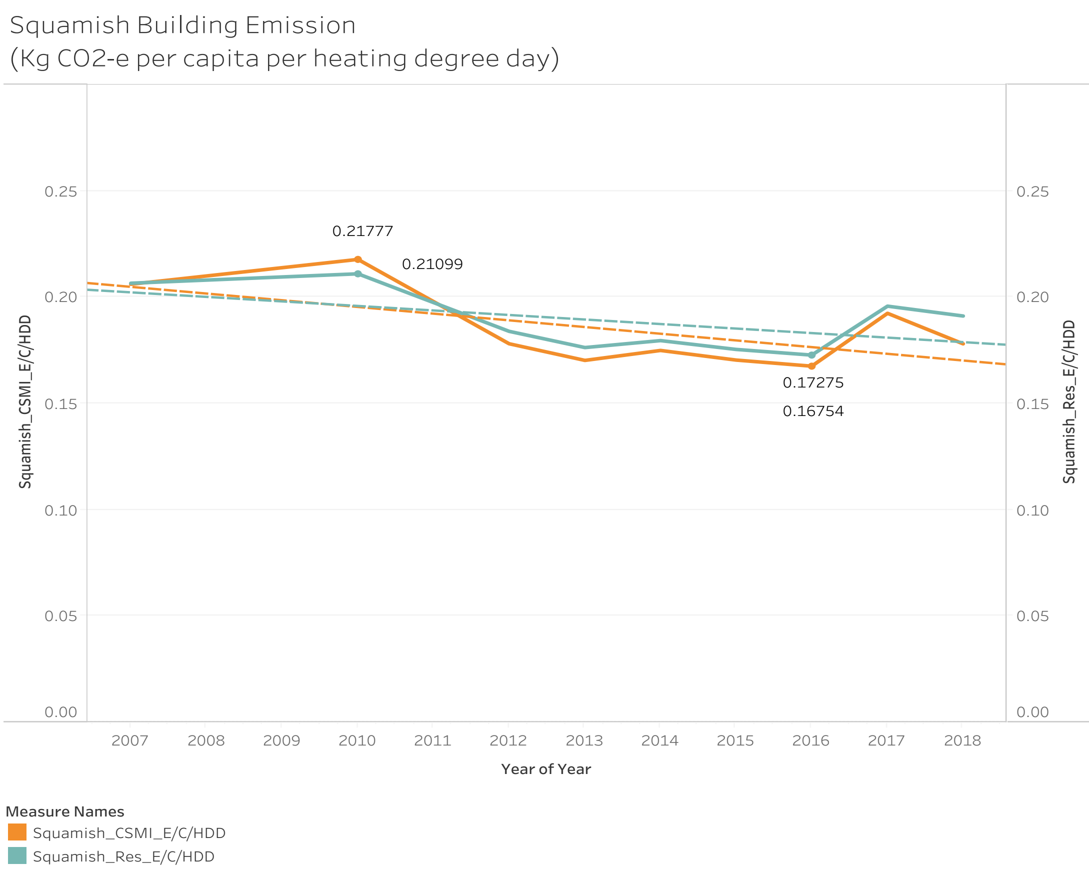


Figure 45: Squamish building emission per capita per HDD

In total, emissions from electricity and natural gas, normalized by population and HDD, show a downward trend over time. However, the residential building emissions per capita per HDD surpassed CSMI in 2011 and continued to be higher until 2018. The BC Energy Step Code went into effect in the District of Squamish on July 1, 2018. All new residential and commercial buildings must be constructed to the following steps of the BC Energy Step Code.

City of Vancouver

The City of Vancouver is the only one in ten researched communities with the trends of emissions in the buildings going down for both natural gas and electricity. Though the downward trend of natural gas in both CSMI and residential buildings is less significant than that of electricity, it is of great effort concerning the large size of the community.

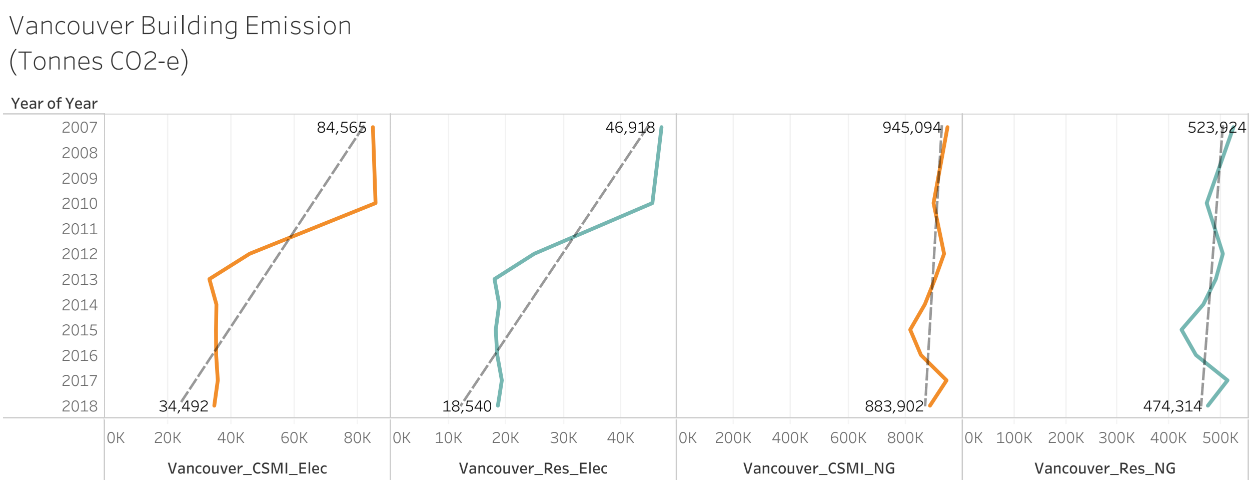


Figure 46: Vancouver building emission

In detail, it is observed that the electricity consumption is not decreasing, but the total emissions decline due to the change in emission factors. The residential buildings use a stable 2000 GWh electricity per year, while CSMI buildings use north of 3000 GWh per year.

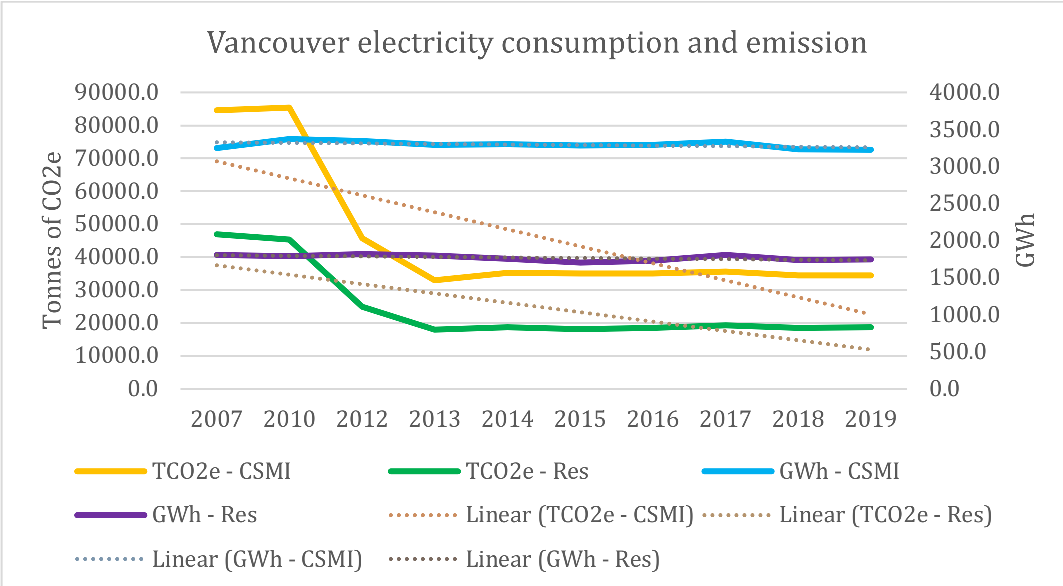


Figure 47: Vancouver electricity consumption and emission

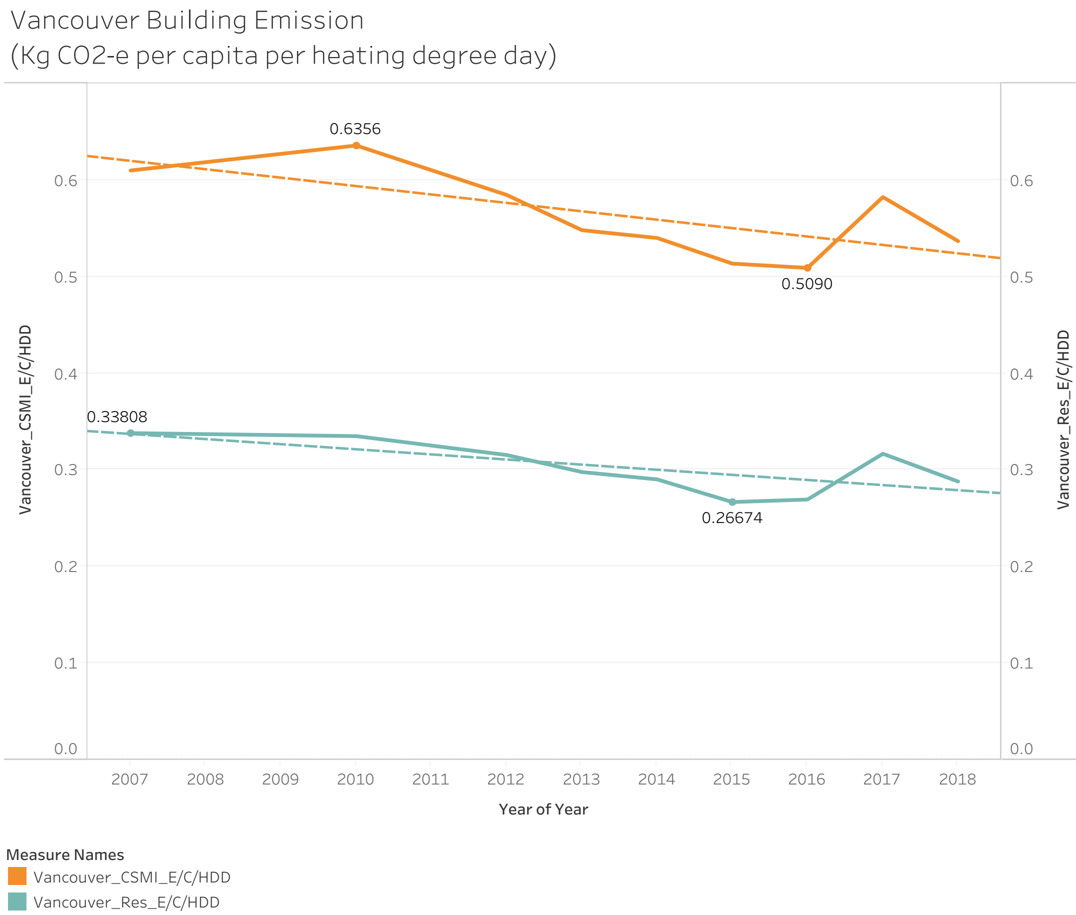


Figure 48: Vancouver building emission per capita per HDD

Vancouver has 2576 HDDs on average. When the emissions are normalized with population and HDD, the CSMI buildings have significantly higher emissions at the maximum point of 0.64 kg CO2e per person per HDD compared to residential buildings at a maximum point of 0.338 kg CO2e per person per HDD.

In the City's Climate Emergency Action Plan, Big Move 4: Zero Emissions Space and Water Heating aim that by 2030 the carbon pollution from buildings will be cut in half from 2007 levels. Detailed actions include setting carbon pollution limits and streamline regulations, supporting early owner action, building industry capacity, and facilitating access to Renewable Energy. In the Big Move 5: low-carbon construction materials, the City sets the objective that by 2030, the embodied emissions from new buildings will be reduced by 40% compared to a 2018 baseline. Detailed actions include setting embodied carbon pollution limits for new buildings, making it easier and less expensive to use lower-carbon materials in new buildings, supporting people using low-carbon materials in new buildings, and having low-carbon planning and strategies.

City of Victoria

The City of Victoria's total emissions from electricity consumption for both CSMI and residential buildings decreased from 2007 to 2018. The opposite trend is witnessed for CSMI with natural gas emissions. The emissions from natural gas in residential buildings are declining slowly in the same period. However, 2012 saw the rocket in natural gas emissions to over 50,000 tonnes of CO2e, quickly falling the following year. There is no known reason for this peak, so the data quality is a concern in this instance.

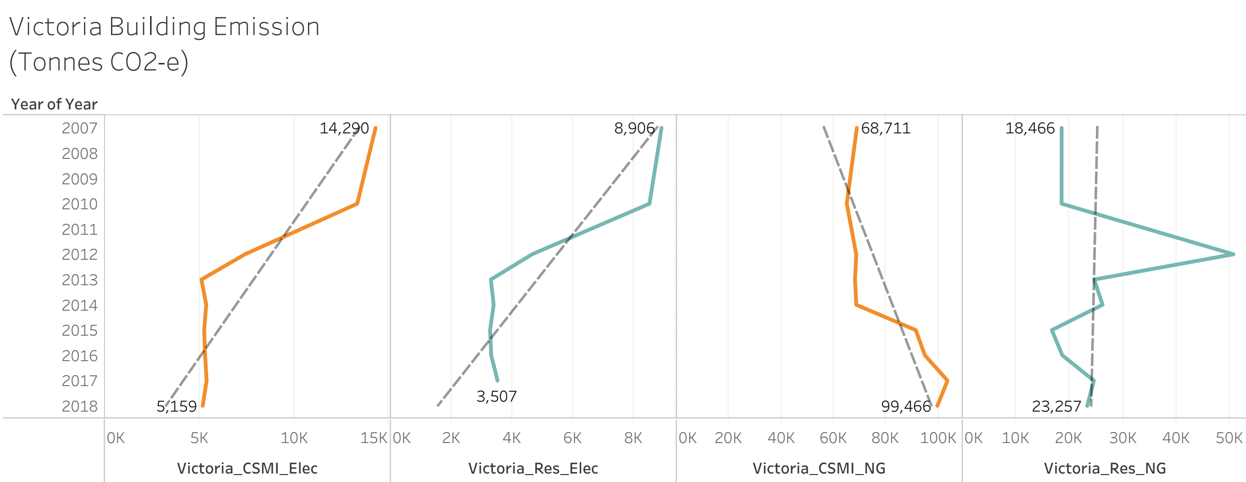


Figure 49: Victoria building emission

The capital city of BC saw a gradual drop (figure 50) in electricity consumption in both CSMI and residential buildings. But generally, the emissions from residential buildings are substantially less than that of CSMI buildings.

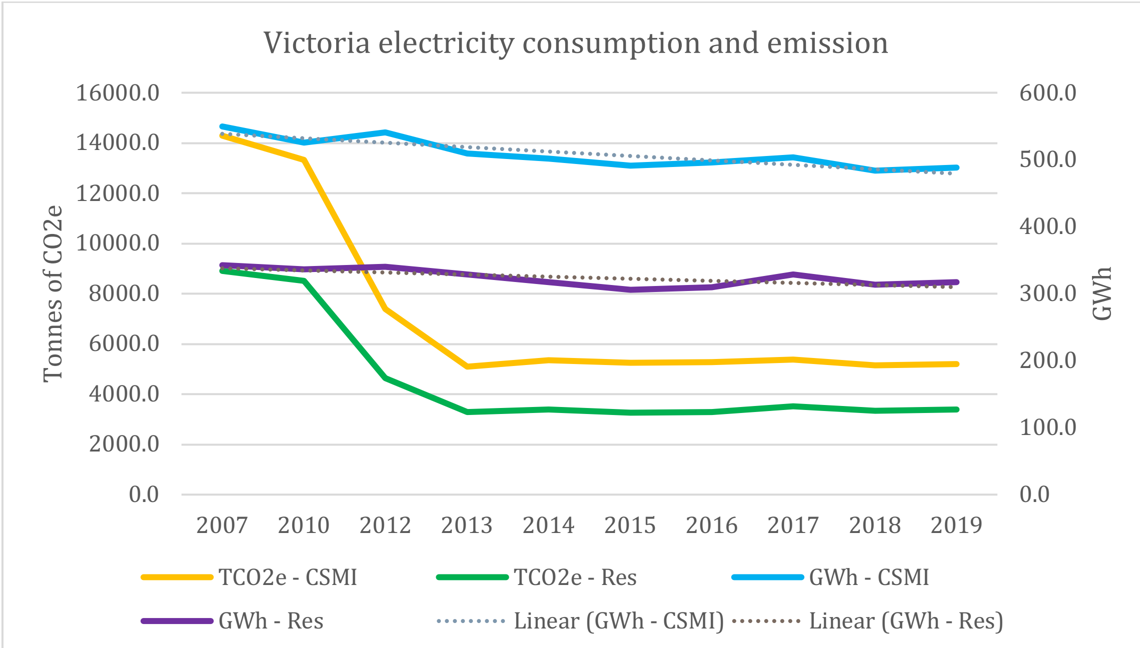


Figure 50: Victoria electricity consumption and emission

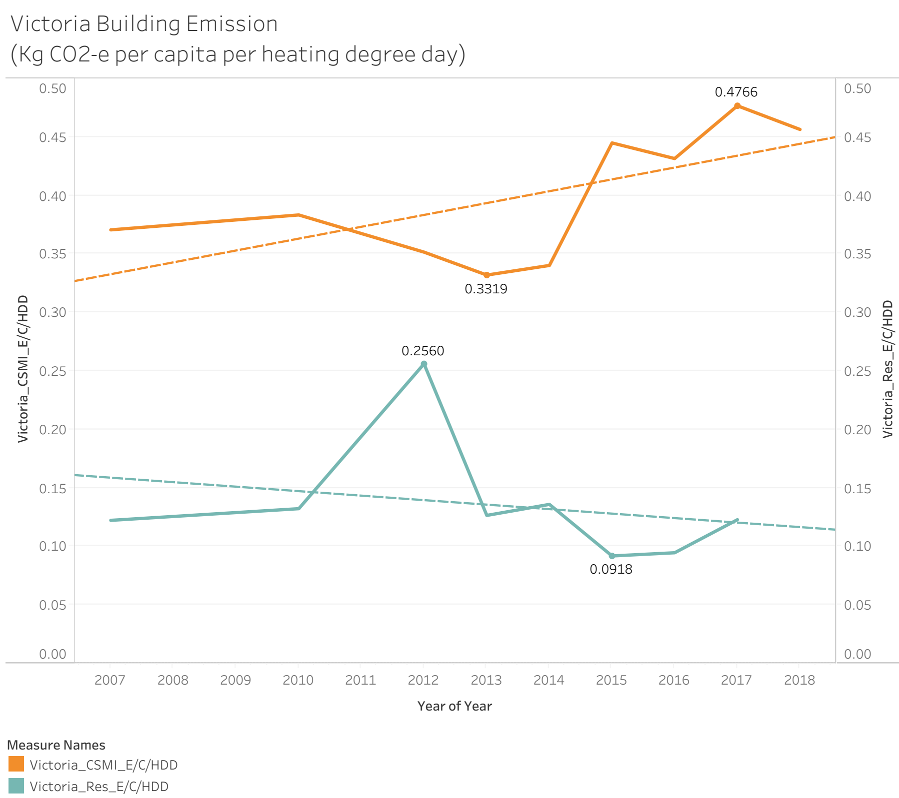


Figure 51: Victoria building emission per capita per HDD

Victoria has 2,537 HDD on average. The residential buildings in the City of Victoria show a considerable decline over time, while the opposite is true for the CSMI buildings concerning the total emission per capita per HDD. In its Climate Leadership Plan, the low-carbon, high-performance buildings section aims to increase energy efficiency and use renewable energy. The City sets the targets that by 2030, all new buildings will be net-zero energy ready, and by 2050, all existing buildings will meet new high-efficiency standards. With regard to the energy use in buildings, the City sets the targets by 2030, heating oil is phased out, and by 2050, all buildings exclusively use renewable energy.

Resort Municipality of Whistler

In the Resort Municipality of Whistler, the total emission from natural gas in both CSMI and residential buildings shows an upward trend, while electricity consumption is the opposite.

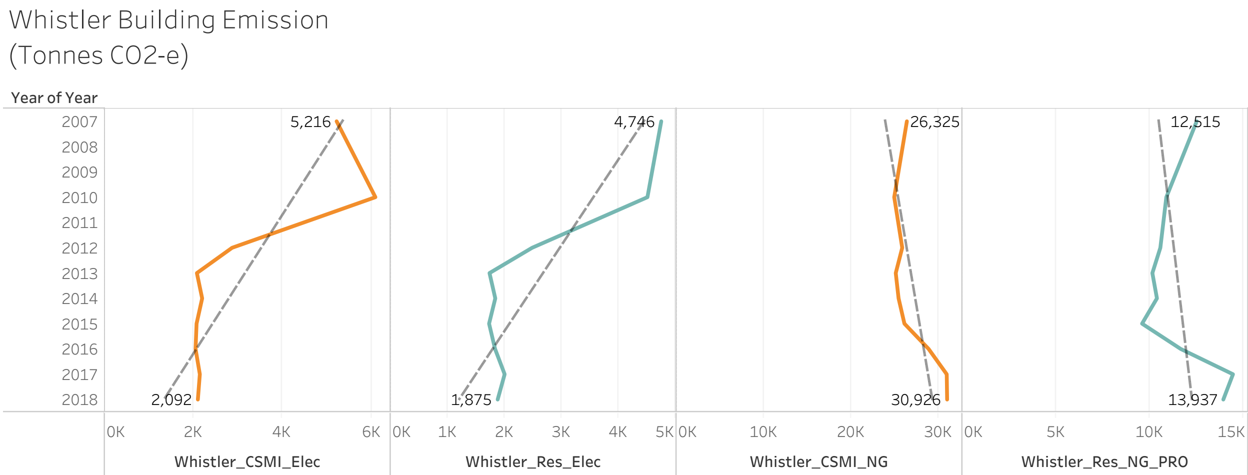


Figure 52: Whistler building emission

Concerning electricity consumption, both types of buildings gradually decline over time. Coupled with the change in emission factors, the total emissions from electricity consumption in both building types decrease significantly.

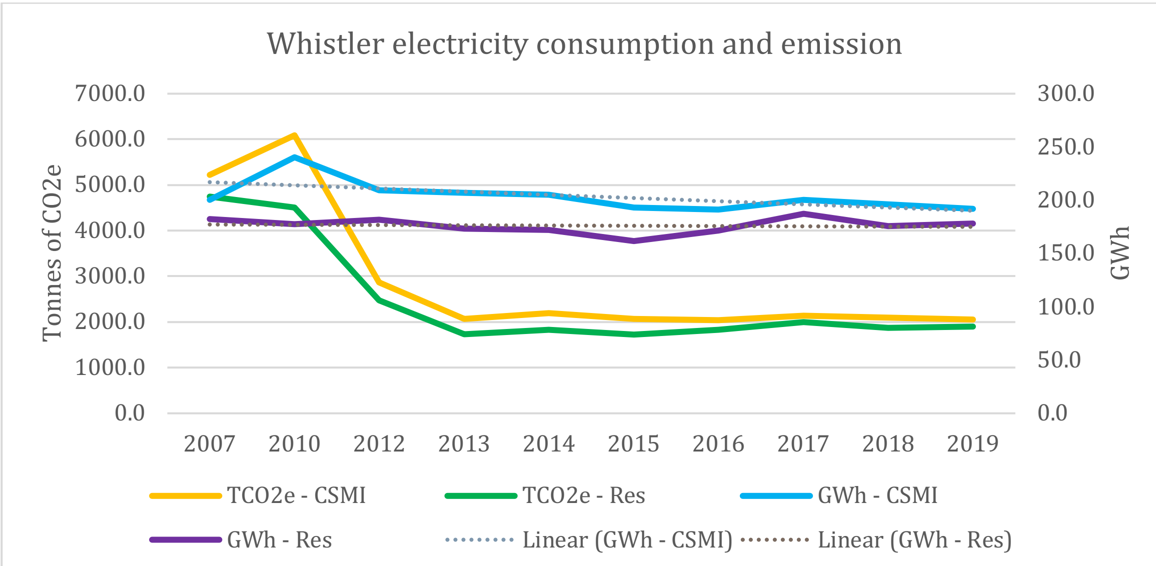


Figure 53: Whistler electricity consumption and emission

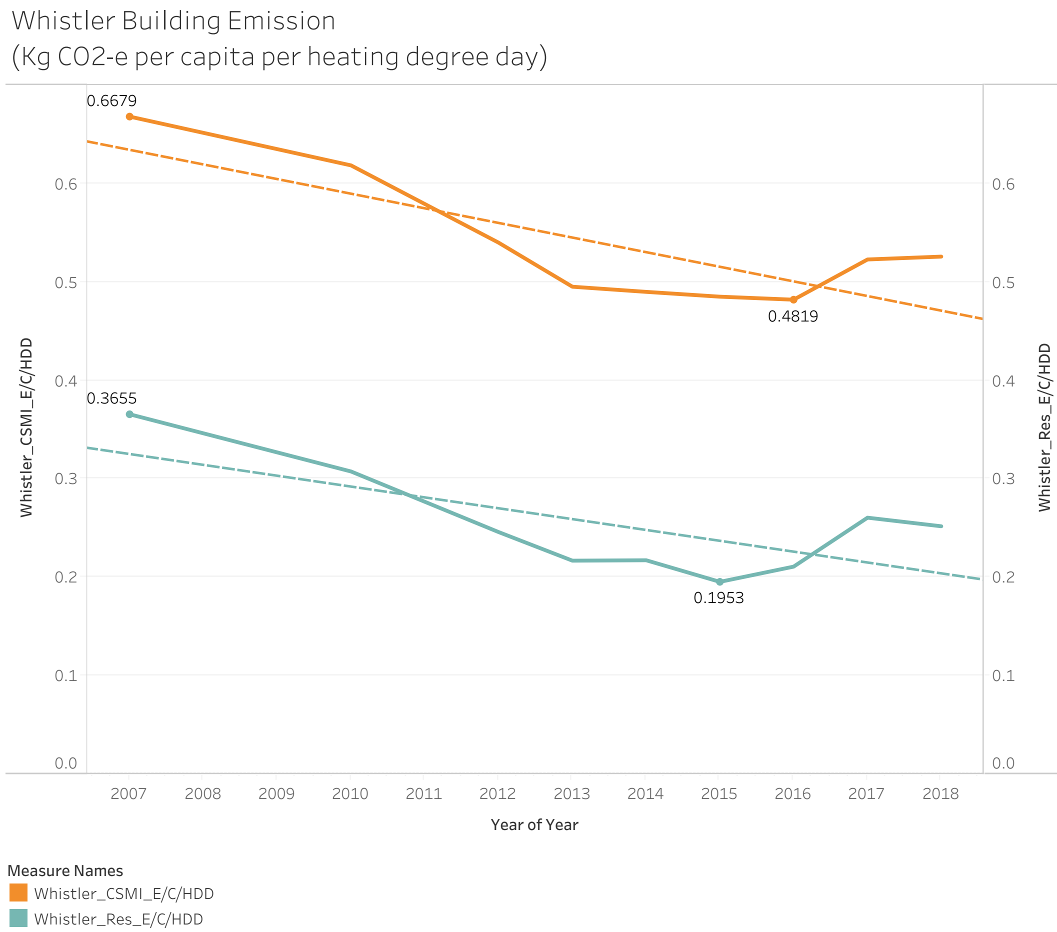


Figure 54: Whistler building emission per capita per HDD

Whistler has 4,937 HDD on average. The total GHG emissions for residential and CSMI buildings, normalized by population and HDD, are presented in figure 54. For both types of buildings, dramatically decreasing trends over time are witnessed. In its Climate Action Strategy, the Big Move 4 of zero emission buildings sets the target that by 2030, all new buildings achieve the top step in B.C.'s Energy Step Code, use only low carbon heating systems, and embodied carbon emissions drop by 40%. Since January 1, 2019, the Resort Municipality of Whistler (RMOW) has been adopting the Energy Step Code for all its new Part 9 residential buildings (generally single family, duplex, and smaller multi-family buildings) with Step 3 and Step 4. Builders will receive incentives from RMOW, EE BC incentives, Canada Greener homes grant[22].

[22] https://www.whistler.ca/business/land-use-and-development/building/bc-energy-step-code

Waste

For all cities, GHG emissions from waste account for a smaller percentage of the overall community-wide emissions than utilities and transportation emissions. In 2017, the District of Squamish had the highest emission percentage from waste at 20%. The communities with the lowest share of waste in their total GHG emissions are Whistler, Vancouver, Nelson, and Kamloops, with less than 5% (table 2).

The below graph shows the total amount of CO2e from all ten communities. In general, the GHG emissions from waste fall slightly over time. The city of Vancouver has the highest share, followed by Prince George, Kelowna, and Kamloops. For the nine years, the share of the waste emission of ten selected cities is very similar. However, in 2018, Prince George surpassed Vancouver to emit the highest amount of emission among ten cities.

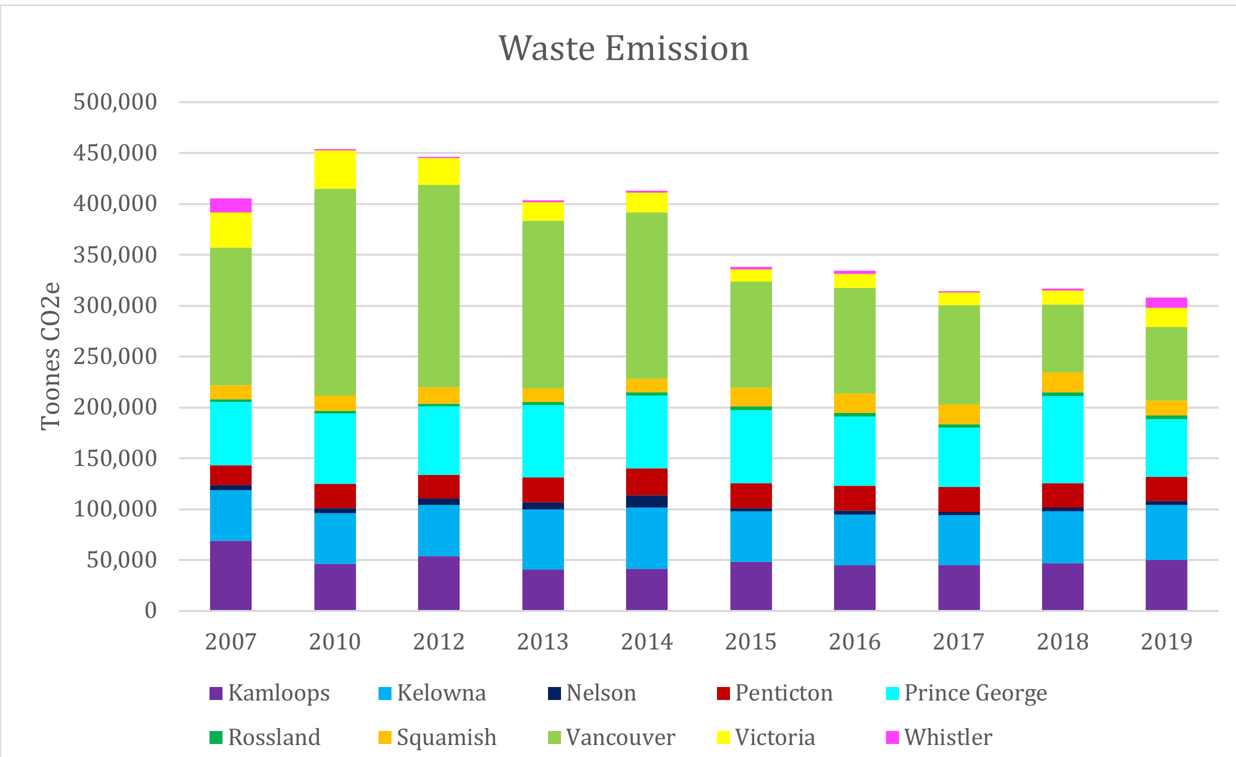


Figure 55: GHG emissions from waste

Notably, the emission from Whistler was relatively high in 2007 but reduced significantly and consistently years after. Since the 2005 closing of Whistler's municipal landfill, the municipality's solid waste has been shipped to Rabanco Landfill, Washington, USA[23]. Although Whistler incurs the costs and emissions with sending the waste, its true amount and emissions have been moved to another place. In the original dataset, the provincial government warns the uncertainty of GHG emissions from solid waste disposal sent to Washington, the USA, due to the lack of historical data and difficulty of distributing emissions to each municipality that contributes to that landfill.

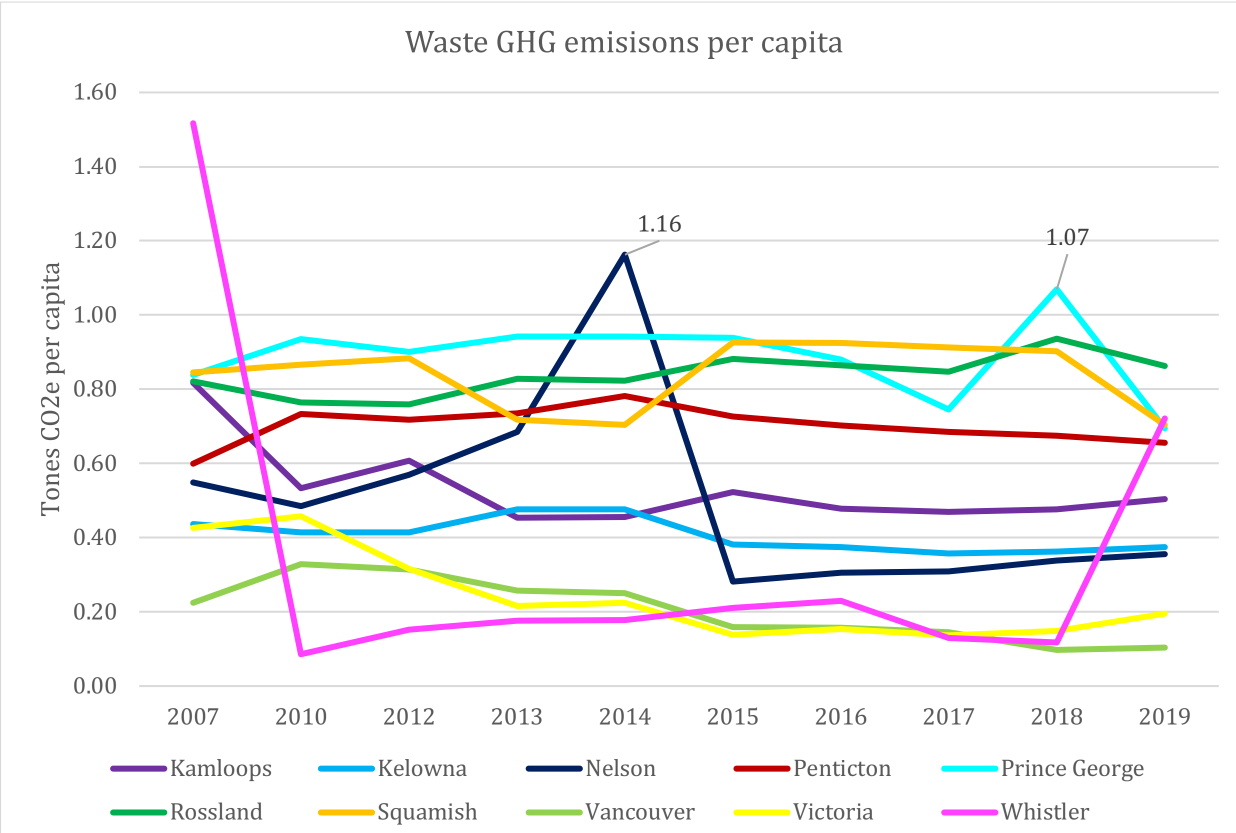


Figure 56: GHG emission per capita from waste sector

Figure 56 shows the GHG emission per capita in the waste sector for ten selected communities. Prince George consistently had the highest emission per capita from 2010 to 2015, then surpassed by Squamish in 2016 and 2017, reaching its peak at 1.07 tonnes of CO2e per person in 2018 before going down in 2019. Per capita waste emissions from Whistler increased sharply from 2018 to 2019 due to the reason explained above. Taking Whistler aside, Vancouver and Victoria saw a gradual decline in emission per capita over time and are two cities with the lowest emission per capita in the waste sector compared to other communities.

[23] https://sustain.ubc.ca/sites/default/files/2020-25_Whistler%20Energy%20Consumption%20and%20GHG_Thorlakson.pdf

Progress of individual cities

City of Kamloops

Emissions related to waste makeup 5% of baseline community emissions in Kamloops. Over time, the city has the amount of waste, and its GHG emissions per capita decrease gradually. In the Climate Change Action Plan[24], Kamloops also has the Big Move 5 with a focus on zero-waste/circular economy. This Big Move aims to reduce waste sent to the landfill by 50% by 2028 and by 90% by 2050.

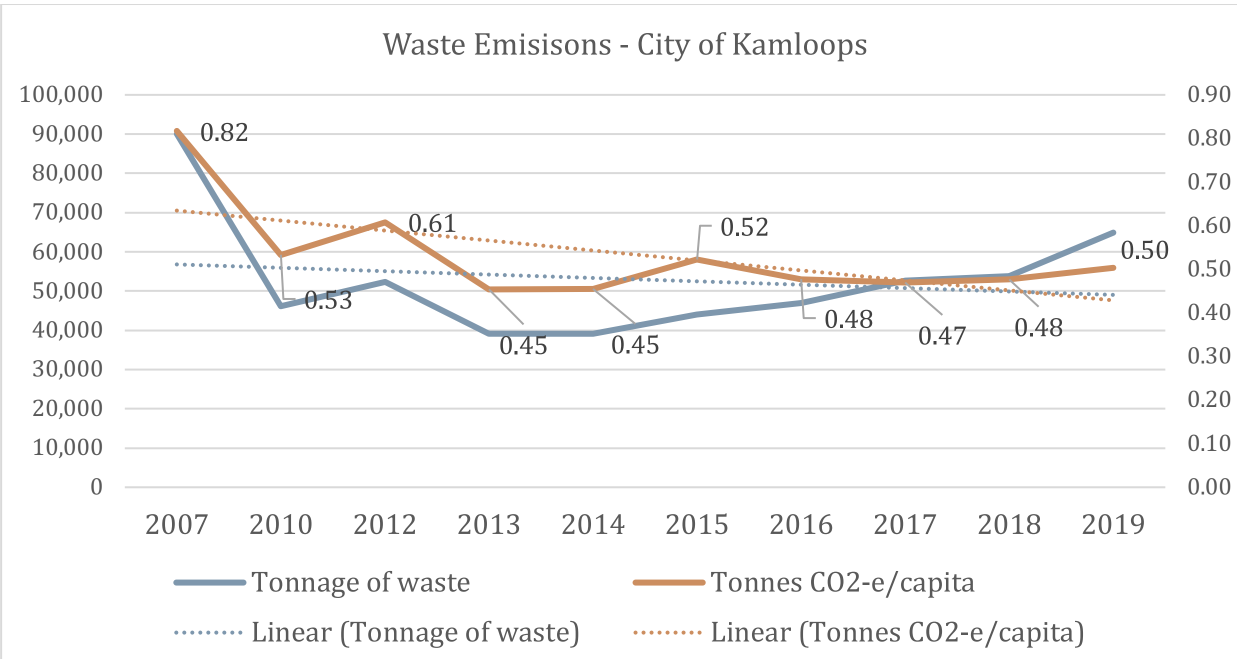


Figure 57: Waste emissions - City of Kamloops

City of Kelowna

Waste accounts for 9% of Kelowna's GHG baseline footprint, and the city aims to reduce waste emissions by 5% in 2023[25]. Despite the effort to implement the 2017 Solid Waste Management Plan, the amount of waste in Kelowna is slightly increasing over time, reaching its highest point in 2018 and going downward in 2019. On the reversed trend, the emissions per capita show a slow decline in the same period.

[24] https://www.kamloops.ca/sites/default/files/docs/cityofkamloops_communityclimateactionplan_june2021_final_0.pdf

[25] https://www.kelowna.ca/sites/files/1/docs/community/community_climate_action_plan_june_2018_final.pdf

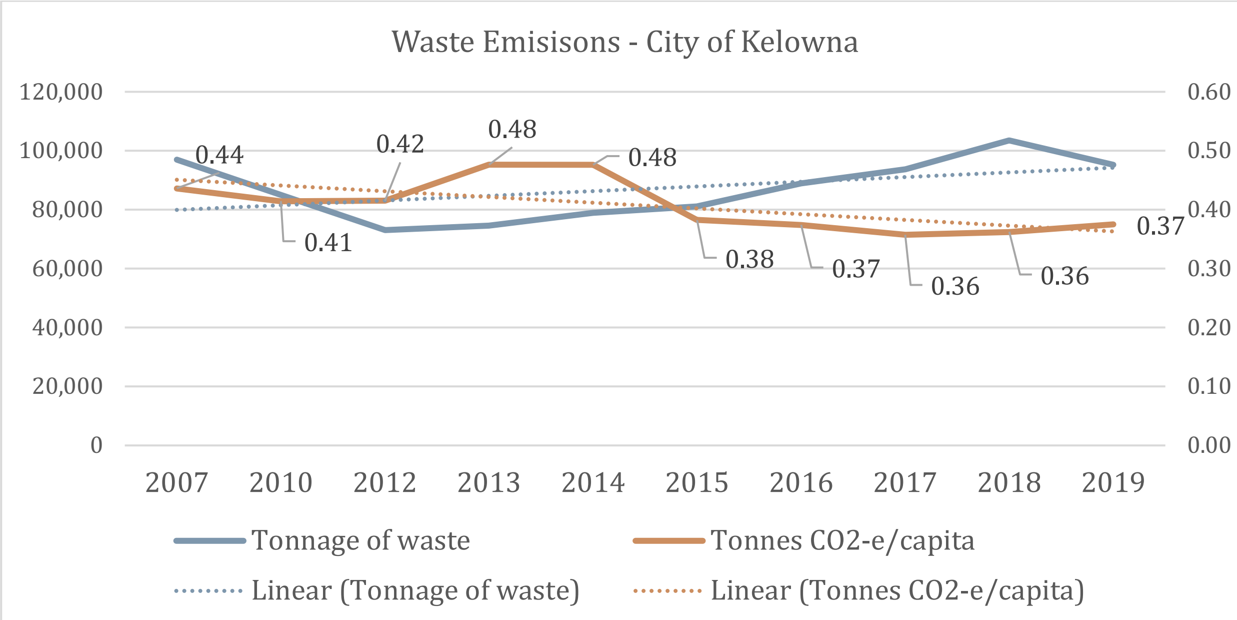


Figure 58: Waste Emissions - City of Kelowna

City of Nelson

Waste accounts for around 4% of the total GHG emissions in the City of Nelson. Over the period from 2007 to 2019, the amount of waste produced is relatively stable. However, the emissions per capita show a peak in 2014. Without a significant change in population in 2014, this peak is believed to be a mistake in the data collection or calculation process.

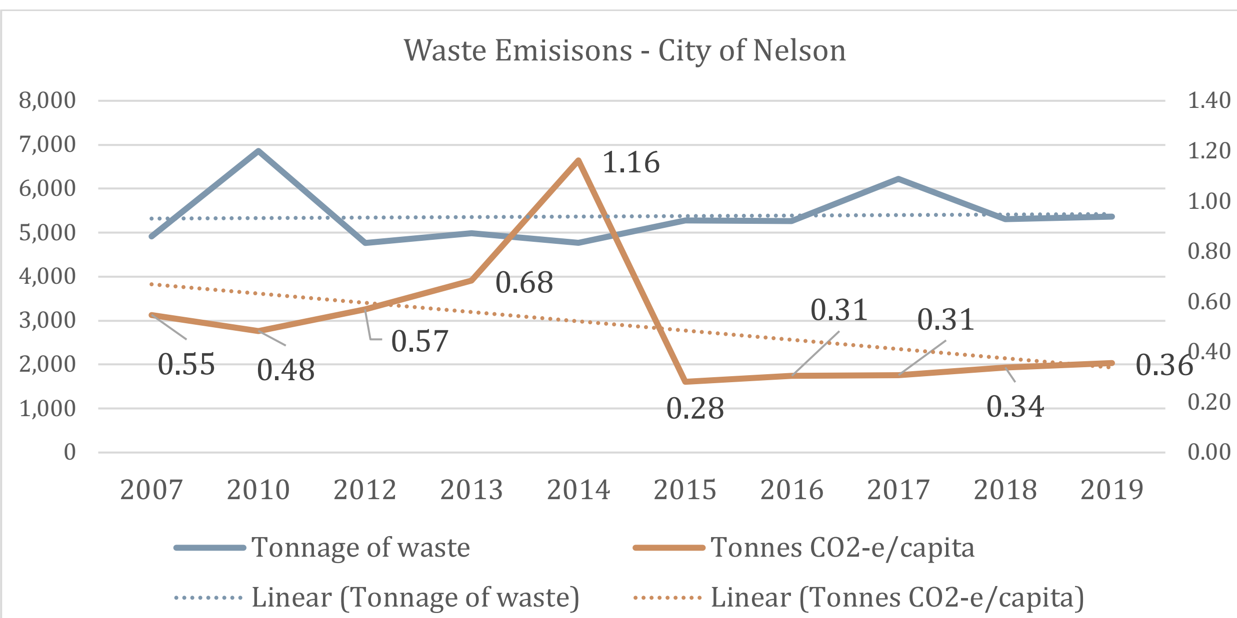


Figure 59: Waste Emissions - City of Nelson

City of Penticton

Waste in the City of Penticton peaked in 2010, fell sharply in 2012, and remained stable afterward. The waste emissions per capita trend is also steady over time. In its Climate Action Plan[26], the City of Penticton aims to divert all organic waste from landfills and recovers value from everything that enters the waste system.

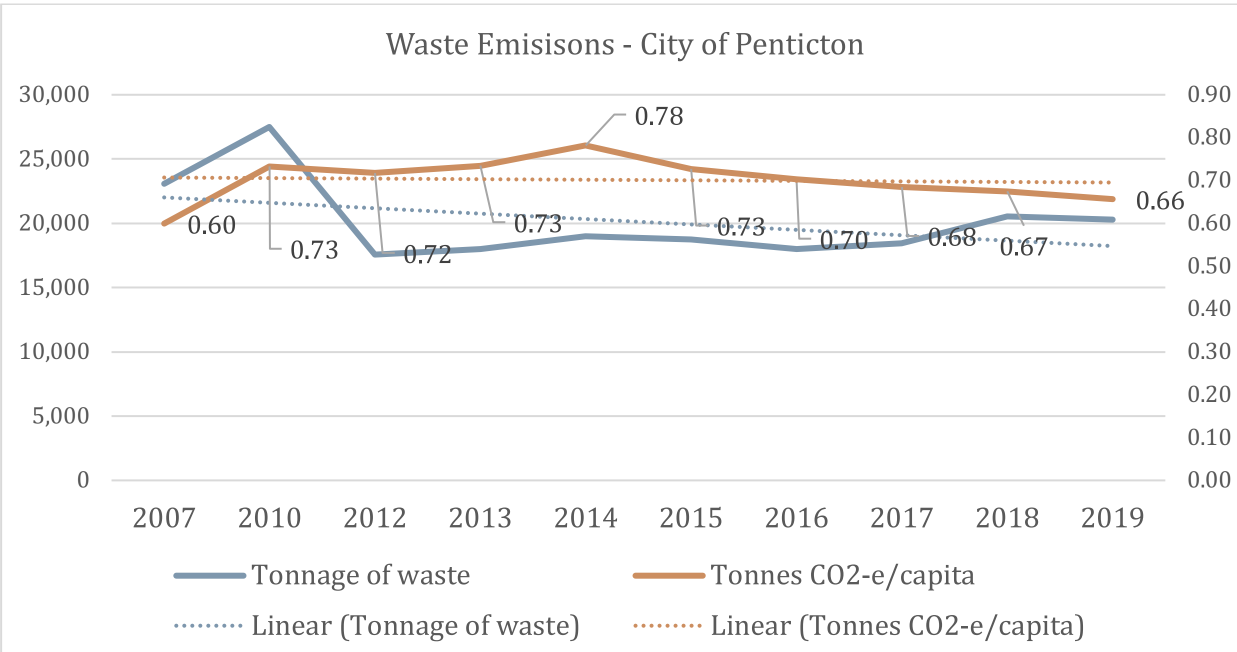


Figure 60: Waste Emissions - City of Penticton

City of Prince George

Waste produced in the City of Prince George and its GHG emissions have a slow downward trend. Notably, there is no change in the amount of waste but the emissions peak in 2018. The data quality is of concern for this year.

In its 2020 Climate Change Mitigation Plan[27], the City places waste as one of six focus areas and aims to divert organics from landfill and increase recycling and water conservation.

[26] Penticton Climate Action Plan

[27] https://www.princegeorge.ca/City%20Services/Pages/Environment/ClimateAction.aspx

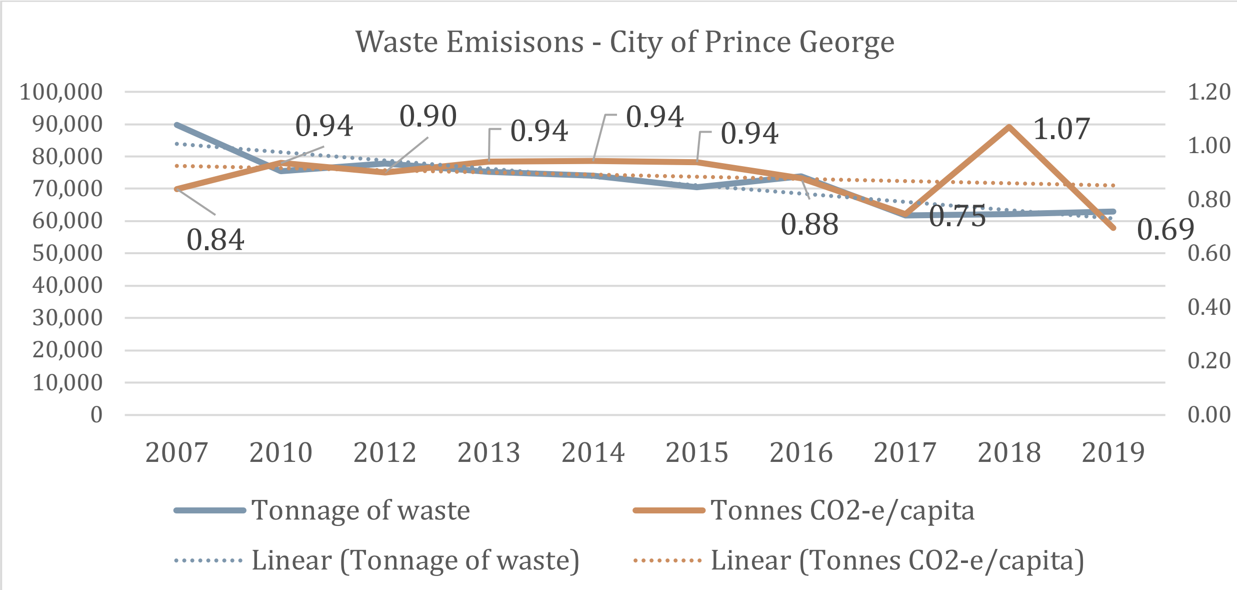


Figure 61: Waste Emissions - City of Prince George

City of Rossland

Waste produced in the City of Rossland slowly increases over time. It is also true for the emission from waste. In the Official Community Plan[28], the waste sector falls under the goal of community greenhouse gas reduction, fostering the conservation and efficient use of energy and other resources in buildings, vehicles, and infrastructure as we work towards net-zero GHG emissions by 2050.

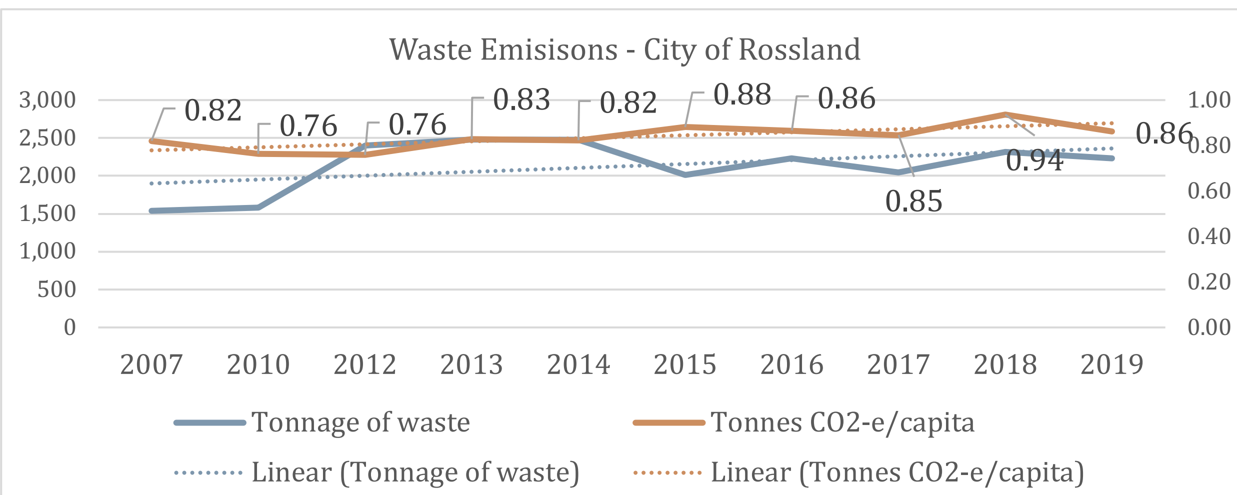


Figure 62: Waste Emissions - City of Rossland

[28] https://rossland.civicweb.net/filepro/documents/21173/?preview=21190

District of Squamish

The District of Squamish also witnesses a slow decline in the amount of waste produced and its associated emissions. In its Climate Change Action Plan[29], waste is placed in Big Move 1 to close the loop on waste being diverting organics, capture landfill gas, and reduce waste.

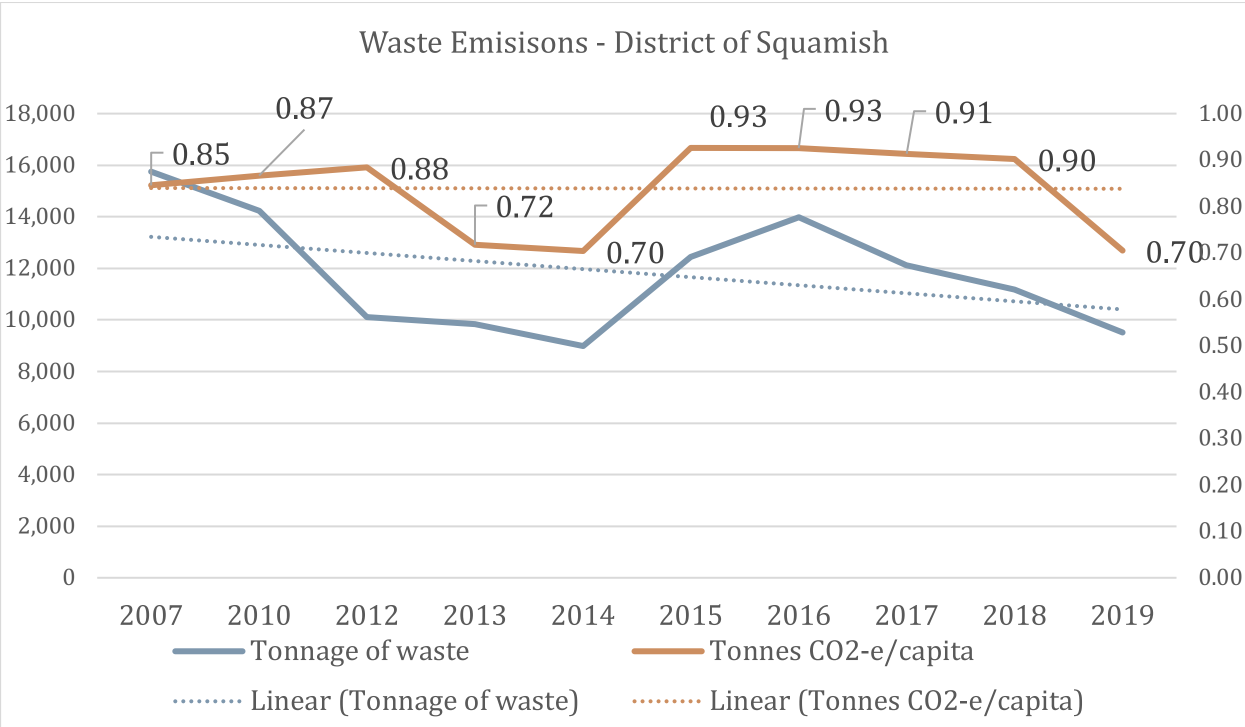


Figure 63: Waste Emission - District of Squamish

City of Vancouver

The City of Vancouver does an outstanding job in managing waste by reducing waste by over 30% in 2019 compared to 2007. Despite producing the largest amount of waste compared to other communities, the City of Vancouver and the City of Victoria have the lowest waste emissions per capita. In its Green Vancouver Plan, the City of Vancouver implements the program Zero waste 2040. And in the Greenest City Action Plan, in 2021, the City claims that it sent 30% less waste to landfill or incinerator and using 26% less waste per capita[30].

[29] https://squamish.ca/assets/5a46b62375/CCAP-Update-January-2020-v2.pdf

[30] https://vancouver.ca/files/cov/2021-greenest-city-action-plan-final-update.pdf

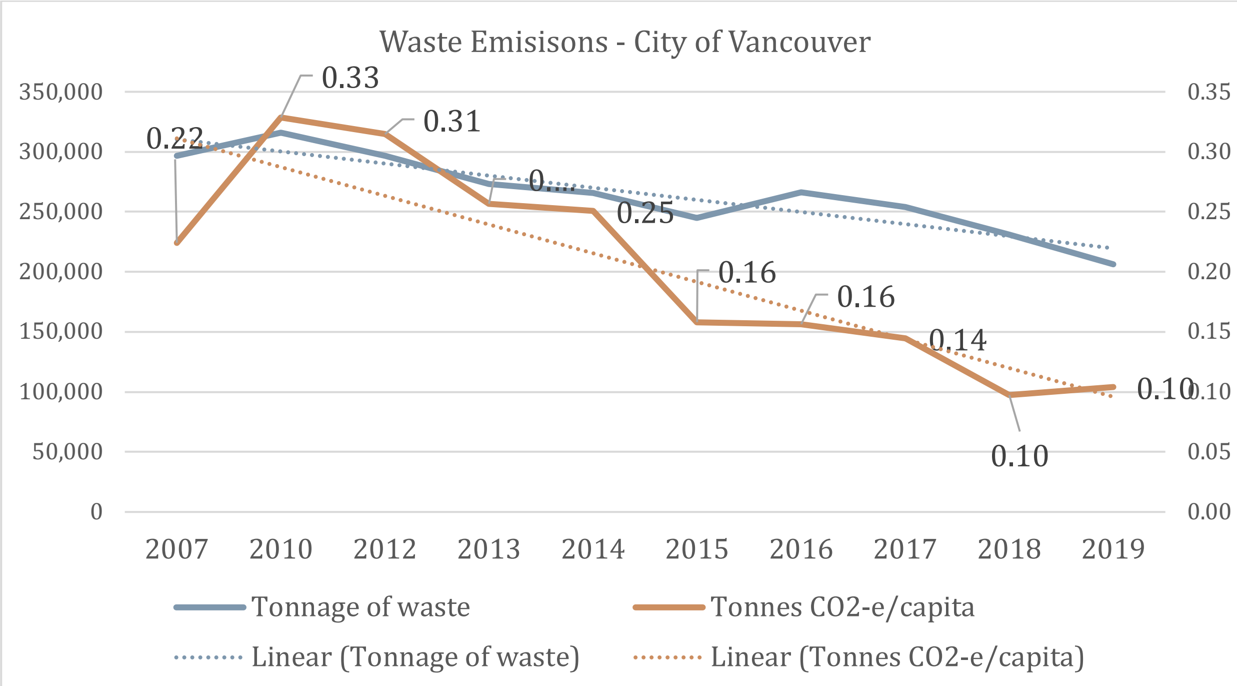


Figure 64: Waste Emissions - City of Vancouver

City of Victoria

The City of Victoria produces less waste over time, and the waste emissions per capita also decreased substantially, from 0.43 to 0.2 tonnes of CO2e per capita in 2007 and 2019, respectively.

In its Climate Change Action Plan[31], the City aims to manage organic materials to avoid GHG emissions.

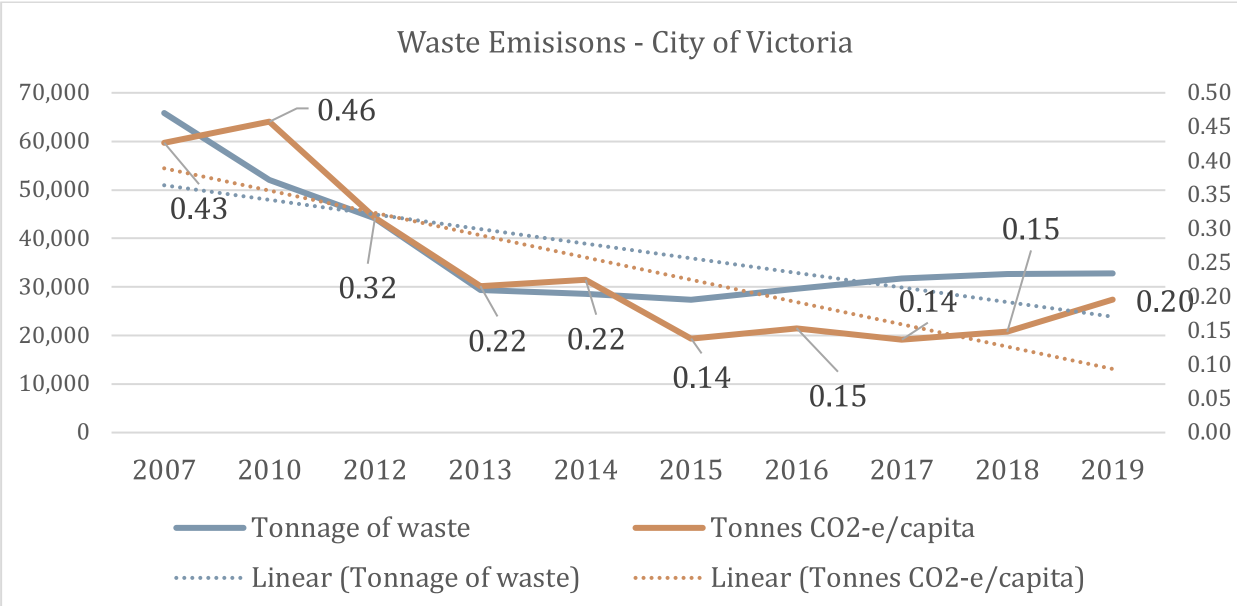


Figure 65: Waste Emissions - City of Victoria

Resort Municipality of Whistler

As mentioned at the beginning section of waste, Whistler waste is relatively stable over time, but the emission amount is not associated with the amount due to the shipping of waste to another place. Remarkably, there is no explanation in the method of calculating emissions from waste for

[31] https://www.victoria.ca/assets/Departments/Sustainability/Documents/City%20of%20Victoria%20Climate%20Action%20Plan.pdf

Whistler, but the emissions in 2019 show a sharp rise, and therefore the emission per capita rises in 2019.

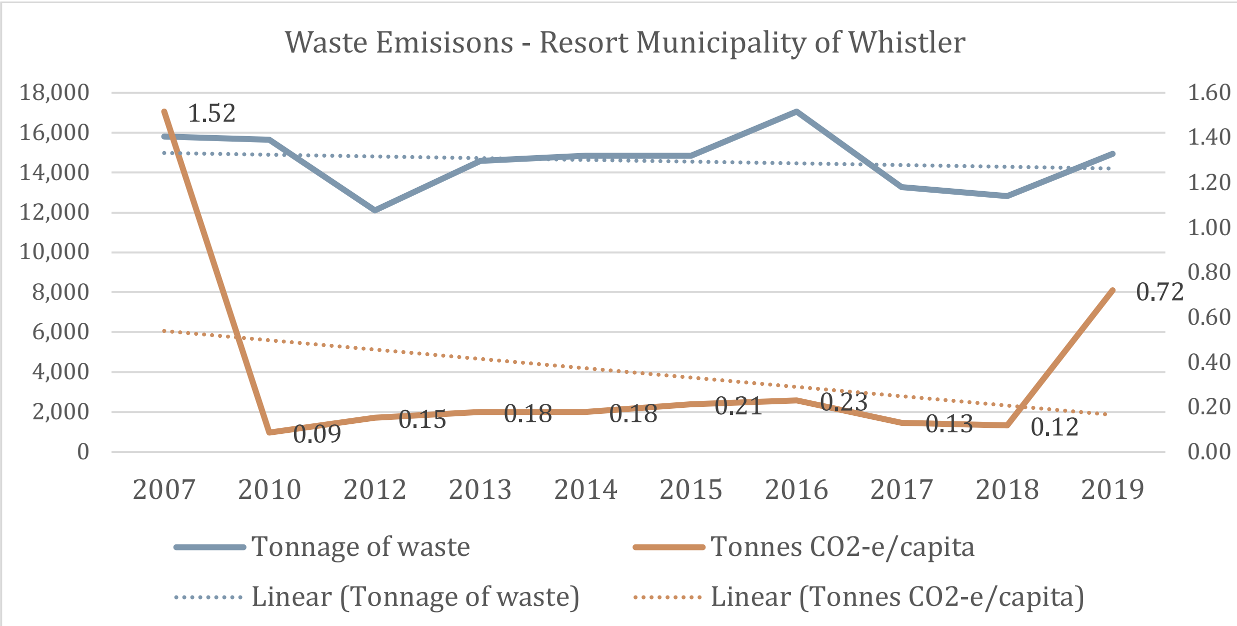


Figure 66: Waste Emissions – Resort Municipal of Whistler

Transportation

GHG emissions from fuel sale data from eight communities have been provided by CEA. Of eight cities, two cities are not in the original selection of this research, namely Summerland and Vernon. However, their sales data are presented here for comparison and information purposes. In addition, the data of Metro Vancouver and Squamish-&-Whistler are provided as regional data. The author uses the interpolation method related to the population to deliver the results for the City of Vancouver, District of Squamish, and Resort Municipality of Whistler.

Overall, the GHG emission from diesel usage shows an increasing trend over time for most cities except for Summerland. This trend is likely due to a slow but steady increase in the number of diesel passenger vehicles over this time. Vancouver had the highest GHG emissions, followed by Prince George and Kelowna.

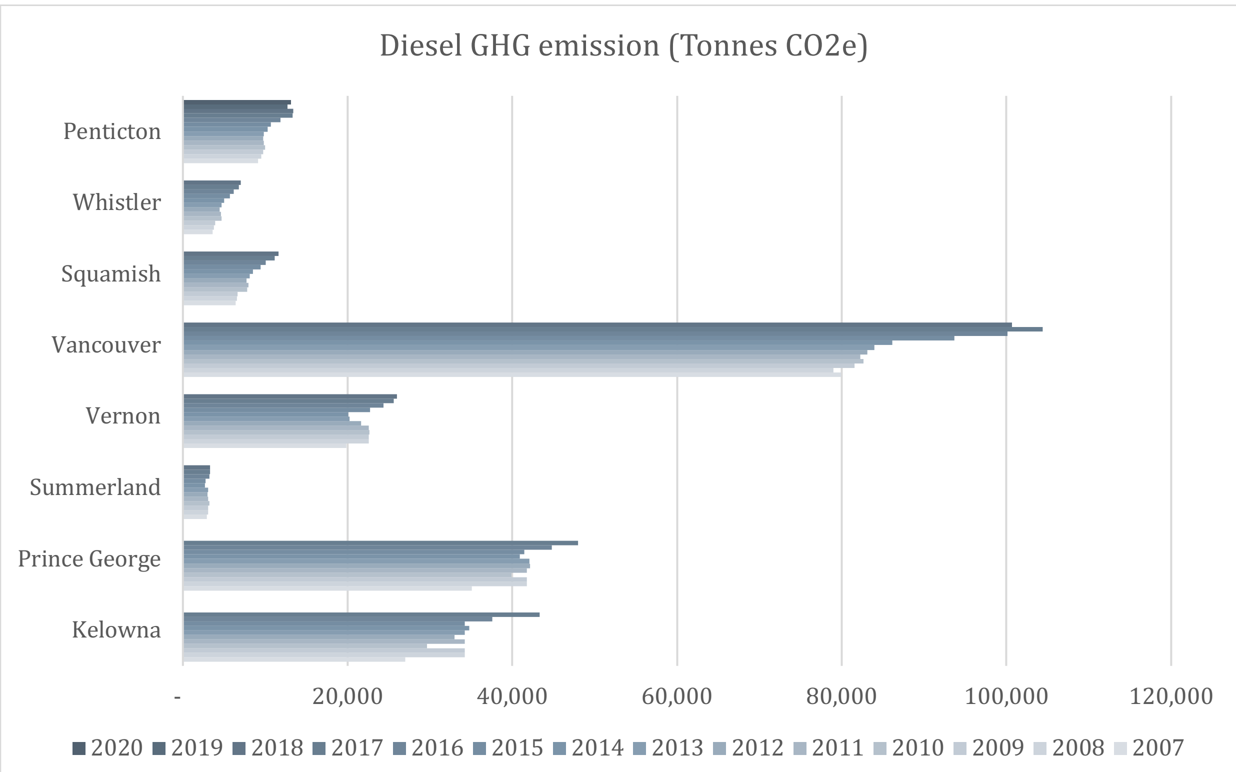


Figure 67: GHG emissions from diesel usage

In general, total GHG emission from gasoline is, on average, 10 times higher than from diesel fuel. However, GHG emissions from gasoline are relatively stable over this period compared to diesel fuel emissions, except for Vancouver. Vancouver also is the most significant emitter, followed by Kelowna and Prince George.

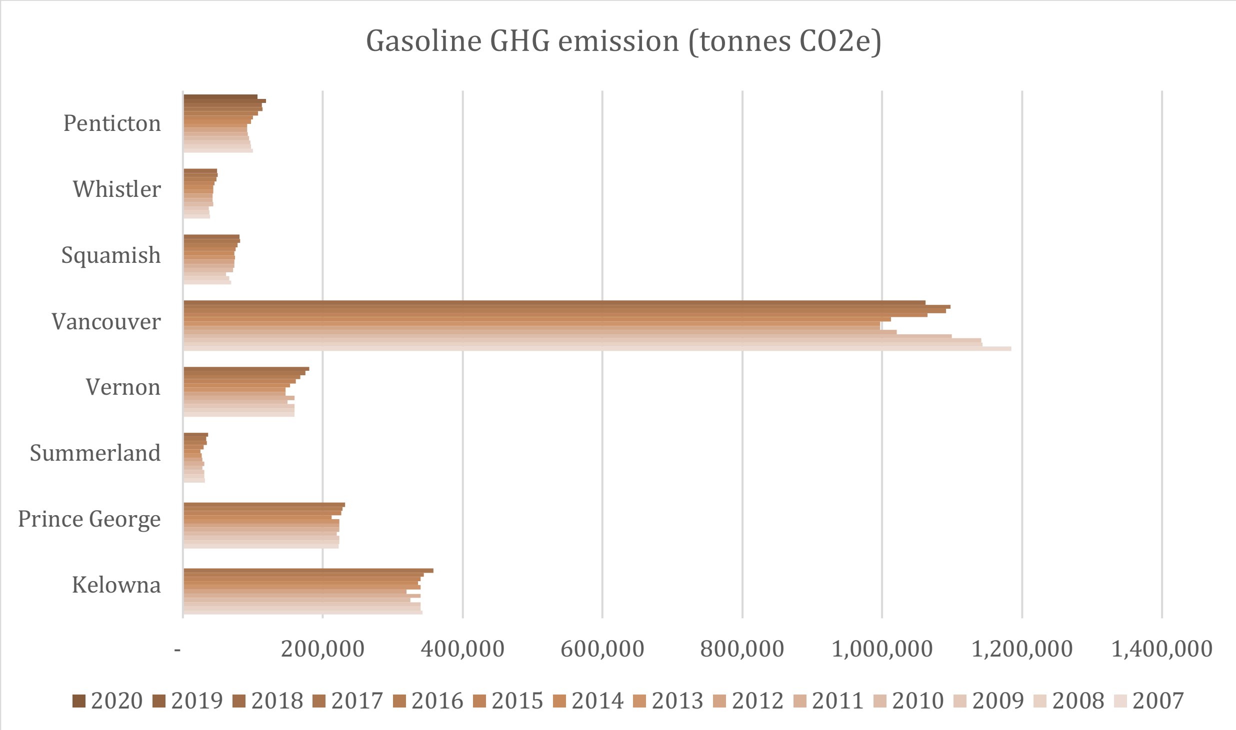


Figure 68: GHG emissions from gasoline usage

The original data of Metro Vancouver and Squamish-&-Whistler are used to compare CO2e emission per capita among eight cities. Metro Vancouver consistently has the lowest emission per capita among all communities and is the only community with emissions per capita lower than BC average data. The metro region also has a steady decline, starting from 2.1 tonnes CO2e per person IN 2007 to 1.7 tonnes CO2e per person in 2018 (figure 69).

Vernon and Squamish-&-Whistler alternatively have the highest emission per capita over this period. Since 2014, Vernon constantly is the most elevated position, ending with 4.8 tonnes CO2e per person in 2018, followed closely by Squamish-&-Whistler at 4.3 tonnes CO2e per person in the same year. For these two communities, there are no known factors other than weather and economy (e.g., visiting tourists) that could be attributed to this fact.

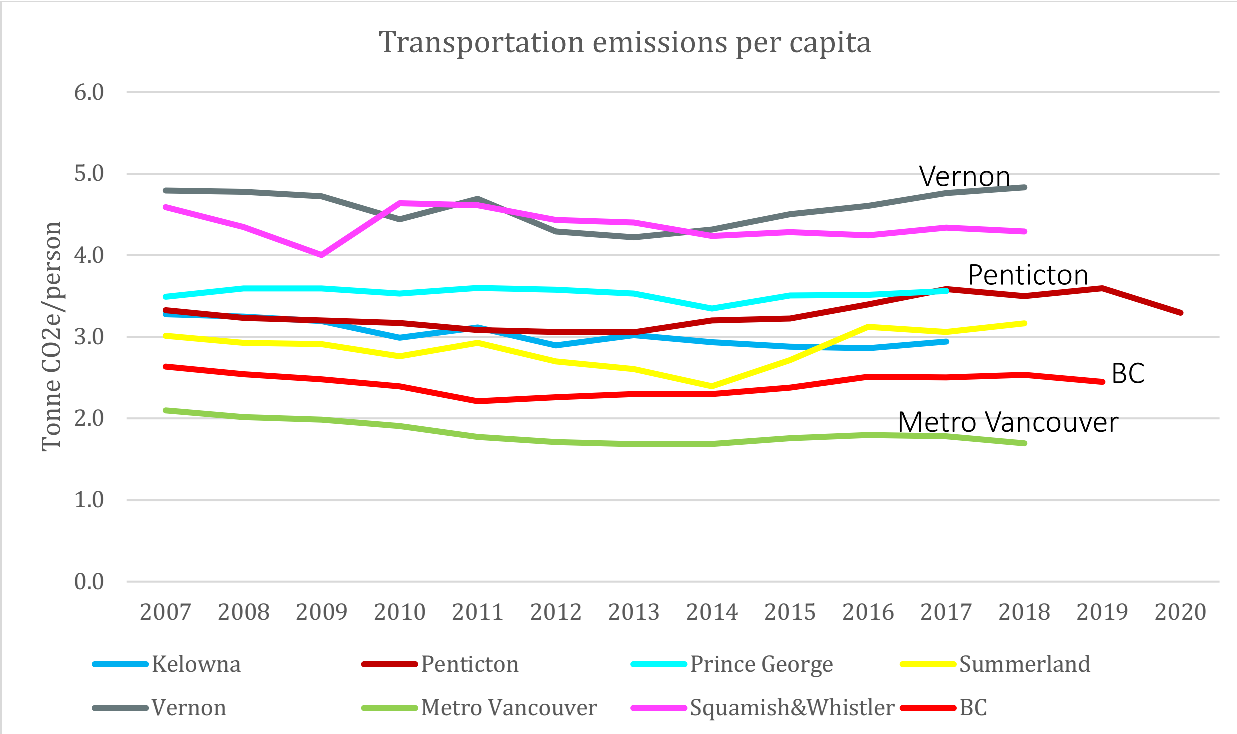


Figure 69: Transportation emission per capita

The following section will detail each selected community for their transportation emission. The four remaining cities that do not have fuel sale data will be assessed based on their public information.

City of Kelowna

With its 2040 Official Community Plan adopted in 2021, the City of Kelowna has clearly defined its commitments to reducing GHG emissions in the transportation sector through Policy 12.7.1 on Low Carbon Fuel, Policy 12.7.2 on Electric Mobility, Policy 12.7.3 on Promote Shared Mobility, and Policy 12.7.4 on Autonomous Vehicle Technology. In its 2040 Transportation Master Plan, which was approved in January 2022, the city also sets out 12 goals for over 100 actions for this sector. Those are bold actions and commitments from local government for the historic emissions.

In general, emissions from transportation have an upward trend. In 2010 and 2012, the total emissions dropped but then went back the following years. Emissions per capita slightly decreased to 2.94 tonnes of CO2e per person in 2017.

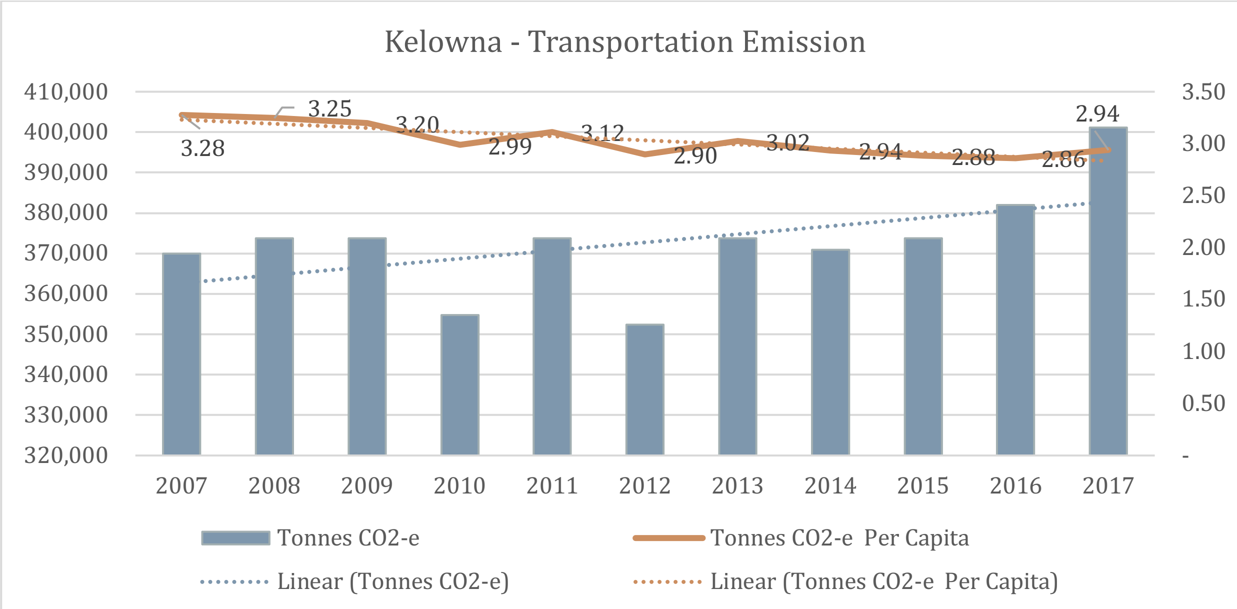


Figure 70: Kelowna - Transportation Emission

It is worth mentioning that from 2010 to 2017, a great effort of the local government for the transportation sector with a focus on active transportation (bike, hike, pedestrian lane) from 2010-2014, public transport and electric vehicles are actions from 2014 onwards. There's also been much growth in the downtown core (condo buildings, etc.), so people do not need to drive much. And there's been substantial growth in the student population at the University of British Columbia Okanagan, and many of those people take the bus to university or use active transportation.

City of Penticton

Penticton is the only city that has 2019 and 2020 fuel sale data. This period is of interest because of the impact of the COVID-19 pandemic on 2020 data.

In general, trend lines of both emission and emission per capita are in parallel with a slight upward trend over 14 years. The COVID-19 pandemic started at the end of 2019, and BC saw the first case in Jan 2020. Since then, travel has been restricted. In the city of Penticton, a 10% reduction in the term of emissions from transportation can be observed in 2020. With the lasting impact of the pandemic in the following year, a further drop in the emission can be expected in 2021.

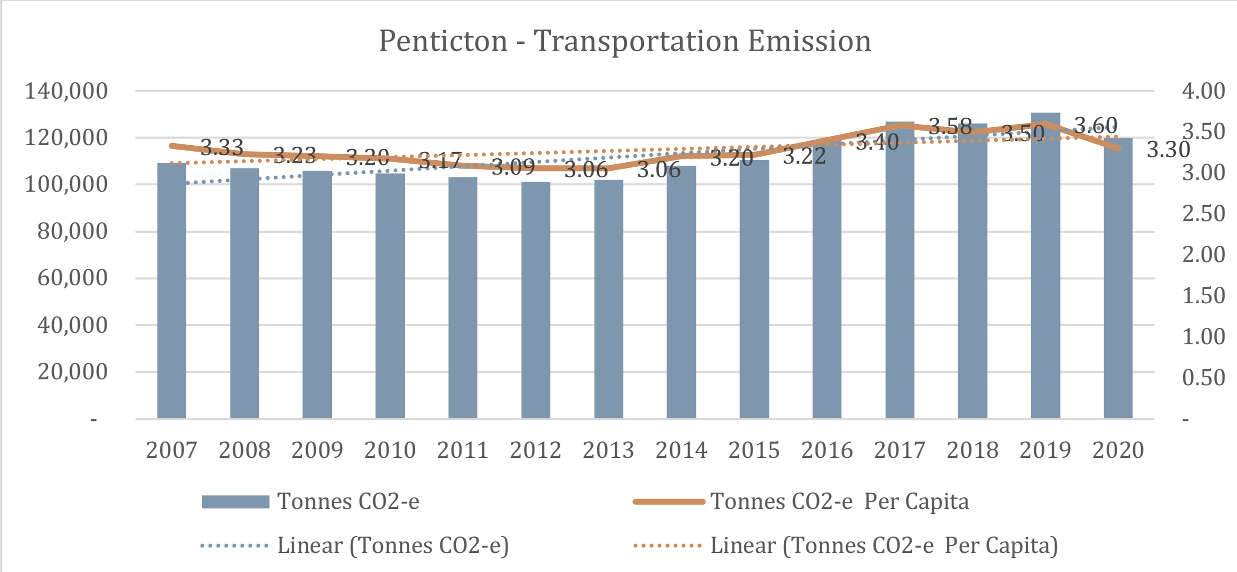


Figure 71: Penticton - Transportation Emission

In its OCP, the City of Penticton also places a vital role in monitoring GHG emissions and has set the goal of promoting and supporting energy reduction practices and local renewable energy production. Policy 4.4.4 encourages transit use, walking, cycling, car-sharing, and low-emission vehicles. Notably, in 2013 Penticton purchased the smaller and right-size bus. However, its impact is hard to see in the emission graphs above.

City of Prince George

Overall, the emissions from fossil fuel consumption in the city of Prince George increase steadily over time. Two substantial drops were observed in 2010 and 2014, but the decreasing trends are reversed right in the following years. There is no known event related to this timeframe, so the quality of data is of concern.

The city has a supporting policy for transportation in its OCP with a focus on active transportation (walking, cycling, transit). In its monitoring report of OCP in 2017[32], the city assessed itself as performing in the right direction with an increasing budget for active transportation infrastructure from 2011 to 2016. And from 2018, it starts having EV infrastructure projects. More recent data is needed to assess this investment's effectiveness.

[32] https://www.princegeorge.ca/Business%20and%20Development/Documents/Planning%20and%20Development/OCP/OCP_Monitoring_Report.pdf

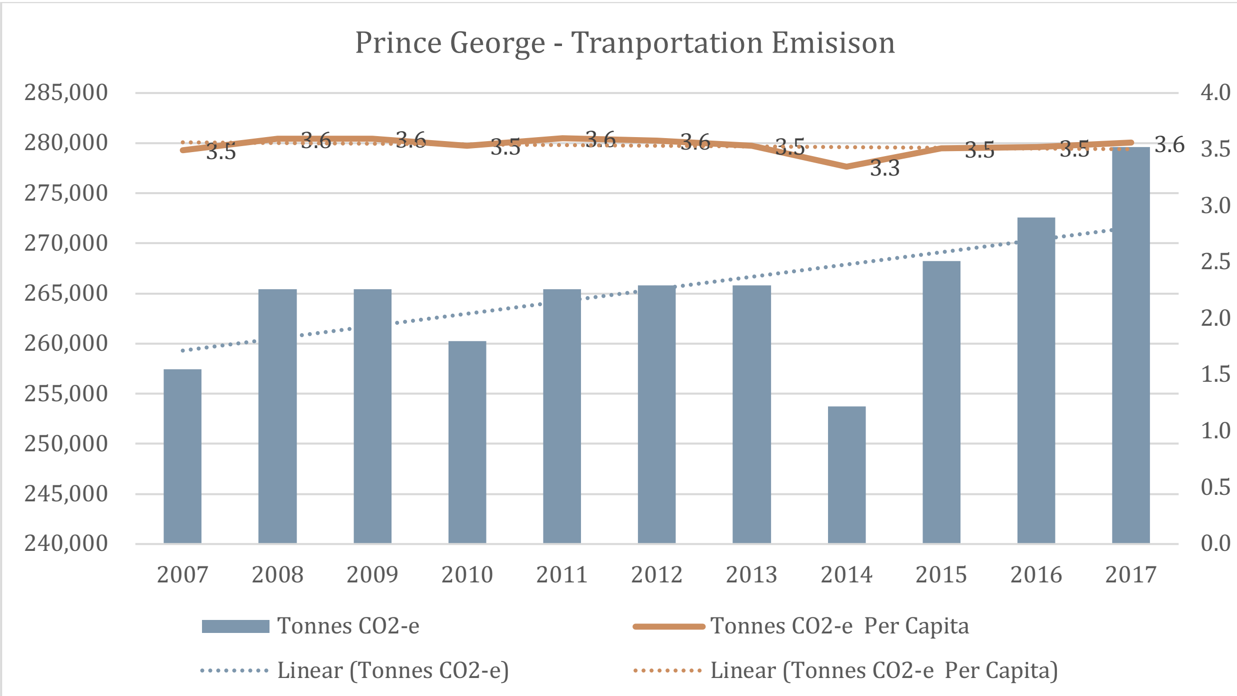


Figure 72: Prince George gasoline emission

District of Squamish

The District of Squamish released a transportation action plan since 2012 and an active transportation plan since 2016. Because of these plans, a lot of efforts in the sector for example cycling lane project and trails master plan in 2010, regional transit strategy in 2013, part-time sustainability coordinator in 2014 and bringing two Modo vehicles[33] to Squamish in 2018.

And the GHG emissions from gasoline and diesel increases gradually over time but the emission per capita decreases. Without any change in the emission factor, the reasons might explain this trend are more fuel efficiency vehicles and the increase in population in the District of Squamish.

[33] Car sharing service. https://www.modo.coop

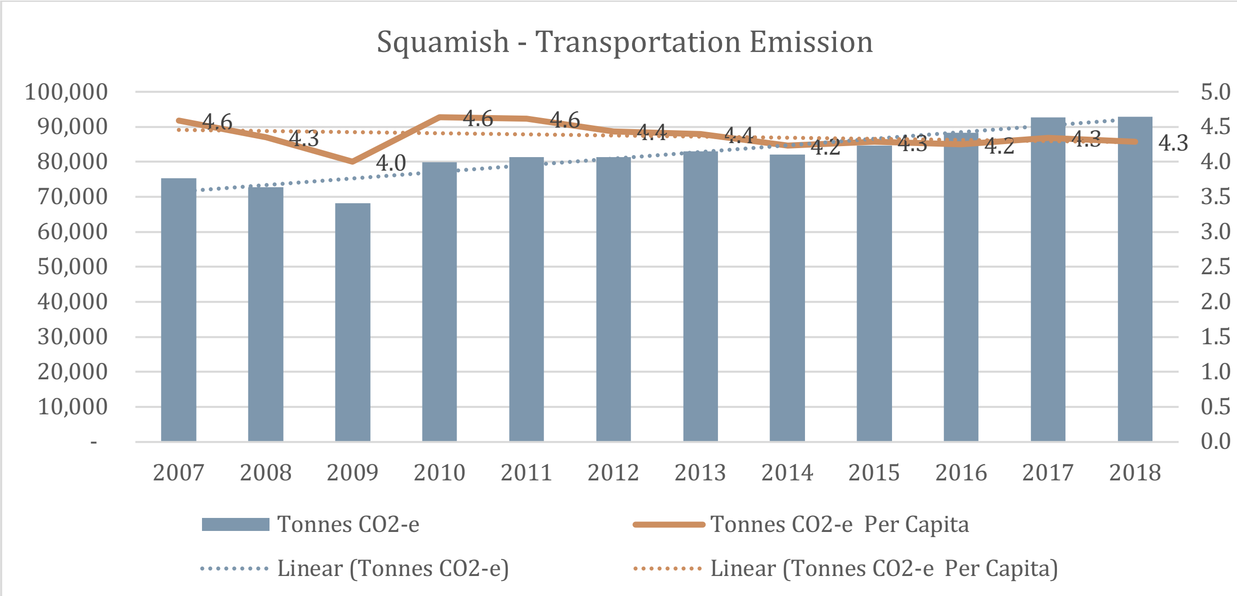


Figure 73: Squamish - Transportation Emission

City of Summerland

In Summerland, the emission and emission per capita of transportation show a slowly increasing trend over time.

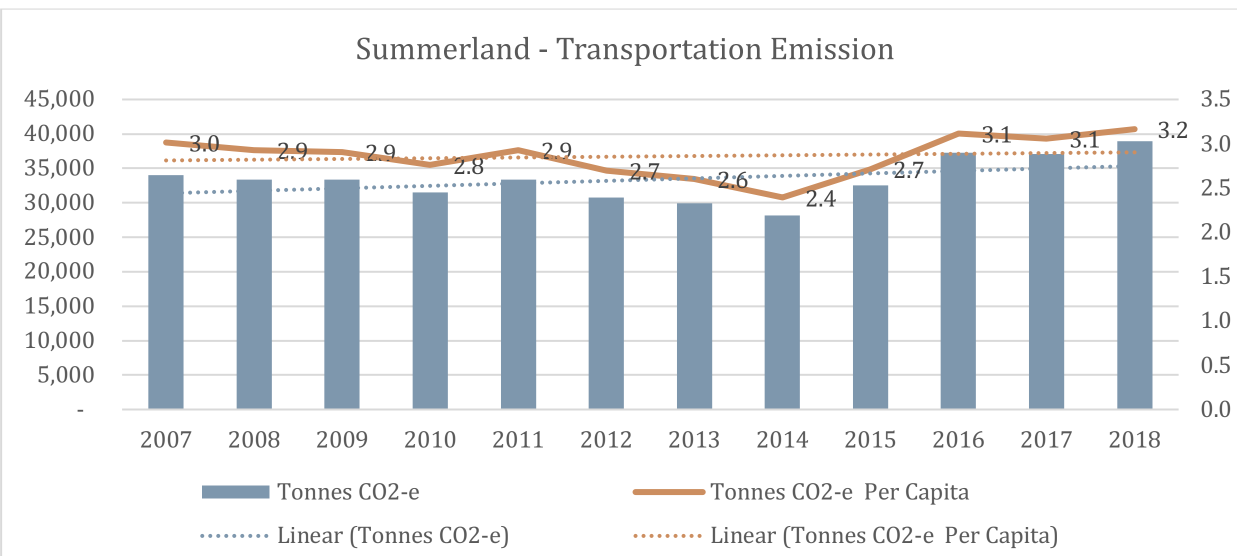


Figure 74: Summerland - Transportation Emission

City of Vancouver

Total emission from transportation from the City of Vancouver is high, but emission per capita is the lowest among the seven cities with data. Vancouver is the only city with transportation emissions per capita lower than BC average data. A significant decline in emissions is witnessed from 2009 to 2012. From 2013 to 2017, the total emissions are increasing but with less amount.

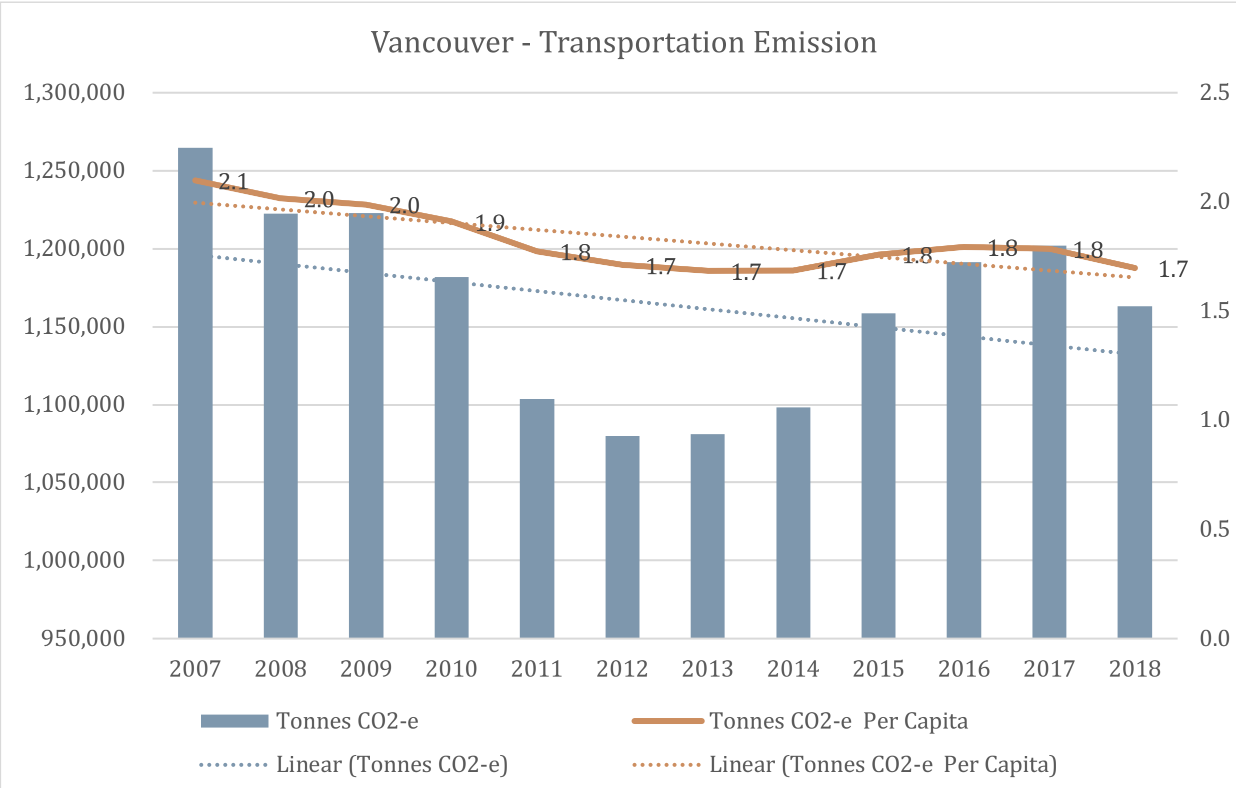


Figure 75: Vancouver - Transportation Emission

The City of Vancouver has bold targets in the Climate Emergency Action Plan[34]. Of six focused Big Moves, three are concentrated on transportation, being Big Move 1 (by 2030, 90% of people live within an easy walk/roll of their daily needs), Big Move 2 (by 2030, two-thirds of all trips in Vancouver will be made on foot, bike or transit), and Big Move 3 (by 2030, 50% of the kilometers driven on Vancouver's roads will be by zero emissions vehicles).

[34] https://council.vancouver.ca/20201103/documents/p1.pdf

City of Vernon

Transportation emissions increase slowly in the City of Vernon, but the emissions per capita trend remains stable over time.

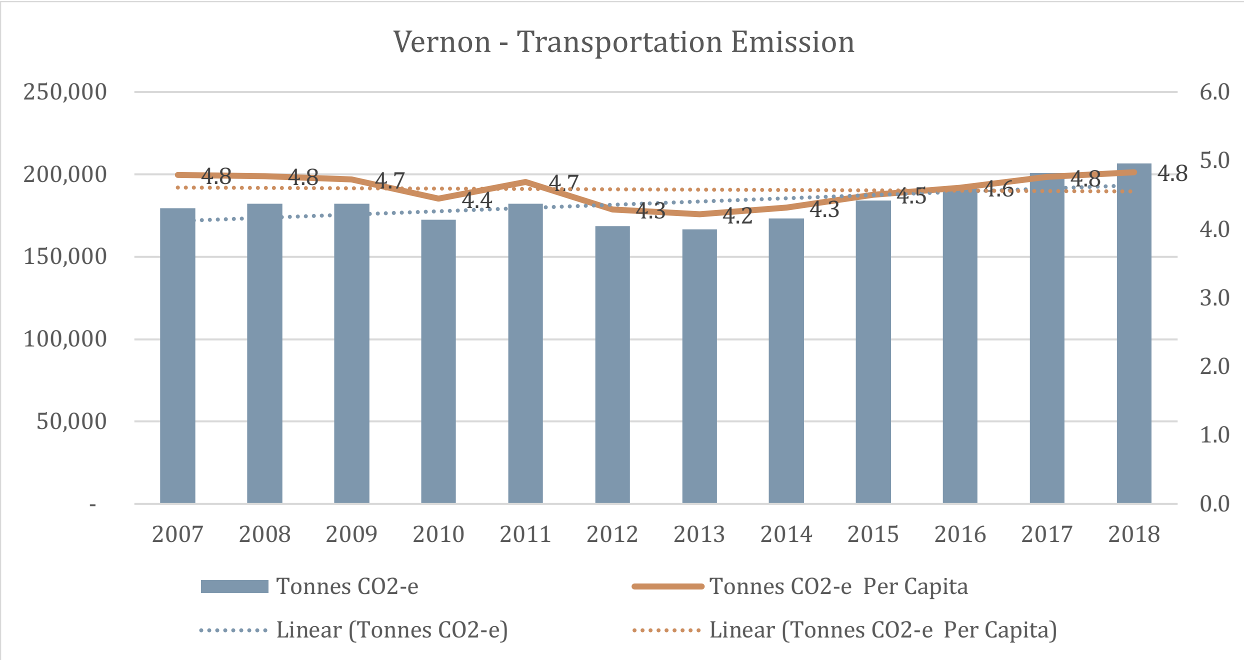


Figure 76: Vernon - Transportation Emission

Resort Municipality of Whistler

The total emission from transportation rises gradually over time in Whistler, but the emissions per capita remain relatively constant. Growing population should be the cause of this trend. In the Whistler Transportation Action Plan 2018 – 2028[35], the goal of minimizing GHG emissions created by the transportation system is placed as the long-term goal.

Note that it is difficult to take account of Whistler's shadow population[36] in the per capita numbers.

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[35] https://www.whistler.ca/sites/default/files/2018/Oct/related/25264/whistler_transportation_action_plan_2018-2028.pdf

[36] People live in the city but not in the census (such as tourists and workers in commercial facilities).

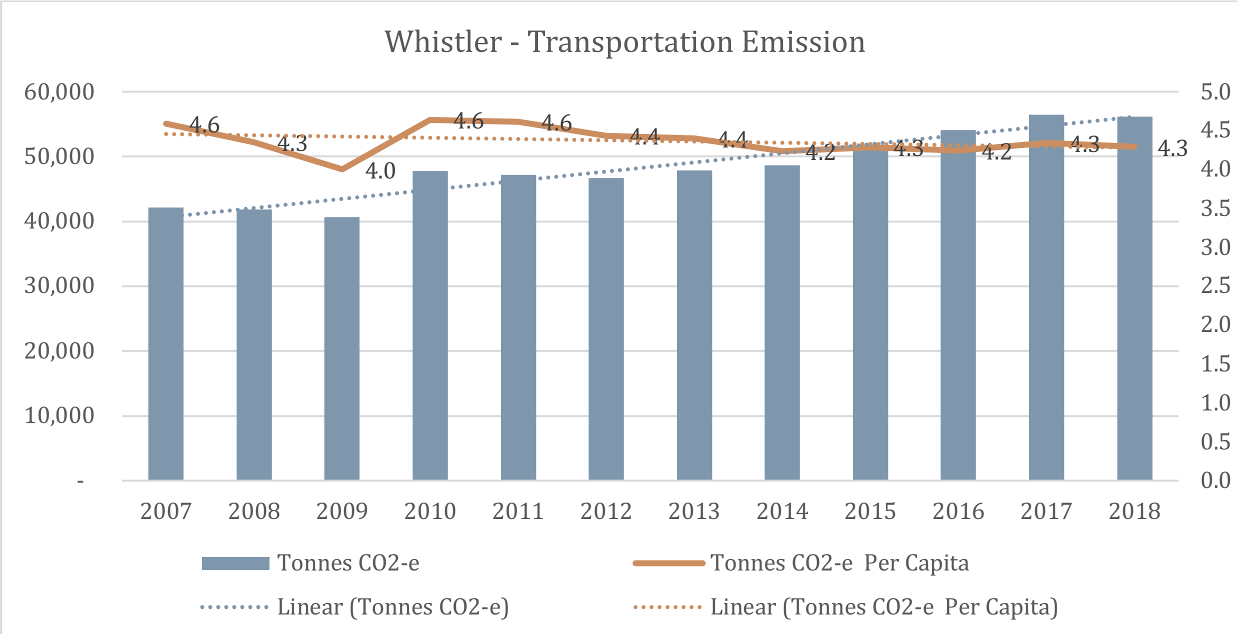


Figure 77: Whistler - Transportation Emission

Google EIE data

Google EIE provides distance traveled for automobiles, standard bus, cycling, walking, and ferry modes for a number of jurisdictions all over the world. There are four cities in the EIE public data, including Kamloops, Kelowna, Prince George, and Victoria are within the scope of this research. Because data from EIE is only from 2018 to 2021, and there is no historical data in this set, a comparison and combination of the two datasets (fuel sale and EIE) can not be made. This dataset, however, contains data from 2019 and 2020 with the impact of the Covid-19 Pandemic. Hence Pandemic impact can be observed.

The below graph shows the share of four modes of transportation in Kamloops from 2018 to 2021. Most of the transport mode is automobiles, which accounts for more than 98% over time. The automobile percentage is going down slightly in 2019 and lowest in 2020 at 98.2%, but in 2021, it is going up again. During the pandemic, the usage of cycling and standard buses is increasing, but for a tiny portion. The share of walking in Kamloops stays stable at less than 1%.

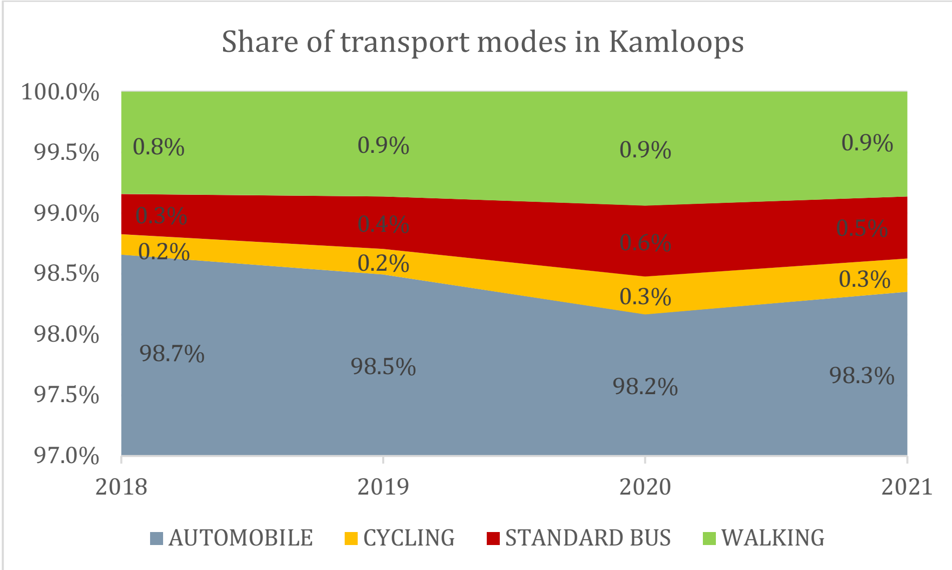


Figure 78: Share of transport modes in Kamloops

The graph below illustrates the share of transport modes in the City of Kelowna, where automobile accounts for more than 97% in 2018, 2019, and 2021. In 2020, it reduced from 97.4% to 96.9%, then rose to 97.2 in 2021. In 2020, people were walking, cycling, and using standard buses more often. The highest increase can be seen in cycling percentage, which rises from 0.6% in 2019 to 1% in 2020 and then drops slightly in 2021.

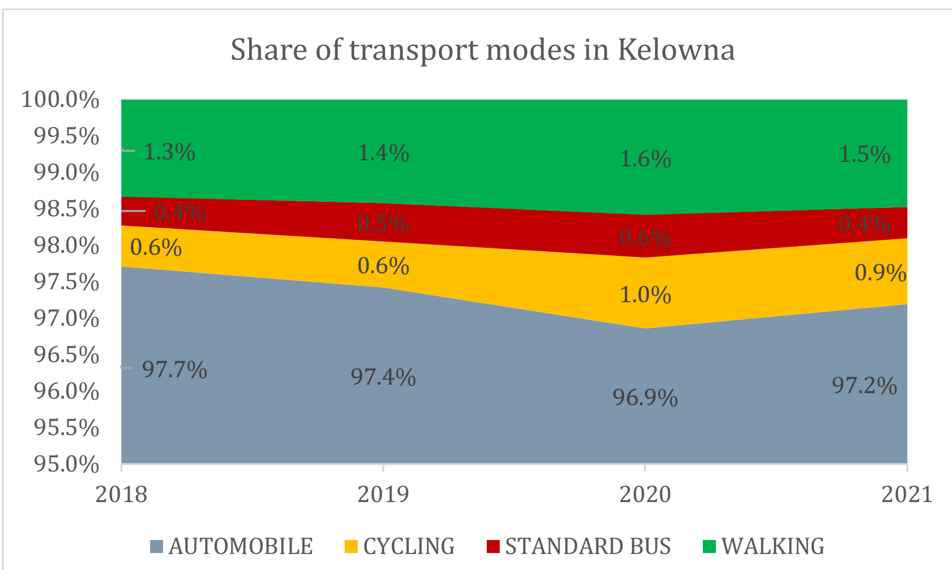


Figure 79: Share of transport modes in Kelowna

In the City of Prince George, the automobile mode of transport also accounts for more than 98% of the total transport modes. Here, the drop in using automobiles and increasing the use of other transport modes is witnessed in 2019, stabilizing in 2020 and decreasing in 2021. The share of standard bus data is only available in 2019, and the trend of using it cannot be seen in this graph.

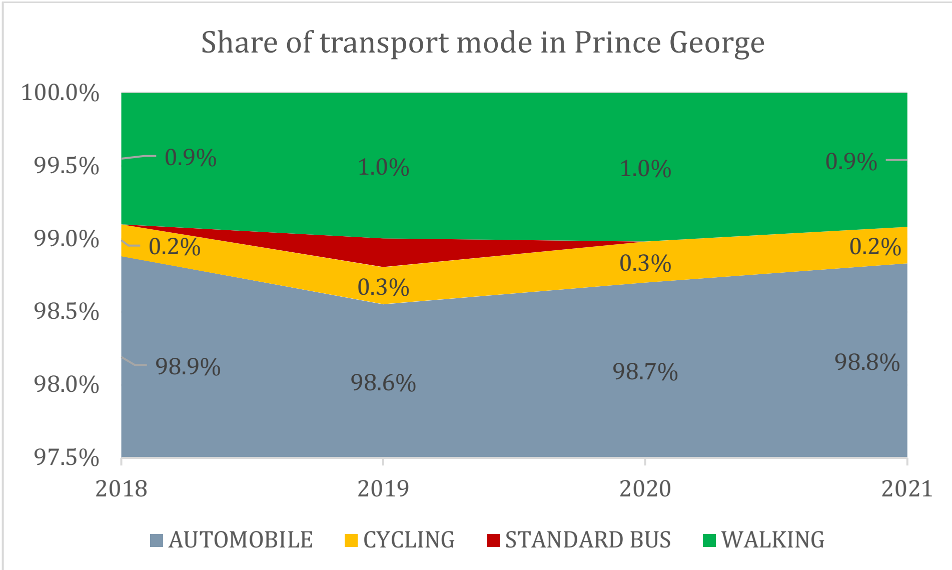


Figure 80: Share of transport mode in Prince George

In the City of Victoria, the share of automobiles is the least among four cities but still the majority of transport and increasing over time at 84.9%, 85.1%, and 86.9% in 2019, 2020, and 2021 respectively. By 2020, cycling is growing from 2.7% in the previous year to 3.5%. The standard bus and walking use decrease slightly in 2020 and continue to fall in 2021. The data on using ferry boats is only available for 2018, at 14% 2018.

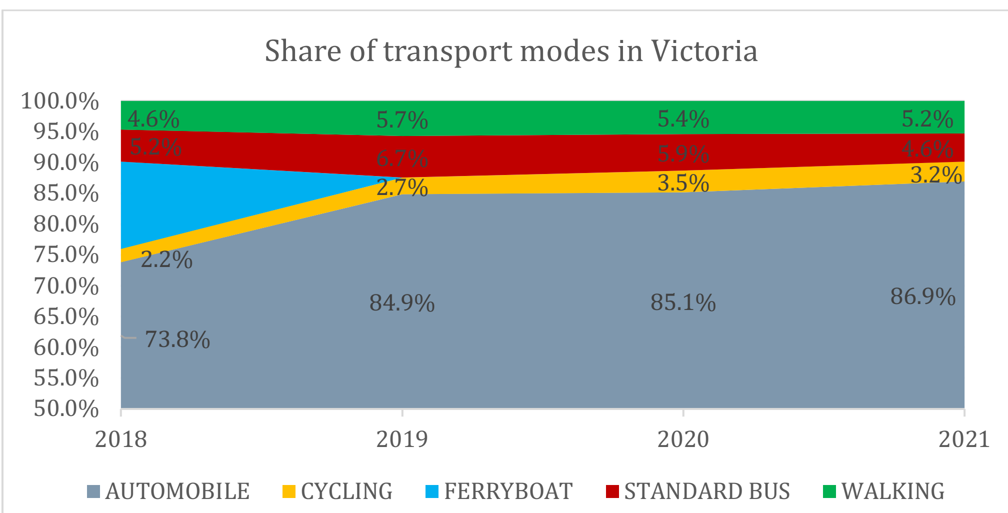


Figure 81: Share of transportation modes in Victoria

All in all, in four cities, it seems the COVID-19 pandemic has positively affected the use of active transportation modes such as cycling and walking. However, this effect is very modest and does not last in 2021. The majority mode of transport is still automobile.

The Google EIE dataset comes with estimated tonnes of CO2e per the mode of transport. Obviously, with the high share of automobiles, it has the highest GHG emissions among all the modes, while cycling and walking do not emit any emissions. Concerning the data quality, fuel sale data for Kelowna and Prince George are crossed checked, and it helps to confirm that, in general, the total emission from the transportation of Kelowna is higher than that of Prince George. However, it is tough to draw any other information because Google EIE data shows a significantly higher number for both cities.

On a side note, distance travel is considered an accurate methodology to quantify GHG emissions in the transportation sector. However, from the provincial GHG emissions inventory, only vehicle kilometer traveled (VKT) data for 2007 and 2010 CEEI sets are available. This data is based on a sophisticated methodology with the aid of Insurance Cooperation of British Columbia (ICBC) data and other surveys and measures, which are unfortunately not available for this study (more detail in Appendix).

Summary

In this research, consumption and emission data from community energy buildings, waste, and transportation sectors are collected and analyzed to identify trends and progress in reaching climate targets.

In summary, the total GHG emissions from three sectors are consolidated and used to compare the current emission amount with the baseline amount. The information on the baseline GHG emission and self-announce claims by local communities in table 2 will be compared with the change found in this research, resulting table 5 below.

The 2007 OCP column shows the available data from the OCP of the concerned communities, the column to the right with 2007 from this research shows the GHG emissions consolidated using the provincial inventory. There are some communities with a significant discrepancy between the two data sets. For example, the City of Prince George, with the baseline emissions in this research, is higher at 52.8% than that in OCP, followed by the District of Squamish at 31.3%, and the City of Kamloops at 22.9%. The city of Vancouver has the positive discrepancy lowest at 7%. On the contrary, GHG emissions from the City of Victoria in this research are less than that in OCP at 23.3%, followed by Resort Municipal of Whistler at 21.2%.

Because of this discrepancy, the last three columns in table 5 will show the change in progress when comparing different methods. Cells with highlighted orange mean no updated data from this research and used OCP data. Therefore, they don't show any difference in the change found in this research to OCP and the community's self-announced change.

It is worth mentioning that this research uses the provincial inventory of utilities and waste, but it uses fuel sale data for transportation instead of vehicle traveled kilometers, and it does not include propane, wood, and heating oil estimated in the utility's dataset. Therefore, the change found in this research does not mean to be the same amount compared to OCP but to confirm the direction of reducing or increasing emissions for each community.

The progress results are less confident in four communities that do not have fuel sale data: the City of Kamloops, the City of Rossland, the City of Nelson, and the City of Victoria. In table 5, the results of these cities are shown as not applicable (NA).

Figure 82 shows the overall assessment based on table 5’s last two columns, namely, change found within this research and change self-announced by the communities in their OCP. In figure 82, if the same trend (three negative numbers or three positive numbers) is observed for one community, it will be highly confident to conclude the progress that the community is heading.

In specific, figure 82 shows that:

- By 2018, the City of Vancouver is progressing in reducing its GHG emissions compared to the 2007 baseline at a 12% reduction. This trend is similar to the progress announced by the City at a 17% reduction in 2020.
- The City of Penticton, the City of Prince George, and the District of Squamish are increasing their community GHG emissions compared to the 2007 baseline at 15.5%, 16.6%, and 21.9%, respectively. This trend is similar to the progress announced in these cities' OCPs.
- There is an increasing trend of total GHG emissions in Resort Municipal of Whistler and the City of Kelowna compared to the 2007 baseline at 1.6% and 9.2%, respectively. However, this trend contradicts the decreasing emission announced in the communities' OCPs.

Table 5: Assessment of the progress of reaching climate action targets

Community	2007 (tCO2e)	2007 (tCO2e)	Discrepancy	Progress				
	OCP	This research	this research vs OCP	Year	tCO2e	Change found within this research compared to OCP*	Change found within this research**	Community's self-announced change***
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
City of Kamloops	612,000	751,963	22.9%	2017	565,000	-7.7%	NA	-7.7%
City of Kelowna	665,234	663,861	-0.2%	2017	724,772	8.9%	9.2%	-3.5%
City of Nelson	71,200	65,329	-8.2%	2018	79,102	11.1%	NA	11.1%
City of Penticton	224,761	199,722	-11.1%	2019	230,710	2.6%	15.5%	11.2%
City of Prince George	540,000	825,245	52.8%	2017	962,198	78.2%	16.6%	1.9%
City of Rossland	24,970	21,402	-14.3%	2020	25,000	0.1%	NA	0.1%
District of Squamish	86,000	112,940	31.3%	2018	137,628	60.0%	21.9%	12.8%
City of Vancouver	2,805,000	3,000,552	7.0%	2018	2,640,770	-5.9%	-12.0%	-16.8%
City of Victoria	399,146	306,213	-23.3%	2017	369,609	-7.4%	NA	-7.4%
Resort Municipality of Whistler	133,019	104,877	-21.2%	2018	106,513	-19.9%	1.6%	-1.4%

Highlighted cells indicate communities without transportation data.

*Change found within this research to OCP: (F) = [(E)-(A)]/(A). The recent total GHG emissions compared to the baseline data from OCP.

**Change found within this research: (G) = [(E)-(B)]/(B). The recent total GHG emissions compared to the baseline data found in this research.

***Community's self-announced change taken from OCP. For communities without transportation data, (H) = (F).

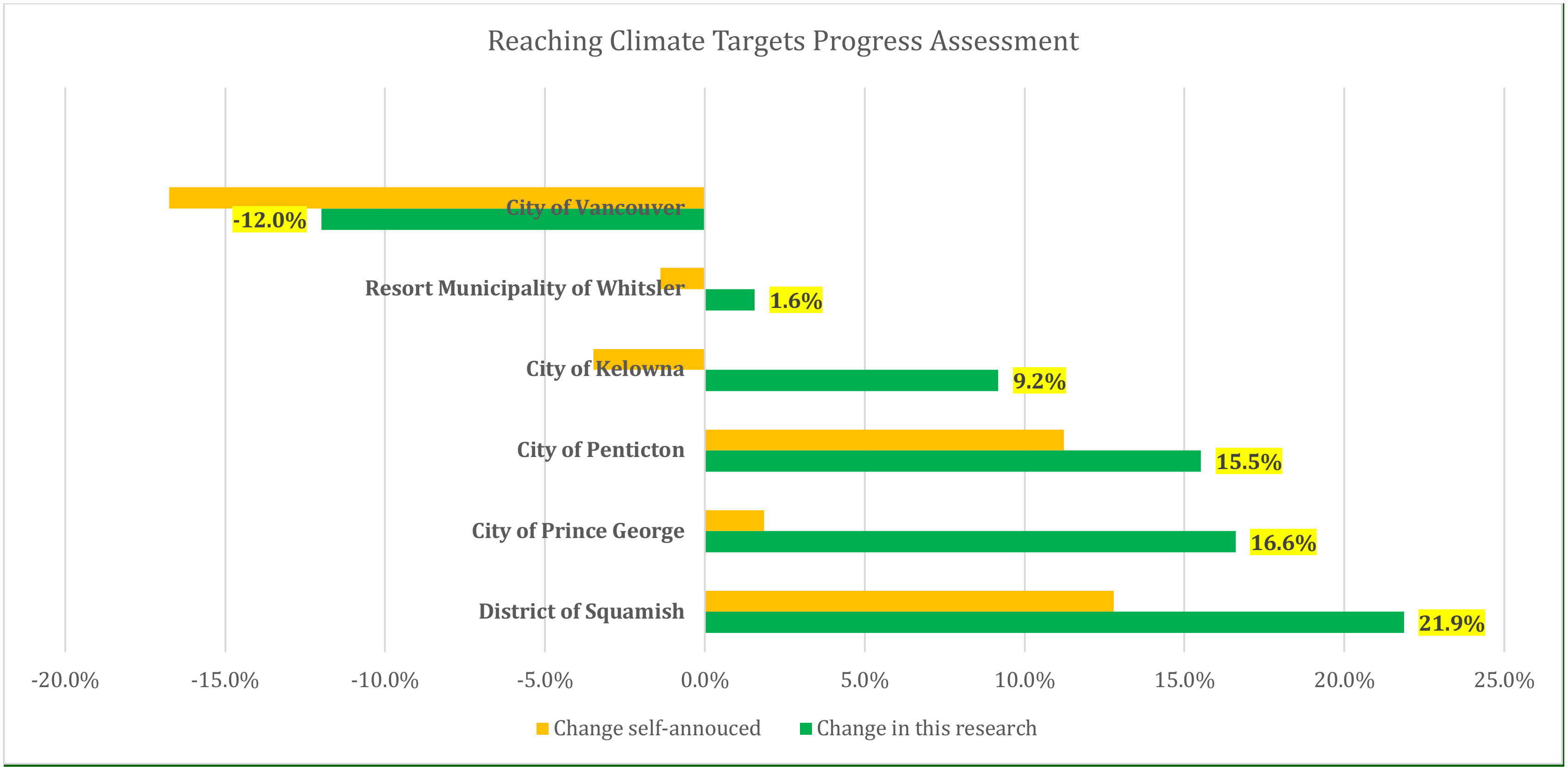


Figure 82: Overall progress assessment

Recommendations

Reaching climate action targets

This research helps to confirm the progress of reducing GHG emissions in the City of Vancouver and the City of Kamloops, as shown in the previous section. It challenges the progress made by the other eight cities. This research, however, made clear that all ten cities need to speed up their actions and have interventions so that their bold climate targets can be met. They all need to work much, much harder on all these emissions sources, in specific:

- All of the efforts in utilities seem not to be sufficient to decarbonize the building sector. More resources need to be placed in a more efficient way in order to have a long-lasting impact on GHG emissions reduction in this sector.

- Transportation is a hard-to-abate sector. Different fuel types should be explored and deployed to drive down the GHG emissions in the transportation sector.

- Waste, though contributing a relatively small portion to the total emissions, still needs to be paid attention to, especially for communities that tip their waste in other jurisdictions.

- All in all, the City of Vancouver is a successful example for other communities to follow in reducing emission progress. The result of emissions reduction from the City of Vancouver is remarkable in all three concerned sectors. Nevertheless, the City still needs to speed up its actions to be able to achieve its bold climate action targets.

The focus for each community will be summarized in the following table:

Table 6: Recommendations for local communities

COMMUNITIES	RECOMMENDATION		
	Utilities	Waste	Transportation
City of Kamloops	Continue and speed up the trend in residential buildings. More effort to reverse the trend in CSMI buildings.	Continue and speed up the trend of reducing waste emissions.	More effort to reduce the GHG emissions from transportation fuels.
City of Kelowna	Continue and speed up the direction of reducing emissions for both CSMI and residential buildings.	More effort to reduce the amount of waste and its associated emissions.	More effort to reduce the GHG emissions from transportation fuels.

City of Nelson	Continue and speed up the trend in CSMI buildings. More effective programs for residential buildings.	More effort to reduce the amount of waste and its associated emissions.	More effort to reduce the GHG emissions from transportation fuels.
City of Penticton	More effort to reduce GHG emissions in both CSMI and residential buildings.	Continue and speed up the trend of reducing waste emissions.	More effort to reduce the GHG emissions from transportation fuels.
City of Prince George	Efforts needed for residential buildings. Much more effort to reverse the trend of CSMI buildings.	Continue and speed up the trend of reducing waste emissions.	More effort to reduce the GHG emissions from transportation fuels.
City of Rossland	More effective programs for both type of buildings.	Much more effort to reverse the trend in waste GHG emissions.	More effort to reduce the GHG emissions from transportation fuels.
District of Squamish	Continue and speed up the trend of decreasing emissions in both types of buildings	More effort to reduce the amount of waste and its associated emissions.	More effort to reduce the GHG emissions from transportation fuels.
City of Vancouver	Continue and speed up the trend of decreasing emissions in both types of buildings	Continue the trend of reducing waste emissions.	Continue and speed up the trend of decreasing GHG emissions in the transportation sector.
City of Victoria	Continue and speed up the trend of decreasing emissions in residential buildings. More efforts to reverse the trend of GHG emissions in CSMI buildings.	Continue the trend of reducing waste emissions.	More effort to reduce the GHG emissions from transportation fuels.

Resort Municipal of Whistler	Continue and speed up the trend of decreasing emissions in both types of buildings.	More effort to reduce the amount of waste and its associated emissions.	More effort to reduce the GHG emissions from transportation fuels.

GHG emissions data monitoring

<u>Recommendation for provincial government:</u>

Keeping Data collection: The ongoing effort to keep data collected and published is of the most importance. It is understandably a long, complicated, and costly process involving a wide range of agencies, but keeping the momentum going will immensely support the evaluation of the climate action commitments of the local and provincial governments. However, there are three aspects that the provincial government can do to improve the dataset's quality.

- **Broadening monitored sectors focusing on transportation data:** Currently, except for the dataset from 2007, 2010, and 2012 that have the transportation emission data, the data set from 2011 to 2019 only covers utilities and waste data. The lack of up-to-date transportation data challenges comprehending the complete picture of total emissions for each local jurisdiction and the province. Later, the effort can be made to track emissions for other economic sectors such as agriculture.

- **Set up a feedback system:** Anyone who found any data problem can send the notice for the next releasing time to improve data qualification. For example, by doing this research, the author found some mistakes regarding emission data, i.e., emission data is inaccurate concerning the number of electricity consumption.

- **Shorten the time to release data:** The current lagging time is two years for collecting and controlling the data quality before publishing it. However, for this year, it is until July 2022 that the data 2019 is published. This delayed time poses a difficulty for assessing climate action progress and hinders timely intervention action.

Support local governments

- **Liaise with local governments:** The provincial government can liaise with local governments to better understand the data provided by utilities and then improve the data quality.

- **Provide more resources for local government:** Using the City of Vancouver as the model and provide resources for other communities to learn from the City of Vancouver.

Recommendation for third parties

The interested third parties, including think tanks, academia, non-for-profit organization, and the like, is to embrace the opportunity this dataset can bring. In the effort to combat climate change, it is essential to monitor the action to be able to provide appropriate intervention if needed. Equally important is the ability to predict GHG emissions to inform policymakers on the potential strategy.

Recommendation for future research

In future research, it is necessary to follow up with a more standard methodology and up-to-date transportation data. The provincial government does not provide transportation data in the CEEI data set after 2012. Therefore, it is hard to quantify the actual GHG emissions from this sector. At the beginning of this research, the author planned to use the raw data from the Insurance Corporation of British Columbia, but the change of insurance policy created multiple registration records, which made it challenging. Standard vehicle kilometer traveled data is also needed to quantify GHG emissions. The author recommends that there should be separated research on transportation emissions concerning the broad and complexity of the topic.

Google EIE data is also a good resource for identifying the progress of increasing active transportation modes such as cycling and walking compared to automobiles. This data source can, in part, help to determine the effectiveness of active transportation plans. To the author's knowledge, few organizations in Canada are cooperating with the Google EIE team. Future research can consider reaching out to those organizations to see if the Google EIE team could expand the jurisdictions in their dataset and further explore the data they provide.

Concerning regional districts like Vancouver and Squamish, the next research could also try to identify the relationship between the decline in residential emissions and densification in the building sector. In other words, an increasing proportion of apartment and condo units compared to single-family homes affect GHG emissions from residential buildings.

Last but not least, among over 200 communities in BC, this research only focuses on the ten selected communities. Future research can expand the scope of this research to include more communities. Ideally, there should be an online progress evaluation tool to support the local and provincial governments in monitoring their GHG emissions reduction in real-time.

Conclusion

This research has analyzed the progress of ten local communities and quantified their GHG emission reduction targets from 2007 to 2019.

The research has helped generate trends within and between communities on energy and emissions through detailed analysis. It also helped to identify factors and actions that contribute to these trends and hence to the success or failure of communities in meeting emissions reduction targets.

Based on the data analyzed, the research provides recommendations for local communities on critical areas to focus on so that it helps to strengthen the ability of communities to meet GHG reduction targets. It strives to inform local governments and supporting organizations to model energy & emissions effectively. And lastly, the research will help to inform ongoing tracking and reporting processes that will feed into future data collection, including identifying supporting progress indicators

Appendices

Appendix A: Federal Government Strategy

2030 Emissions Reduction Strategy

Summary of the 2030 Emissions Reduction Plan[37]

AREAS OF PRIORITY	KEY ELEMENTS
Switching to electric vehicles	Investing in new charging stations
	Providing financial support for buyers
	Supporting clean medium- and heavy-duty transportation projects
	Sale mandate: 100% new passenger vehicles sold in Canada will be zero emission by 2035
Greening homes and buildings	Will develop national net-zero by 2050 building plan
	Canada Green Buildings Strategy
	Highest tier building codes
	Community-scale retrofits
	Deep energy retrofits for large buildings
Clean technology and net-zero in industries	Greater incentives for clean technologies and fuels
	(Carbon capture, utilization, and storage).
Cleaning Canada's grid	Will develop a regulated Clean Electricity Standard
	Canada's electricity grid to net-zero by 2035
	Access to reliable, affordable power
Reducing oil and gas emissions	Net-zero by 2050
	Reduce oil and gas methane emissions by at least 75% by 2030
Supporting farmers in building a clean, prosperous future	Provide fund to develop and adopt sustainable practices, energy-efficient technologies, and other solutions (such as capturing carbon from the air)
Empowering communities to take climate actions	Expanding the Low Carbon Economy Fund to support communities across the country
Embracing the power of nature to fight climate change	Fund to help Canada's ocean, wetlands, peatlands, grasslands, and agricultural lands capture and store carbon.
	Explore the potential for negative emission technologies from the forest sector.

[37] https://publications.gc.ca/collections/collection_2022/eccc/En4-460-2022-eng.pdf

A Healthy Environment and A Healthy Economy's Five Pillars

Cutting energy waste
- Energy efficient homes and buildings are more comfortable and cost less to power
- Cut polution and create good jobs in construction, technology, manufacturing, and sales.

Transportation and power
- Supply of clean electricity (renewables and next generation clean energy)
- Cleaner modes of transportation (zero-emisison vehicles and transit)

Pollution isn't free
- Carbon pollution pricing will be rising through to 2030
- Households receive more money back where federal backstop applies

Clean industrial advantage
- Producing low-carbon products, services, and technologies.
- Performane standards, investments and incentives

Healthier families and resilient communities
- Planting 2 billion trees, and better managing, conserving and restoring natural spaces.
- Protect lands and oceans
- Banning single-use plastics.

Pan-Canadian Framework on Clean Growth and Climate Change (PCF)

Pricing carbon pollution
- Cut polution and create good jobs in construction, technology, manufacturing, and sales.

Complementary climate actions
- Addressing market barriers
- Tightening energy efficiency standards and codes

Adapt and build resilience
- Infrastructures are prepared for climate risks
- Supporting particularly vulnerable regions

Clean technology, innovation, and jobs
- More investments to improve the efficiency and equip Canada's with the knowledge and skills

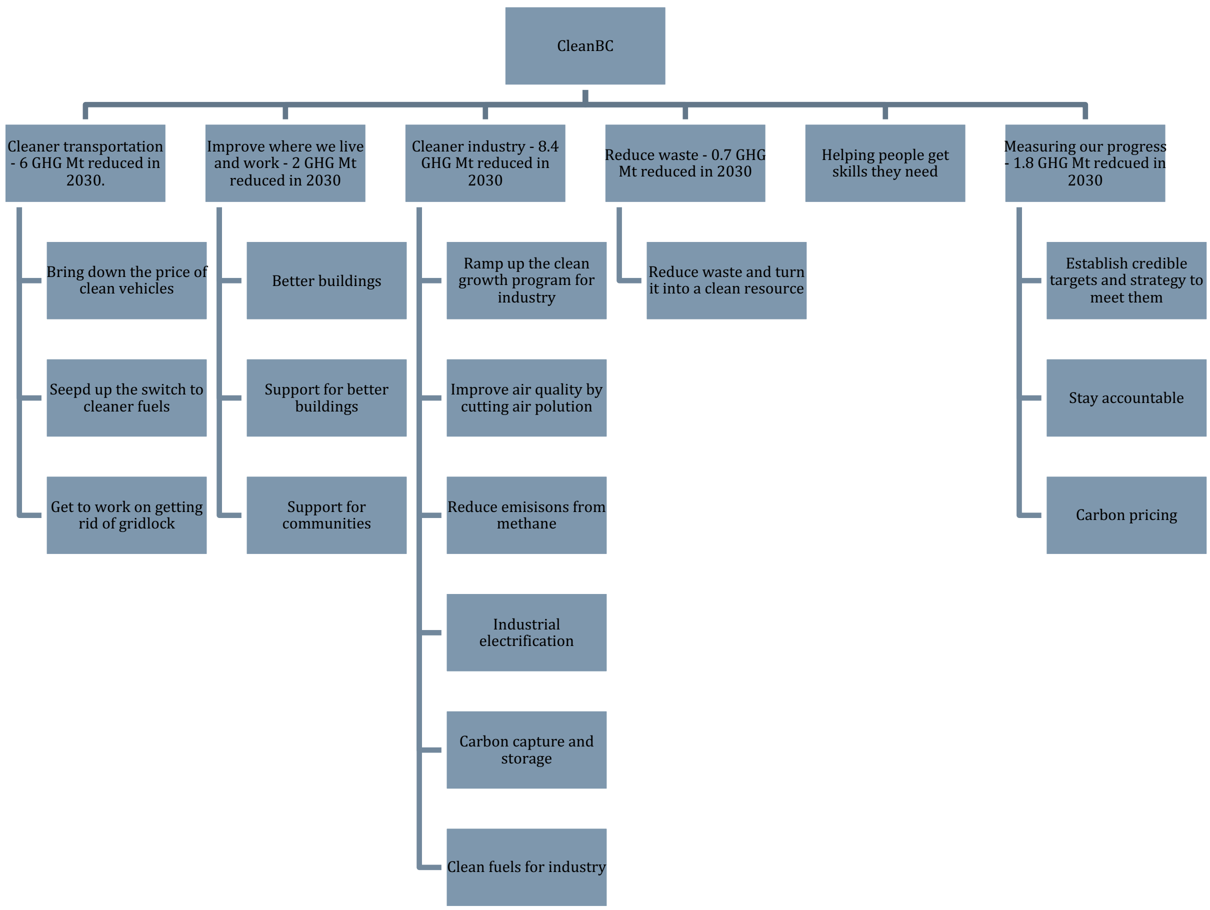
Canadian Net-Zero Emissions Accountability Act (Net-Zero by 2050)

Achieving net-zero emissions means our economy either emits no greenhouse gas emissions or offsets its emissions, for example, through actions such as tree planting or employing technologies that can capture carbon before it is released into the air. This is essential to keeping the world safe and livable for our kids and grandkids.

Canada has joined over 120 countries in committing to be net-zero emissions by 2050, including all other G7 nations (United Kingdom, United States, Germany, Italy, France, and Japan). A number of provinces and cities have already made net-zero-by-2050 commitments, including Guelph, Vancouver, Hamilton, Toronto, Halifax, Newfoundland and Labrador, and most recently Quebec. Prince Edward Island has also pledged to reach net-zero greenhouse gas emissions by 2040. Nova Scotia and British Columbia have put into place, or plan to put into place, provincial net-zero-by-2050 legislation.

Appendix B: BC provincial government emissions targets and supports

CleanBC Plan- CleanBC initiatives by sector



Climate Action Revenue Incentive Program (CARIP)

CARIP was a conditional grant program that typically provides funding to local governments that have signed the B.C. Climate Action Charter equal to 100 percent of the carbon taxes they pay directly to support local government operations. The program encouraged investment in climate action.

Local governments need to sign the B.C. CAC, committed to take action and develop strategies to achieve the following three goals:

- Work toward becoming carbon neutral in their local government corporate operations
- Measure and report on their community GHG emissions profile (reporting requirements waived for 2020 reporting year)
- Create complete, compact, energy-efficient communities

The CARIP grant is equal to 100% of the carbon tax that eligible local governments have directly paid in a given year.

2018 CARIP report

local governments reporting: 186

local governments measuring: 147

Carbon neutral local government: 50

Level 1 – Demonstrating Progress on Charter Commitments: For local governments who demonstrate progress on fulfilling one or more of their Charter commitments.

Level 2 – Measuring GHG Emissions: For local governments that achieve Level 1, and who have measured their Corporate GHG Emissions for the reporting year and demonstrate that they are familiar with their community's energy and emissions inventory (i.e. CEEI)

Level 3 – Accelerating Progress on Charter Commitments: For those local governments who have achieved Level 1 and 2 and have demonstrated undertaking significant action (corporately or community wide) to reduce GHG emissions in the reporting year (e.g. through undertaking a GHG reduction project, purchasing offsets, establishing a reserve fund).

Level 4- Achievement of Carbon Neutrality: For local governments who achieve carbon neutrality in the reporting year.

Local Government Climate Action Program (LGCAP)

LGCAP provides local governments and Modern Treaty Nations with predictable and stable funding to support the implementation of local climate action that reduces emissions and prepares communities for the impacts of a changing climate.

To be eligible for the first year of funding, applicants are required to:

- Be signatories to the B.C. Climate Action Charter or be a B.C. Modern Treaty Nation
- Measure and report corporate greenhouse gas emissions in the first year or prepare for mandatory emissions measurement and reporting for year two
- Demonstrate climate investment (i.e., matching funding or in-kind contributions) equivalent to 20% of the provincial funding received
- Report on projects linked to one or more objectives from the CleanBC Roadmap to 2030 and/or the Climate Preparedness and Adaptation Strategy
- Have their Chief Financial Officer, or equivalent position, submit and publicly post:
- a completed and signed attestation form to confirm all funds were, or will be, used towards climate action
- a completed PDF version of the required program survey

https://www2.gov.bc.ca/assets/gov/environment/climate-change/lg/lgcap/lgcap_faqs.pdf

Appendix C: Emission Factors: Fleet fuel – Standard Mixes

B.C. Best Practices Methodology for Quantifying GHG

Emission factors: Fleet fuel - Standard Mixes

Vehicles	Fuel type	CO2e (kg/L)
Light-duty vehicle	Gasoline (E5)	2.346
	Diesel (B4)	2.649
Light-duty truck (including SUV and Minivan)	Gasoline (E5)	2.379
	Diesel (B4)	2.65
Heavy-duty	Gasoline (E5)	2.262
	Diesel (B4)	2.63
Motorcycle	Gasoline (E5)	2.232

Appendix D: Vehicle Kilometer Traveled

ICBC data and CEEI data

CEEI technical report[38] presented a methodology to quantify emission, in summary:

+ GHG emission (CO2e) = fuel consumption * emission coefficient * global warming potential.

+ Fuel consumption = vehicle * proportion of year insured * fuel consumption rate * quarterly vehicle kilometers traveled.

In which, the fuel consumed is calculated using 9 steps:

1. Filter the vehicle registration data (from ICBC)
2. Identify vehicle characteristics using vehicle identification number and other data fields.
3. Group vehicles into sub-sectors.
4. Match the characteristics to the NRCan fuel consumption rate (default rate will be applied if undefined vehicles)
5. Calculate reference-case average VKT by sub-sector and insurance type from AirCare odometer data
6. Assign VKT to individual vehicles
7. Calculate fuel consumption for each individual vehicle by using the formula above.
8. Place vehicles into organizational units by postal code in the Lower Mainland.
9. Summarize total fuel consumed by sub-sector.

Insurance Company British Columbia (ICBC) has published data of registration vehicle from 2016 until 2020. However, this data does not have vehicle identification number therefore it is hard to identify the exact number of vehicles in the case the owner decides to change the vehicle insurance for a short time period. In CEEI methodology report, it also acknowledged that: “Changes to a vehicle’s insurance policy will create another occurrence of the vehicle in the dataset.” CEEI team then had an agreement with ICBC to collect vehicle identification numbers to be able to proceed further.

[38] https://www2.gov.bc.ca/assets/gov/environment/climate-change/data/ceei/technical_methods_and_guidance_document_for_the_ceei_reports.pdf

Within the framework of this research, however, due to the lack of data for step 2 (vehicle identification number) and step 5 (AirCare odometer data and reference survey for average VKT), the author can't proceed further with the public data from ICBC. It is worth to mention that the step 3 is also of concern because the size of ICBC dataset is very large due to it has vehicle record based on vehicle body style, make, model, which are very good in defining the subsector but the software to aggregate the data need to be also powerful and agile.