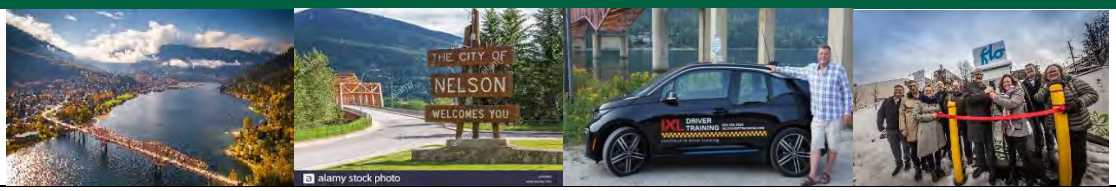
Appendix C: Nelson's Community Greenhouse Gas Inventory



City of Nelson

Community Energy and Emissions Inventory Report

June 2020

City of NELSON BRITISH COLUMBIA

Community Energy Association

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Summary

The City of Nelson has reduced per-capita emissions by 6.4% in 2018 compared to 2007, however total emissions have risen by 10.8% in the same time frame. Total emissions are on a trajectory to be 11.8% higher in 2030 vs. 2007 levels. Further actions will be required to align with provincial targets and international greenhouse gas (GHG) emission targets.

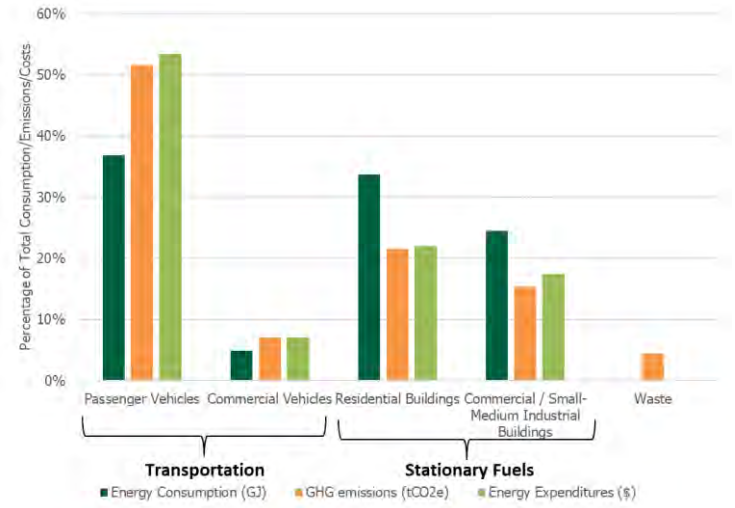
This report describes Nelson's community inventory data from 2007 to 2018, and Business As Usual (BAU) projections through to 2050. The goal being to help the City understand its current energy and emissions situation, in light of their recent commitment to 100% Renewable Energy by 2050, their current development of a comprehensive Climate Change Action Plan, and their recent interest to align their community GHG reduction targets with global standards, i.e. the Intergovernmental Panel on Climate Change's (IPCC's) recent 1.5°C report[1].

Inventory data was collected for 2007-2018, with BAU projections to 2050. The last full inventory year for which required data is available was 2018, and the results are split by sector in Figure E.1.

In 2018:

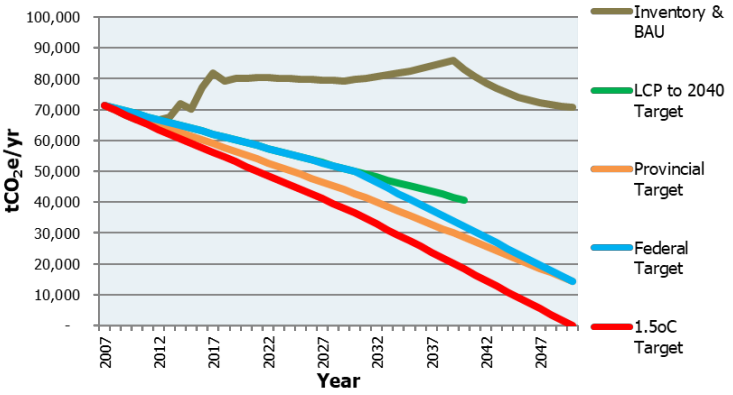
- Total energy consumption is estimated at 1,705,262 GJ
- Total GHG emissions are estimated at 79,102 tonnes of CO_2e
- Total energy expenditures are estimated at $41,829,783

FIGURE E.1 CONSUMPTION, EMISSIONS, COSTS BY SECTOR



Inventory GHG data and BAU projections are shown in Figure E.2, and compared to the City of Nelson's current *Low Carbon Path to 2040* targets (43% below 2007 levels by 2040) approved in 2011. The IPCC's 1.5°C target (45% reduction from 2010 levels by 2030, 100% reduction by 2050), commonly described as the upper-limit for global warming, is also shown, as well as the provincial and federal targets – for the sake of comparison. Note that reductions in the BAU projection incorporate planned and approved federal and provincial actions, particularly the provincial Zero-Emission Vehicles Act which mandates 100% of new light duty vehicle sales to be zero-emissions by 2040.

FIGURE E.2 EMISSIONS AND TARGETS

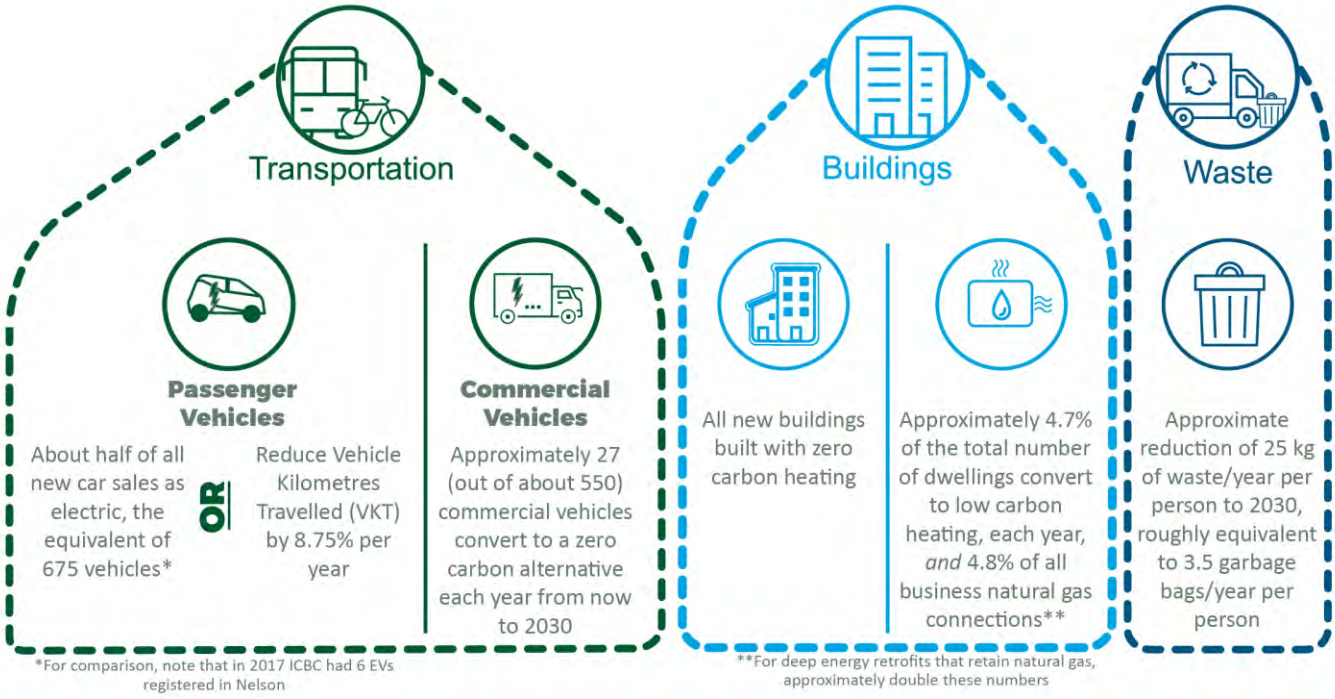


From 2007 to 2018, Nelson's total emissions rose by 10.8%. This clearly indicates that much work remains if the City wishes to meet their original GHG targets, let alone align with Provincial, Federal/ IPCC targets.

[1] IPCC's Special Report: Global Warming of 1.5°C, 2019 (https://www.ipcc.ch/sr15/)

Below are examples of the physical changes required annually to meet federal/IPCC targets in Nelson, in an attempt to illustrate the level of investment and effort that will be required. For every year, from now to 2030, Nelson would have to complete the following (as an example):

FIGURE E. 3 ANNUAL CHANGES TO MEET IPCC 2030 TARGETS IN NELSON



The next stage is to use the updated GHG Inventory to develop new targets in line with provincial, federal and international standards, and specific actions to meet them.

Introduction

This report describes greenhouse gas (GHG) community inventory data from 2007 to 2018 for the City of Nelson, and Business As Usual (BAU)[2] projections through to 2050. The goal being to help the City understand its current energy and emissions situation, in light of recent commitment to 100% Renewable Energy by 2050, their current development of a comprehensive Climate Change Action Plan, and their recent interest to align their community GHG reduction targets with provincial, federal and global standards, i.e. the United Nations Intergovernmental Panel on Climate Change's (IPCC's) recent 1.5°C report, also known as the Paris Agreement[3]. The inventory described in this report is informed by Community Energy & Emissions Inventory (CEEI) data reported by The Province of BC, alongside several supplementary data sources (described below). The CEEI itself was compiled according to the 2005 IPCC Guidelines for National GHG Inventories. Using supplementary data sources alongside the CEEI data provided by the Province, allows for a much more accurate snapshot of community emissions.

The emissions inventory is based on, and will be presented through the following sectors and subsectors, as categorized through the CEEI:

- Transportation
    - Passenger Vehicles
    - Commercial Vehicles
- Stationary Fuels
    - Residential Buildings
    - Commercial/Small-Medium Industrial Buildings
- Waste

The specific methodology and assumptions are described in Appendix 1 – Methodology & Assumptions. Raw inventory data is in Appendix 2 – Energy & Emissions Inventories, Raw Data. Results from Nelson's Heating Survey are detailed in Appendix 3 – Citizen Survey on Climate Change Results.

Current Energy Consumption & Emissions

The last complete inventory year dataset available from the Province of BC is from 2018, and was used alongside provincial utility and waste data and local transportation data (from retail gas stations) to describe Nelson's current energy consumption and emissions. See Appendix 1 – Methodology & Assumptions for a full description.

In 2018, for the whole community of Nelson:

- Total energy consumption is estimated at 1,705,262 GJ
- Total GHG emissions are estimated at 79,102 tonnes of CO_2e

[2] See 'Business as Usual (BAU)' definition on page 9

[3] In the 2015 Paris climate agreement, the countries participating in the United Nations Framework Convention on Climate Change (UNFCCC) agreed to hold the rise in global average temperature "well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius." Since then, 1.5°C has become a global, long term emissions goal and the basis Canada and British Columbia's GHG targets.

- Total energy expenditures are estimated at $41,829,783

GHG emissions (in tonnes of CO_2e) split by source are shown in , with associated energy consumption by fuel in Figure 2, and energy costs by fuel in Figure 3. The vast majority of emissions in Nelson are due to the use of mobility fuels (gasoline & diesel), and natural gas. Wood and waste contributes a small proportion, while electricity, propane, and heating oil are almost negligible.

Mobility fuels and electricity are the two largest costs, but natural gas is also significant. Note that although electricity has very low GHG emissions, the reduction of energy consumption should still be tackled in order to manage community energy expenditures, as it is quite an expensive fuel compared to natural gas (about 3 times as more expensive). On the other hand, since Nelson has its own electrical utility, some of the costs are recycled back into the community.

FIGURE 1– GHG EMISSIONS BY FUEL TYPE AND WASTE IN 2018

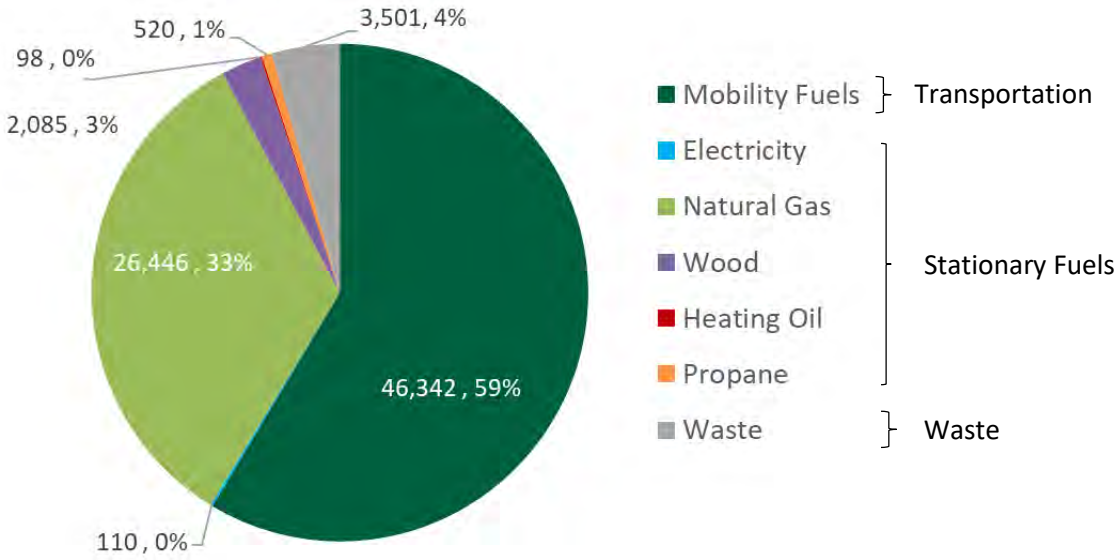


FIGURE 2 ENERGY CONSUMPTION BY FUEL TYPE IN 2018

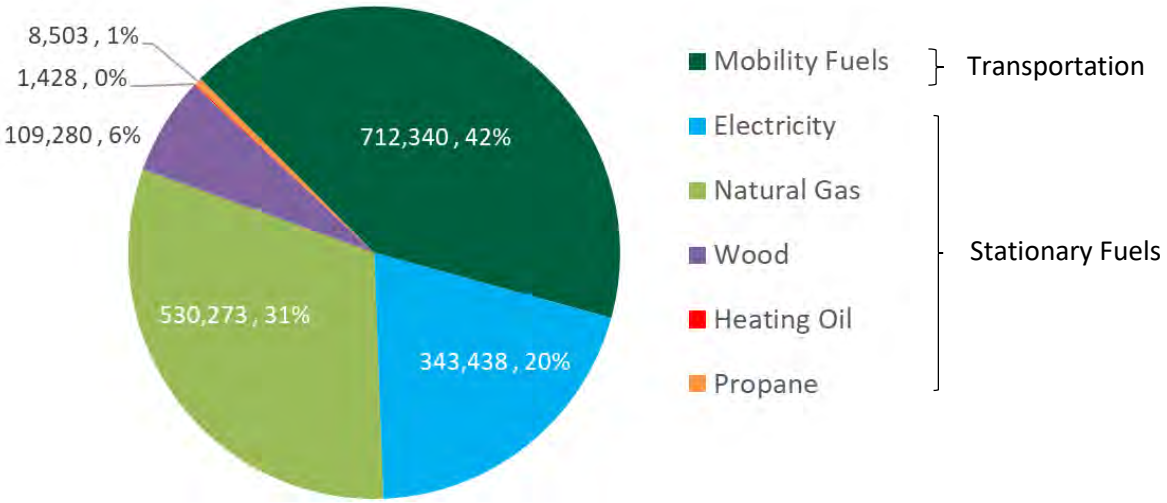


FIGURE 3 ENERGY EXPENDITURES BY FUEL TYPE IN 2018

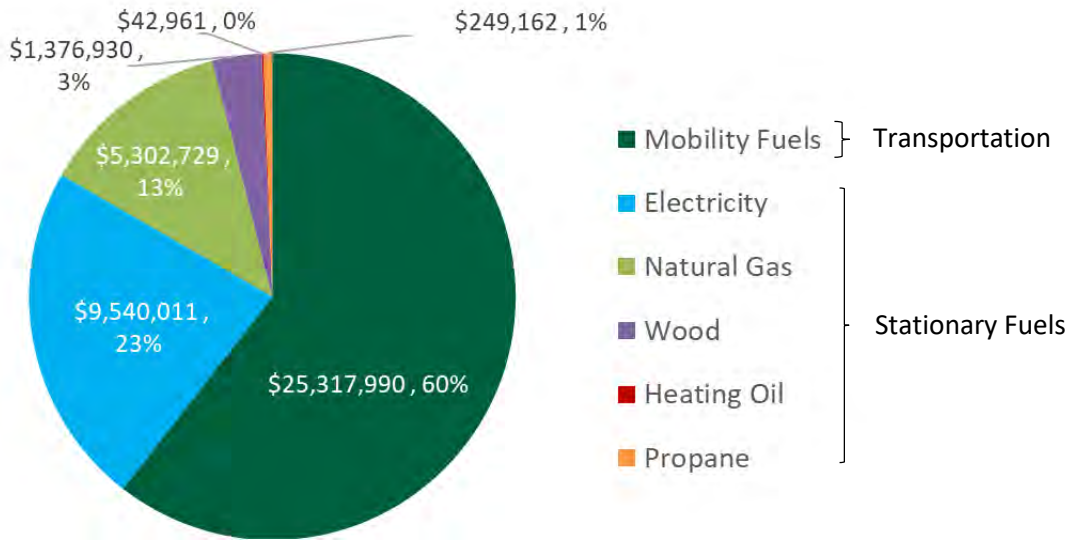


Figure 4 and Figure 5 show the proportion of energy consumption, emissions, and estimated energy expenditures all together. Figure 4 shows the split between fuels and waste; Figure 5 by sector. Note that the mobility fuels category includes passenger and commercial vehicles.

FIGURE 4 – PROPORTION OF ENERGY, EMISSIONS, AND COST BY SECTOR IN 2018, %

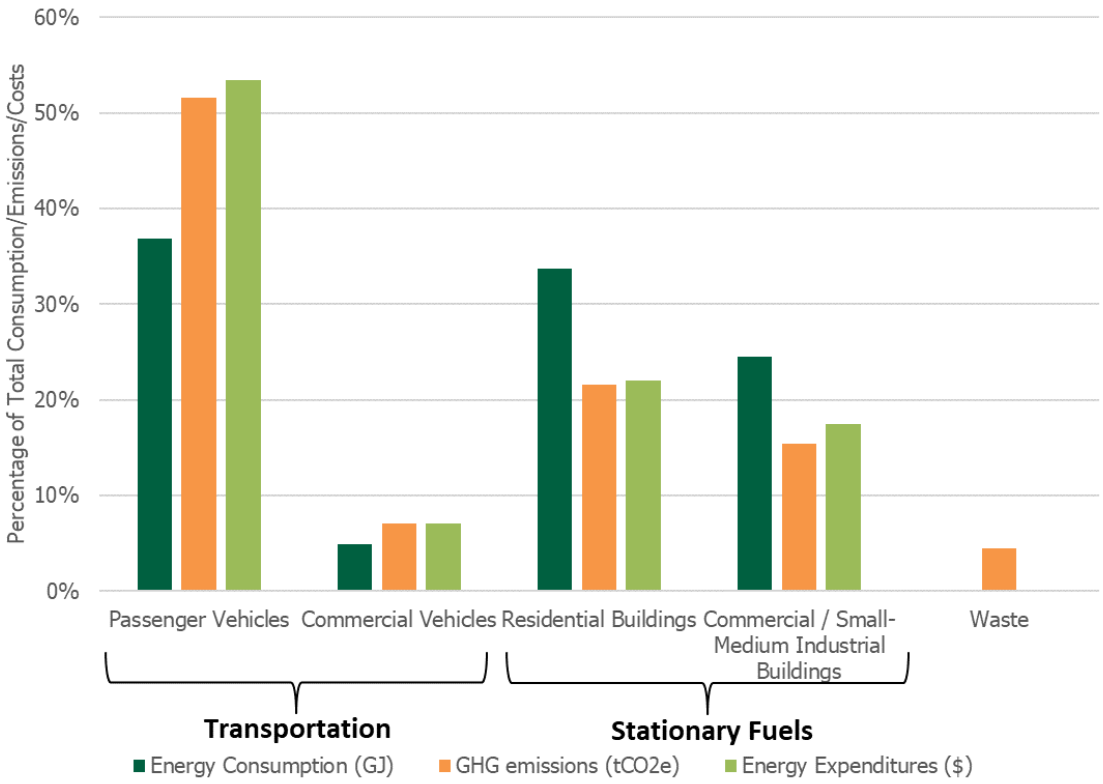
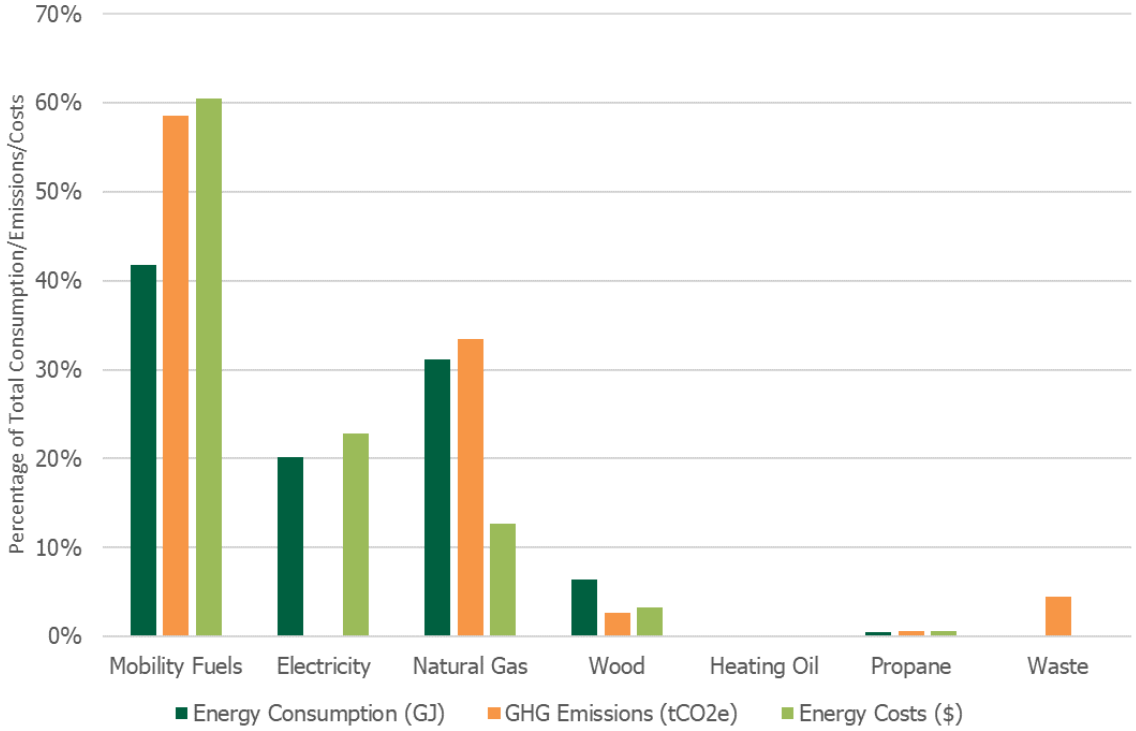


FIGURE 5 – PROPORTION OF ENERGY, EMISSIONS, AND COST BY FUEL TYPE AND WASTE IN 2018, %



Mobility fuels contribute the largest proportion of community cost and emissions at 61% and 59%, respectively, while natural gas also contributes a large proportion of emissions and energy consumption at 33% and 31%, respectively. Rapidly curbing these two fuel sources should be a priority for the City moving forward.

Dissecting mobility by user, passenger vehicles contribute the largest proportion of all three categories, representing 53% of total cost, 52% of total emissions, and 37% of total energy consumption. Note that energy consumption from diesel vehicles is likely understated, as described in Appendix 1 – Methodology & Assumptions.

Residential buildings contribute a fair proportion of energy consumption at 34%, while also contributing 22% of emissions and cost.

Landfill methane emissions from waste contribute only a small portion, at 4%.

Change in 2007 Baseline Year

One of the outcomes of the work undertaken to develop Nelson's 2018 inventory, is that emissions for the 2007 baseline year have been calculated differently, compared to the original 2007 inventory from the *Low Carbon Path to 2040 (LCP)* document, and the Province's Community Energy & Emissions Inventory (CEEI) refresh in 2016. Details on this are shown in Table 1.

TABLE 1 – DIFFERENCES IN 2007 BASELINE YEAR BETWEEN 2011 LCP, 2016 CEEI REFRESH, AND THIS ANALYSIS

Category	2011 LCP, 2007 baseline yr		Refined CEEI, 2007 baseline yr		CEA's analysis, 2007 baseline yr	
	Total	%	Total	%	Total	%
Residential buildings	15,200	23%	15,500	24%	15,500	22%
Commercial buildings	11,600	17%	11,400	18%	11,400	16%
Vehicles	39,100	59%	31,600	49%	39,000	55%
Solid waste	600	1%	5,300	8%	5,300	7%
Overall	**59,100**	**100%**	**63,800**	**100%**	**71,200**	**100%**

The reasons for the variations are as follows:

- Buildings data – is still obtained from the Province of BC's Climate Action Secretariat as before, and broadly speaking, the Province uses the same methodologies as the CEEI. However, utility data can vary after it is released – which has been the case for Nelson - and GHG emission factors have also changed slightly. Despite this, emissions for buildings are very similar between the three inventories.
- Vehicles – are a significant area of difference. The 2011 Low Carbon Path (LCP) used the Province of BC's original CEEI (2007), which used a methodology as follows:
    - ICBC vehicle registrations in the community
    - Efficiencies estimated for the vehicle types in l/km
    - Vehicle kilometres travelled (VKTs) estimated for these vehicle types based on odometer readings from the AirCare testing program in Metro Vancouver
    - Econometric modelling adjustments made for estimates outside of the Metro Vancouver area.

  The Province only created these estimates up to 2010, and CEA was not able to replicate their original methodology to update Nelson's inventories, as ICBC and other data sources used by the Province up to 2010 are no longer available. The CEEI refresh in 2016 showed a significant decrease in vehicle emissions for the 2007 baseline, relative to the original CEEI data. The *Technical Method and Guidance Document for the CEEI Reports* identified that the transportation methodology in CEEI reports has changed over time, with the current method using third-party regional VKT estimates. CEA's methodology, using Kent Group data, is outlined in Appendix 1 – Methodology & Assumptions. One of the key differences in the methodologies is that the Kent Group data does not include fuel sold from card lock stations, which will include larger commercial vehicles.

- Solid waste – is an area of significant difference. Nelson's waste was relocated from the Central Landfill to Ootischenia in 2015. Due to the "waste-in-place" method that the Province uses to calculate emissions, which is based on the historical tonnage of the landfill, it led to an artificial decrease in waste emissions. CEA's recommendations on waste are therefore based on reducing tonnage.

Trends and Forecast

Targets & Business As Usual Forecast

Inventory data from 2007 to 2018 is shown in this section, with Business As Usual (BAU) projections through to 2050.

Nelson's 2011 'Low Carbon Path (LCP) to 2040' Community Energy and Emissions Action Plan listed actions that needed to be completed to allow Nelson to achieve the following targets over a 2007 baseline year, by 2040:

- 57% reduction in per capita GHG emissions (from 7 to 3 tonnes per year)
- 43% reduction in community-wide GHG emissions
- 26% reduction in community-wide energy use

A summary of LCP targets compared to provincial, federal and IPCC targets, as well as their baseline years, are shown in Table 2. Note, only net reduction community emissions targets are shown as per capita and energy use targets are no longer standard GHG target formats.

What does 'Business As Usual' mean?

Business As Usual, or BAU, is a way of describing what is estimated to happen to Nelson's emissions if the City takes no further action to decrease emissions beyond what they are already doing and plan to do. A number of factors are taken into account to develop BAU emissions scenarios, population growth being one of the most important considerations. As the number of people increase in a community, more buildings are needed/used and more vehicles are driven on roads.

Other considerations that were taken into account to develop Nelson's BAU emissions scenario for this report include the following:

- Changing climate patterns— as warmer winters and hotter summers occur, they are and will continue to change the way that energy is consumed in buildings
- Likely future impacts of policies already adopted by other orders of government, such as:
  - Renewable and low carbon fuel standards
  - Vehicle tailpipe emissions standards
  - Zero-Emission Vehicle (ZEV) mandate as part of the CleanBC Plan, requiring 10% of new vehicle purchases by 2025 as ZEVs, 30% by 2030, and 100% by 2040
  - The greening of the BC Building Code ready buildings by 2032 (progressive steps towards net zero energy). The City of Nelson has already adopted Step 1 of the Step Code, which is a good first step.

TABLE 2 – LOCAL, PROVINCIAL, FEDERAL AND INTERNATIONAL TARGET REDUCTIONS

	LCP to 2040	Provincial	Federal	IPCC
Baseline year	2007	2007	2005	2010
Community GHG Emissions	30% by 2030 43% by 2040	40% by 2030 60% by 2040 80% by 2050	30% by 2030 80% by 2050	45% by 2030 100% by 2050 (Net zero)

Figure 6 and Table 3, show graphical and numerical representations of Nelson's BAU projections compared to the current net reduction Community GHG Emissions targets from the LCP (listed above), with emissions targets that would be congruent with meeting the Provincial target, the Federal target and the 1.5°C global standard.

FIGURE 6 – INVENTORY AND BAU PROJECTIONS, IN RELATION TO THE CURRENT LCP GHG EMISSION REDUCTION TARGETS VS PROVINCIAL, FEDERAL AND 1.5°C TARGETS

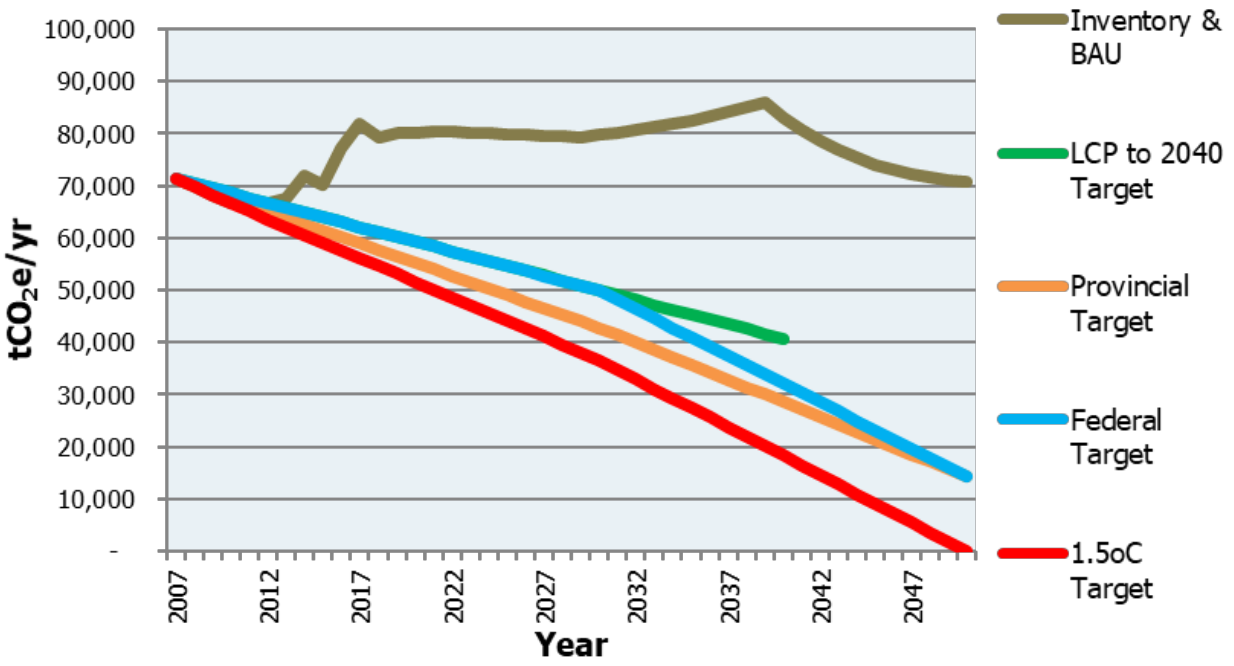


TABLE 3 – EMISSIONS AND TARGETS BY NUMBERS & PERCENTAGES

	2007	2010	2018	2030	2040	2050
Inventory & BAU estimate (tCO_2e)	71,409	66,567 (-6.8%)	79,102 (10.8%)	79,804 (11.8%)	83,088 (16.4%)	70,672 (-1.0%)
LCP net reduction trajectory (tCO_2e)	71,409	68,617 (-3.9%)	61,173 (-14.3%)	50,008 (-30.0%)	40,703 (-43.0%)	n/a
Province of BC target (tCO_2e)	--	--	--	42,845 (-40.0%)	28,563 (-60.0%)	14,282 (-80.0%)
Federal Target (tCO_2e)	--	--	--	49,986 (-30.0%)		14,282 (-80.0%)
1.5°C target (tCO_2e)	--	--	--	36,612 (-45.0%)	18,306 (-72.5%)	0 (-100.0%)

Note: LCP and Province targets are based on 2007 baseline, while the 1.5°C target is based on a 2010 baseline. Federal is based on 2005 baseline, however no inventory data is available for 2005, therefore a 2007 baseline is being shown *for illustration purposes only*.

Figure 6 and Table 3 show that the City was initially on track towards its targets until 2013, however increased emissions from passenger transportation starting in 2014 and a spike in natural gas and wood heating in 2017/2018 have resulted in a 10.8% increase in emissions overall.

Note that reductions in the BAU projection incorporate federal and provincial actions, particularly the provincial zero-emission vehicle mandate which comes into effect in 2040.

Overall, these results indicate that significant action is necessary to bring Nelson back on track towards its current targets, and any future targets they may develop to more closely align with provincial, federal and international standards. In particular, focusing on shifting away from natural gas heating, and shifting towards electric vehicles on a large-scale.

Emission changes for each fuel and solid waste are shown in Table 4, with only electricity and solid waste demonstrating reductions. Note that the solid waste "reductions" were due to waste being sent to the Ootischenia landfill starting in 2015 compared to the Central landfill in 2014 and before. This altered the "waste-in-place" calculation that the Province uses. The reductions were therefore artificial, and should not be used at face value as a metric for progress. From a tonnage perspective, waste tonnage actually increased by 28% from 2007-2018. Therefore, decreasing waste tonnage, particularly organic waste, should be considered moving forward.

TABLE 4 – EMISSION REDUCTIONS 2007-2018 BY FUEL & WASTE

Category	Absolute decrease*	Percentage decrease*	Reason
Mobility fuels	(7,249)	(19%)	Significant rise in passenger vehicle fuel consumption
Electricity	154	58%	Slight increase in consumption, but strong decrease in GHG intensity
Natural gas	(2,250)	(9%)	Significant rise in consumption in 2017
Wood	(142)	(7%)	Significant rise in consumption in 2017
Heating Oil	(7)	(7%)	Significant rise in consumption in 2017
Propane	(38)	(7%)	Significant rise in consumption in 2017
Solid waste	1,838	34%	Tonnage sent to landfill increased by 28%, but waste started to be sent to Ootischenia starting in 2015 vs. Central landfill in 2014 and before. This altered the "waste-in-place" calculation that the Province uses
Solid waste tonnage	(1,322 tonnes)	(27%)	
Overall	(12,074)	(17%)	Combination of the above

*Brackets indicate a negative (or increase vs. decrease)

Again, even with the 6.4% decrease in per capita emissions, the *actual* emissions indicate that considerable work must be done to curb natural gas and mobility fuel consumption in order to reduce associated emissions, particularly if the City wishes to align with a 1.5°C by 2030 target.

BAU by Fuels and Sectors

Figure 7 and Figure 8 are similar to Figure 6, but they show exactly where emission reductions have fluctuated historically, where they will change in a BAU scenario, and where reductions will need to be made to meet the 1.5°C targets. Note that in Figure 7, electricity and heating oil are nearly invisible. This is due to the minimal GHG emissions associated with each source.

FIGURE 7 – INVENTORY AND BAU PROJECTIONS SPLIT BY FUELS & WASTE, WITH LCP, PROVINCIAL, AND 1.5°C TARGETS

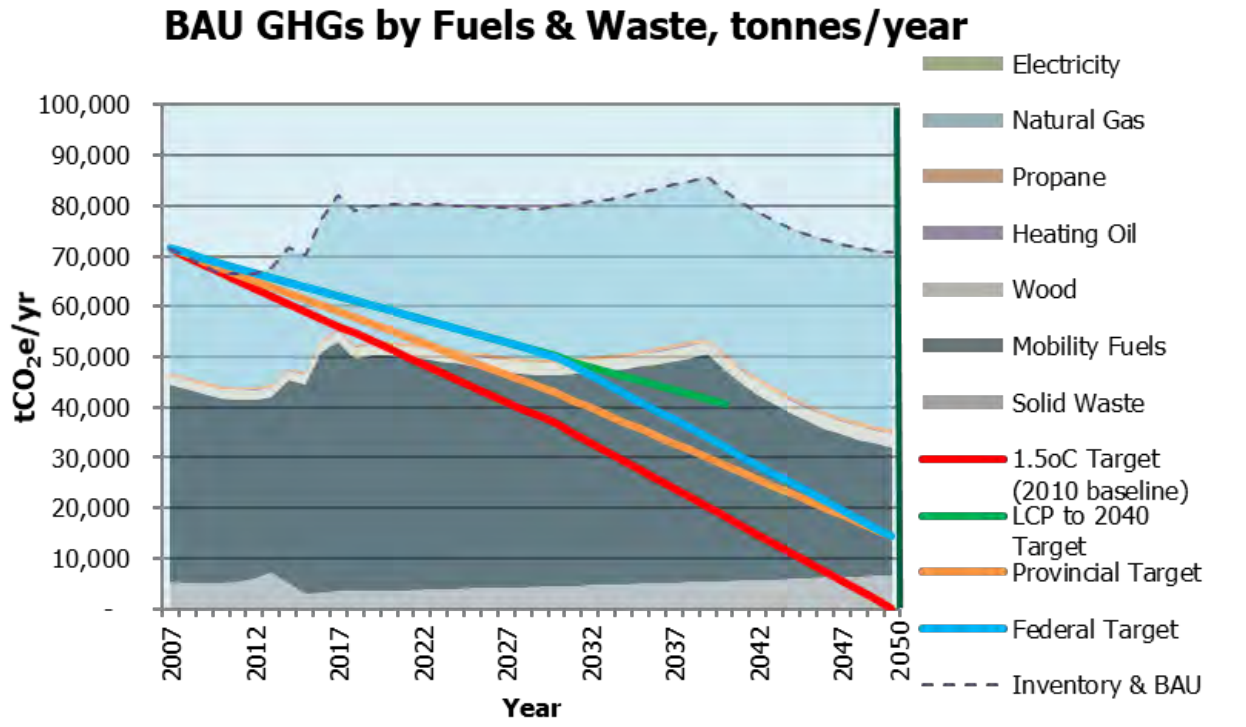
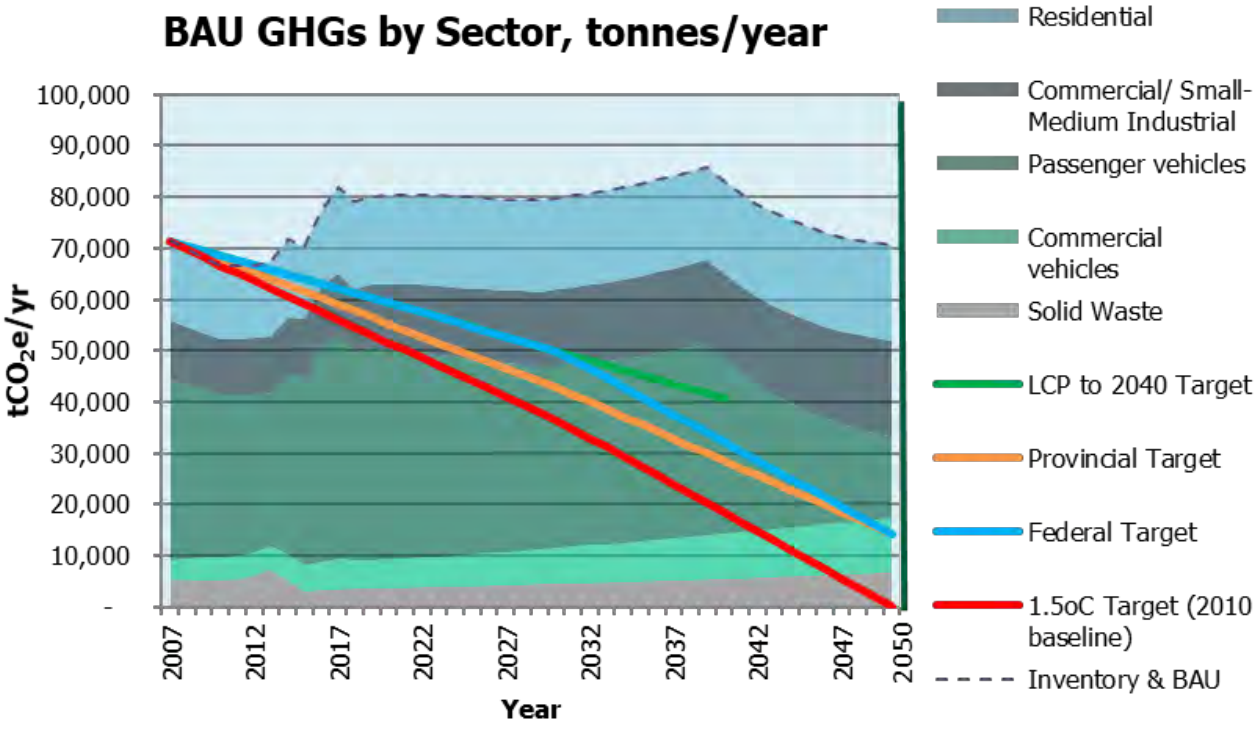


FIGURE 8 – INVENTORY AND BAU PROJECTIONS SPLIT BY SECTOR, WITH LCP, PROVINCIAL, FEDERAL, AND 1.5°C TARGETS



From 2007 to 2018, emissions have primarily fluctuated due to a) increased use of mobility fuels, especially gasoline - likely due to fluctuations in economic activity, and b) heating energy consumption increases in 2017, with natural gas producing the largest increase in emissions (see Appendix 2 – Energy & Emissions Inventories, Raw Data).

Projecting forwards, in a BAU scenario it is believed that emissions from passenger vehicles will decrease because of Federal tailpipe emission standards[4] (200 g CO_2e/km in 2015 to 119 g CO_2e/km, in 2025), BC Renewable & Low Carbon Fuel Standard requirements[5] (10% reduction in carbon intensity by 2020, 20% by 2030), and vehicle electrification. Natural gas emissions are also expected to increase slowly, especially in the residential sector, due primarily to population growth.

T to meet Nelson's current 2030 targets, natural gas will need to be tackled for the residential and commercial/small-medium industrial sectors, along with passenger and commercial vehicles. For 2050 targets, all emissions sources will need to be addressed, even solid waste.

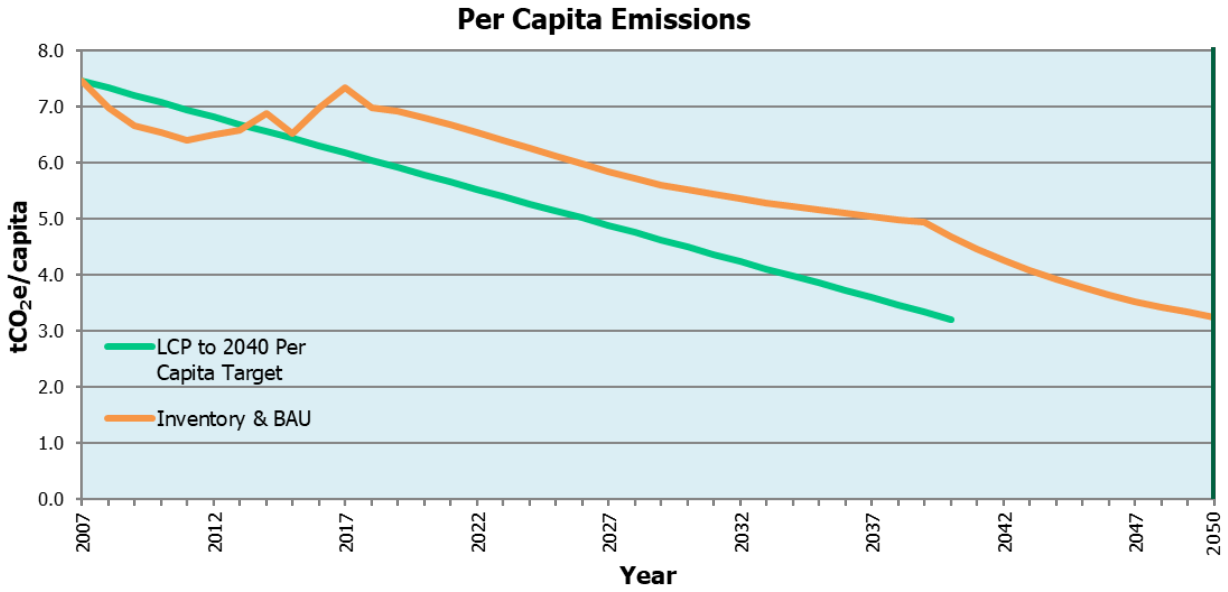
Per-Capita BAU Forecast

Given Nelson's population growth (2007: 9,559; 2018: 11,313; 2050 projection: 21,707) in comparison to similarly sized communities, and Nelson's per capita emissions target from the LCP, it is worth also reflecting on per capita emissions. A growing population makes it more challenging to reduce absolute GHG emissions, as each additional person requires energy for their daily needs. Per capita emissions and targets are shown in Figure 9.

[4] SOR/2010-201. Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations. Available from: http://laws-lois.justice.gc.ca

[5] BC Low Carbon Fuel Standard. Available from: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels

FIGURE 9 – PER CAPITA INVENTORY AND BAU PROJECTIONS, IN RELATION TO THE CURRENT LCP GHG EMISSION REDUCTION TARGET, AND 1.5°C TARGETS



Per capita emissions:

- Nelson's GHG per capita emissions decreased by 6.4% from 2007 to 2018
- The LCP 2040 per capita target would be a 57% decrease from 2007 levels
- The 1.5°C 2030 per capita target would be a 66% decrease from 2007 levels, or a 61% decrease from 2010 levels

From a per capita perspective, Nelson had been on pace to meet its LCP per capita target until approximately 2014, when passenger vehicle consumption increased by 0.5 tCO_2e/capita; and again in 2016 producing another 0.5 tCO_2e/capita increase; followed by an increase in natural gas heating in 2017, amounting to a 0.19 tCO_2e/capita increase. The latter increase is partially supported by an increase in heating degree days in the Nelson area by 17% in 2017.[6] However, even with this context, the LCP per capita target continues to be challenging to meet. With respect to re-evaluating targets moving forward, per-capita emissions may be useful in some contexts, but population growth can skew results such that per-capita emissions are decreasing, while total emissions actually increase, as observed with Nelson.

Total Energy Consumption BAU Forecast

With respect to total energy consumption, the LCP also contained a target of 26% reduction below 2007 levels by 2040. Figure 10 below, shows Nelson's performance with respect to energy consumption from

[6] Historical Climate Data, Government of Canada. (2020). https://climat.meteo.gc.ca/historical_data/search_historic_data_e.html

2007 to 2018, as well as projections to 2050. Table 5 shows energy consumption for specific years of interest, and the percentage reduction (or increase) relative to 2007.

FIGURE 10 – ENERGY CONSUMPTION INVENTORY & BAU, IN RELATION TO THE CURRENT LCP ENERGY REDUCTION TARGET

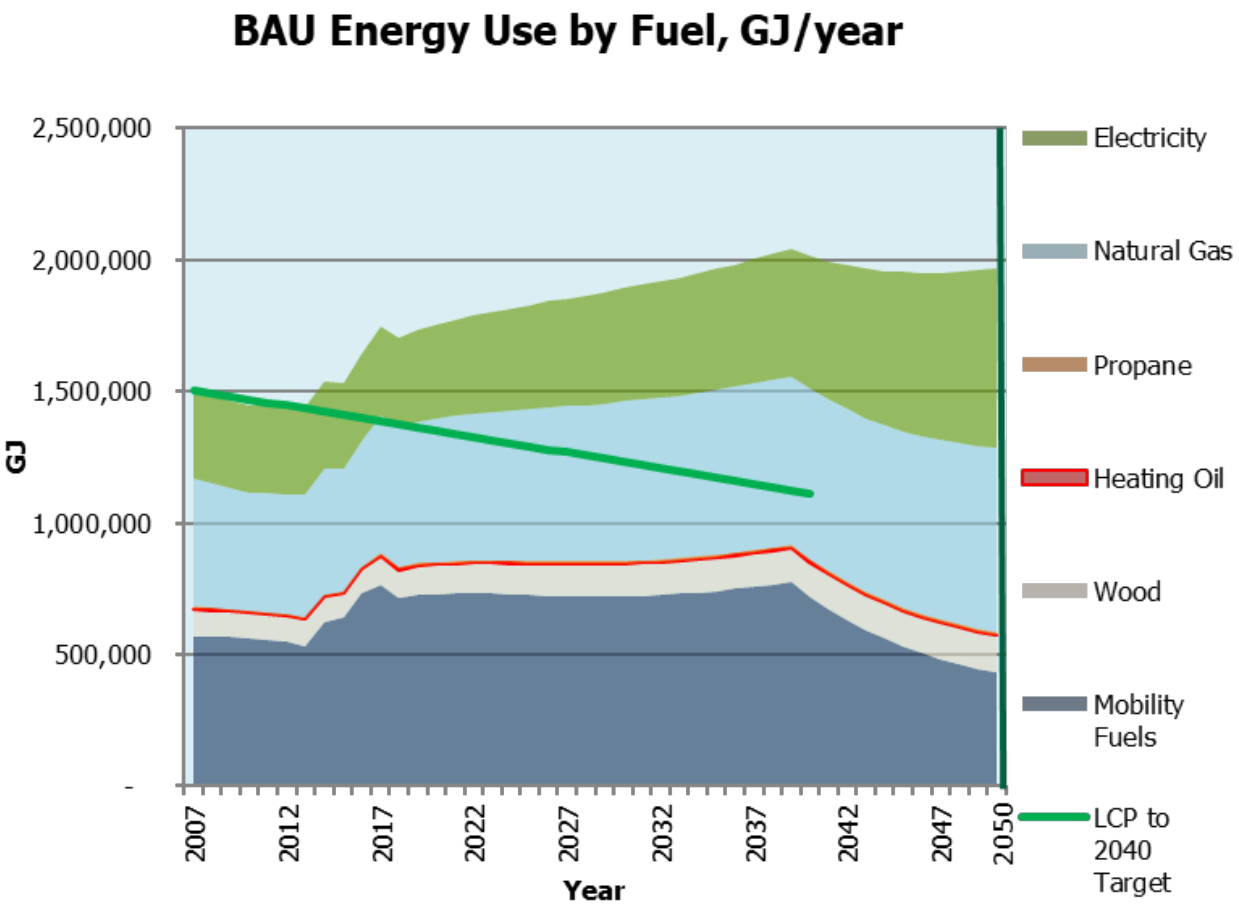


TABLE 5 – ENERGY CONSUMPTION AND LCP TARGET

	2007	2010	2018	2030	2040	2050
Inventory & BAU estimate (GJ)	1,504,604	1,443,554 (-4.1%)	1,705,262 (13.3%)	1,853,211 (23.2%)	1,969,537 (30.9%)	1,912,175 (27.2%)
LCP net reduction trajectory (GJ)	1,504,604	1,469,041 (-2.4%)	1,374,205 (-8.7%)	1,231,952 (-18.1%)	1,113,407 (-26.0%)	n/a

Compared to the 2007 baseline, energy consumption rose 13.3% in 2018. Two spikes in consumption occurred in 2014 and 2016 from increased mobility fuel consumption, and another spike in 2017 was due primarily to significantly higher heating consumption for natural gas. It would be notable to identify natural gas consumption from the Provincial inventory for 2018 and 2019 to determine if the increase was an anomaly, or if it will become an ongoing trend. Given that Nelson's LCP target is a 26% reduction in energy consumption by 2040, Nelson would have to reduce overall energy usage by 35% to 2040, relative to 2018.

Moving Forward - Meeting the 2030 1.5°C Target, the Scale of the Challenge

Below are *examples* of the physical changes that would be required annually (until 2030) to meet IPCC targets in Nelson, in an attempt to illustrate the level of effort and investment that will need to be considered:

- Transportation, passenger vehicles:
    - Approximately 675 internal combustion engine vehicles convert to electric every year from now to 2030, which is about half of all new car sales. (For comparison, note that in 2017 ICBC had 6 EVs registered in Nelson.)
      OR
    - Decrease the Vehicle Kilometres Travelled by passenger vehicles 8.75% per year from now to 2030— approximately 11 million VKTs per year.
- Transportation, commercial vehicles:
    - Approximately 27 commercial vehicles converting to a zero carbon alternative each year from now to 2030, out of the estimated 550 vehicles that would be on the road in 2020
- Buildings:
    - All new buildings built with zero carbon heating
    - Approximately 246 residential buildings using natural gas converted to zero carbon heating every year from now to 2030. This is about 4.7% of the total number of dwellings estimated in Nelson, each year. For deep energy retrofits that retain natural gas, approximately double these numbers
    - Approximately 25 businesses using natural gas converted to zero carbon heating every year from now to 2030. This is about 4.8% of the total number of business natural gas connections estimated in Nelson, each year. For deep energy retrofits that retain natural gas, approximately double these numbers.
- Waste:
    - Approximate reduction of 25 kg of waste/year per person, based on tonnage of 6,859 t in 2010, 6,231 t in 2017, and estimated tonnage of 6,623 t in 2020

Next Steps

The next stage is to develop updated targets based on the findings described in this report, and then actions for meeting these targets, in line with the scale suggested in the previous section.

Actions should be informed by this data, research and public engagement, and then modelled against new targets to ensure that they are sufficient in terms of obtaining the emissions reductions required.

Performance should then be monitored via updated Inventories in 3-5 year intervals.

Appendix 1 – Methodology & Assumptions

This appendix contains details on the methodology and assumptions for creating the GHG inventory and projections for Nelson.

Inventory Methodology

Nelson's GHG inventory was created using data for buildings, transportation, and waste obtained from the Province of BC's Community Energy & Emissions Inventory (CEEI) data,[7] and utilities and landfill waste data at the utility level.[8]Data on gasoline and diesel sales from Nelson gas stations obtained from Kent Group. Data from the City of Nelson's electrical utility was also obtained for 2018. Based on the data compiled, full inventory years were able to be complied for 2007, 2010, and 2012-2018.

The City of Nelson also conducted a 'Citizen Survey on Climate Change' in 2019 that captured heating fuel information, which was used to determine the fraction of home owners that used wood, heating oil, and propane and was also incorporated into the inventory. Determining heating oil, wood, and propane consumption for each year was based on annual natural gas consumption to estimate average building heating load. Energy conversion efficiencies were then applied (85% for heating oil and propane furnaces, 50% for wood stoves) in conjunction with the survey results to determine energy consumption for each fuel source. Propane data for the Nelson sewage treatment plant for 2019 was also included, and back cast using population growth for previous years.

Emissions factors for inventory years are shown in the following table, and are sourced from the Province of BC's 2017 GHG Inventory. Note that 2018 emission factors are based on 2017 data.

TABLE 6 – EMISSIONS FACTORS USED FOR INVENTORY YEARS

GHG/GJ, by Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoline	0.068	0.067	0.066	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
Diesel	0.070	0.069	0.068	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067
Mobility fuels	0.069	0.067	0.066	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.066	0.066
Electricity	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Wood	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Heating oil	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
Propane	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061

Note: some of the emission factors have changed over time. For example, the emission factors for mobility fuels have decreased as a result of the Renewable and Low Carbon Fuel Requirements Regulation and the emissions factor for electricity has decreased as a result of ongoing efforts to decarbonise the BC Hydro electricity grid.

To determine fuel consumption by the three fuels, an average heating load for a typical house was required. This was determined by using natural gas consumption for each year, divided by the number of connections (houses), and incorporating the efficiency of a natural gas furnace (estimated at 85%). For example, in 2017, natural gas consumption per house was estimated at 82.8 GJ/year. Incorporating

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

natural gas efficiency, this equates to 70.4 GJ/year heating load. The proportion of houses that used each fuel in the survey, was multiplied by the number of houses in the City, to determine the equivalent number of houses in the City using each fuel. Heating oil and propane were estimated to provide 100% of heating in the homes where they were used, while wood was considered secondary heating, and estimated to provide 50% of heating.

With respect to solid waste, tonnage estimates from Provincial sources were compared to tonnage data from the City and from the Regional District of Central Kootenay (RDCK). The most recent inventory year from the Province from 2017 indicated a tonnage of 6,231 tonnes, taken as the population-based proportion of regional district waste attributed to Nelson. From RDCK-attained 2019 data for the Grohman Transfer Station, which is weighed and thus considered accurate, tonnage was estimated at 6,289 tonnes, with approximately 3,270 tonnes from residential and non-account businesses. Note that these numbers also include waste generated from the Hwy 6/3A junction to Six Mile, and are therefore likely a slight overestimate. Nevertheless, tonnage numbers are very close to the Provincial estimate, therefore we consider the Provincial tonnage and emissions estimates reasonable.

Emissions from Land Use, Land Use Change, and Forestry are not included in the community profile as per the Province's methodology for their 2017 inventory.

Inventory Assumptions

Assumptions made with respect to the inventory are as follows:

- The Province of BC made a series of standard assumptions in the creation of the CEEI data for 2007,2010, and 2012 which are outlined on the CEEI webpage: https://www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei.
- The Province of BC made other assumptions for the post-CEEI data for additional buildings and landfill waste emissions information after 2012, which are outlined in the community level spreadsheets on the Provincial Inventory webpage: https://www2.gov.bc.ca/gov/content/environment/climate-change/data/provincial-inventory. Note that the 2017 Provincial Inventory incorporated updated assumptions including backcasting, which incorporated new or improved methodologies to current and prior years as applicable. This is why updated CEEI data may be different from the original CEEI data.
- In creating the inventories, CEA made other assumptions in addition to these:
    - For all years of fuel data (2007-2018), Kent Group data was used as described below. This is because the most recent year that the Province provided transportation data for Nelson was 2010. CEA regularly uses Kent Group data for inventories where data is available. Note that while new ICBC data was available at the 3-digit postal code level up to the 2018 year, data quality issues (particularly discrepancies relative to the CEEI data provided) led to the decision to use Kent Group data.
    - Provincially-sourced electricity data is predominantly from Nelson Hydro. For 2017 and 2018, Nelson Utility data was available directly from the City, while the remaining years used provincial data.

  - Though FortisBC gas data was included with the new Provincial inventory up to 2017, only residential numbers were incorporated, as commercial/industrial data for 2012 and beyond included large industrial. FortisBC commercial/industrial gas data post-2012 is prorated with population growth. Natural gas data was obtained for the 2018 year as well, however the data appeared to use different community boundaries, as about 45% more connections were included vs. the Provincial data, resulting in a 28% increase in consumption. We decided to not use the data due to the discrepancy in the number of connections and the subsequent rise in emissionsand instead projected based on population growth to populate the 2018 year for natural gas.

- As mentioned in the previous bullet points, fuel data was derived through Kent Group fuel sales data for Nelson, Castlegar, and Trail for 2007-2018, then prorated based on population proportions between the three cities. The prorating methodology was chosen over examining gas stations within City of Nelson boundaries only because data was only available for five gas stations in the City, as opposed to 13 between the three cities. Commuters were also more likely to travel across municipal boundaries throughout the Central Kootenays, rather than remaining confined to Nelson city boundaries.
- CEA now uses Kent Group data for inventories as a best practice where data is available and representative of the community, since CEEI transportation data is outdated (last data point is 2010). The Kent Group data was corroborated against the CEEI transportation estimate, and in doing so an assumption was made that all vehicle sizes up to and including medium duty trucks from CEEI data would be within the service boundary for Kent Group gas stations. Heavy duty trucks were excluded, as they are assumed to be fuelled by commercial card lock fuel stations, which are outside the service boundary for Kent Group. Using the aforementioned methodology and assumptions for quantifying consumption, the Kent Group data yielded a difference of 31% for gasoline, and -14% for diesel vs. our estimated consumption numbers in 2018 using 2010 CEEI and scaled by population growth. Though the gasoline component from the Kent Group methodology is considerably higher than the CEEI/population growth methodology, the CEEI data is 8 years out of data. The underestimate for diesel from the Kent Group data also makes sense since card lock stations are not included, and would likely account for a fair proportion of diesel consumption.
- In addition to some methodological challenges to using fuel sales data, a major drawback is the lack of information on fuel sales through card lock stations, which are not included with the data.[9] This means that many commercial diesel vehicles are excluded. Based on a previous release of the CEEI data, and making assumptions based on population growth, commercial card lock vehicles may have accounted for 5,260 tonnes in 2010. If that is approximately accurate, then that would constitute a small but not inconsiderable omission, as Nelson's 2010 GHG

[9] The fuel sales approach to estimating transportation energy consumption and emissions is different to the one that the Province has taken with CEEI before. It will include tourism and through-traffic, while the Province's approach would have only included vehicles registered in the community. For a discussion on the pros and cons of the different approaches see 'Assessing vehicular GHG emissions, a comparison of theoretical measures and technical approaches' by Pacific Analytics. https://www2.gov.bc.ca/assets/gov/environment/climate-change/z-orphaned/ceei/ceei-comparison-study.pdf

emissions are estimated at 66,600 tonnes of CO_2e excluding most commercial vehicles. 5,260 tonnes would be about 8% of this.

Projections

As previously described, there are full or partial inventory years that describe the community's emissions profile from 2007-2018. From 2019 onwards, all of the data is an estimate as a BAU projection.

The assumption is that energy consumption and emissions will increase proportionally with increases to population, although the impact of policies from higher levels of government are also incorporated, and other assumptions. Only policies that have already been adopted and that will have quantifiable impacts are incorporated.

Assumptions related to projections are as follows:

- The Province's incremental steps to net zero energy ready buildings by 2032, via the BC Energy Step Code
- Federal and provincial tailpipe emissions standards: new light duty vehicle emissions decline from 200 g CO_2e/km in 2015 to 119 g CO_2e/km in 2025 (Federal policy), and then decline again to 105 g CO_2e/km in 2030 (Provincial strengthening of this policy). This is for new vehicles, and is included in the projections taking account of vehicle turnover rates
- Renewable & low carbon transportation fuel standards: 20% by 2030, as in CleanBC Plan
- An average annual decrease of 1.2% in natural gas consumption per residential connection is included, to align with FortisBC planning
- The Province's CleanBC Plan Zero Emission Vehicle Mandate of 100% of new vehicles by 2040. From the impacts of this, in our BAU scenario we assume that the proportion of electric vehicles on Nelson roads will be:
    - 1% in 2025
    - 2% in 2030
    - 13% in 2040
    - 66% in 2050 (even with 100% of all new vehicles sold having zero emissions, there is still a lag with vehicle turnover rates)
- How the impacts of a changing climate will affect building energy consumption:
    - Climate change data for the region was obtained from ClimateData.ca. CEA obtained this from the "downloads" section of the website, selected the BCCAQv2 (annual) dataset, Heating Degree Days (HDD's) or Cooling Degree Days (CDD's) variables, and the location on the map to be analysed
    - Projected global emissions to 2030 currently places the world in the range for the IPCC's Fifth Assessment Report's Representative Concentration Pathway (RCP) 6.0 scenario. As RCP 6.0 scenario not available on ClimateData.ca, RCP 4.5 (median values) were used as a proxy even though this is a more conservative scenario
    - Decreases in residential and commercial natural gas consumption are assumed to be proportional to decreases in HDD's and the proportions of natural gas consumed for space heating for each sector, with this data obtained from the Navigant 2017 Conservation Potential Review for FortisBC Gas

- Based on ClimateData.ca RCP 4.5 median values, the 30 year average of HDD's around 2018 are 4,342, and in 2050 they will be 3,753
- Decreases in residential and commercial electricity consumption are assumed to be proportional to decreases in HDD's and the proportions of electricity consumed for space heating for each sector. However, for residential this is partially offset by, and for commercial more than offset by the proportions of electricity consumed for space cooling by each sector and how this will increase proportional to projected increases to CDD's. These proportions were obtained from the Navigant 2016 Conservation Potential Review for BC Hydro
- Based on ClimateData.ca RCP 4.5 median values, the 30 year average of CDD's around 2018 are 54, and in 2050 they will be 132

Appendix 2 – Energy & Emissions Inventories, Raw Data

This appendix contains the raw energy & emissions inventory data for each complete inventory year: 2007, 2010, and 2012-2018

2007

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	515,209	35,243
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	55,332	3,849
Solid Waste	Community Solid Waste	Solid Waste		5,339
Buildings	Residential	Electricity	159,305	124
Buildings	Residential	Natural Gas	260,062	12,970
Buildings	Residential	Propane	6,658	407
Buildings	Residential	Heating Oil	1,332	91
Buildings	Residential	Wood	101,861	1,943
Buildings	Commercial/Small-Medium Industrial	Electricity	178,525	139
Buildings	Commercial/Small-Medium Industrial	Natural Gas	225,093	11,226
Buildings	Commercial/Small-Medium Industrial	Propane	1,229	75

2010

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	491,958	31,880
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	70,844	4,745
Solid Waste	Community Solid Waste	Solid Waste		5,037
Buildings	Residential	Electricity	163,114	124
Buildings	Residential	Natural Gas	238,345	11,887
Buildings	Residential	Propane	6,308	386
Buildings	Residential	Heating Oil	1,262	86
Buildings	Residential	Wood	96,520	1,842
Buildings	Commercial/Small-Medium Industrial	Electricity	165,844	126
Buildings	Commercial/Small-Medium Industrial	Natural Gas	208,151	10,381
Buildings	Commercial/Small-Medium Industrial	Propane	1,208	74

2012

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	477,068	30,915
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	69,264	4,639
Solid Waste	Community Solid Waste	Solid Waste		5,934
Buildings	Residential	Electricity	166,680	68
Buildings	Residential	Natural Gas	234,776	11,709
Buildings	Residential	Propane	6,539	400
Buildings	Residential	Heating Oil	1,308	89
Buildings	Residential	Wood	100,039	1,909
Buildings	Commercial/Small-Medium Industrial	Electricity	176,400	72
Buildings	Commercial/Small-Medium Industrial	Natural Gas	216,804	10,813
Buildings	Commercial/Small-Medium Industrial	Propane	1,217	74

2013

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	463,131	30,012
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	70,181	4,701
Solid Waste	Community Solid Waste	Solid Waste		7,229
Buildings	Residential	Electricity	161,175	59
Buildings	Residential	Natural Gas	243,749	12,157
Buildings	Residential	Propane	6,635	406
Buildings	Residential	Heating Oil	1,327	91
Buildings	Residential	Wood	101,516	1,937
Buildings	Commercial/Small-Medium Industrial	Electricity	175,299	64
Buildings	Commercial/Small-Medium Industrial	Natural Gas	217,311	10,838
Buildings	Commercial/Small-Medium Industrial	Propane	1,220	75

2014

Sector	Subsector Description	Fuel	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	543,005	35,188
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	76,669	5,135
Solid Waste	Community Solid Waste	Solid Waste		5,143
Buildings	Residential	Electricity	155,669	50
Buildings	Residential	Natural Gas	255,647	12,750
Buildings	Residential	Propane	6,607	404
Buildings	Residential	Heating Oil	1,321	90
Buildings	Residential	Wood	101,086	1,929
Buildings	Commercial/Small-Medium Industrial	Electricity	174,198	56
Buildings	Commercial/Small-Medium Industrial	Natural Gas	220,612	11,003
Buildings	Commercial/Small-Medium Industrial	Propane	1,260	77

2015

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	563,735	36,531
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	74,945	5,020
Solid Waste	Community Solid Waste	Solid Waste		3,057
Buildings	Residential	Electricity	152,001	49
Buildings	Residential	Natural Gas	237,064	11,823
Buildings	Residential	Propane	6,038	369
Buildings	Residential	Heating Oil	1,208	83
Buildings	Residential	Wood	92,380	1,763
Buildings	Commercial/Small-Medium Industrial	Electricity	176,924	57
Buildings	Commercial/Small-Medium Industrial	Natural Gas	227,868	11,365
Buildings	Commercial/Small-Medium Industrial	Propane	1,292	79

2016

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	649,787	42,107
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	80,994	5,425
Solid Waste	Community Solid Waste	Solid Waste		3,368
Buildings	Residential	Electricity	153,664	49
Buildings	Residential	Natural Gas	243,802	12,159
Buildings	Residential	Propane	6,109	374
Buildings	Residential	Heating Oil	1,222	84
Buildings	Residential	Wood	93,467	1,783
Buildings	Commercial/Small-Medium Industrial	Electricity	178,976	57
Buildings	Commercial/Small-Medium Industrial	Natural Gas	233,622	11,651
Buildings	Commercial/Small-Medium Industrial	Propane	1,306	80

2017

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	677,306	43,891
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	87,503	5,861
Solid Waste	Community Solid Waste	Solid Waste		3,430
Buildings	Residential	Electricity	160,937	51
Buildings	Residential	Natural Gas	283,338	14,131
Buildings	Residential	Propane	7,253	444
Buildings	Residential	Heating Oil	1,451	99
Buildings	Residential	Wood	110,966	2,117
Buildings	Commercial/Small-Medium Industrial	Electricity	176,560	56
Buildings	Commercial/Small-Medium Industrial	Natural Gas	236,246	11,782
Buildings	Commercial/Small-Medium Industrial	Propane	1,333	82

2018

Sector	Subsector Desc	Measurement Desc	Energy (GJ)	CO2E (t)
On-Road Transportation	Mostly Light Duty Cars	Gasoline	629,206	40,774
On-Road Transportation	Mostly Heavy Duty Trucks	Diesel Fuel	83,134	5,568
Solid Waste	Community Solid Waste	Solid Waste		3,501
Buildings	Residential	Electricity	168,205	54
Buildings	Residential	Natural Gas	289,167	14,422
Buildings	Residential	Propane	7,142	437
Buildings	Residential	Heating Oil	1,428	98
Buildings	Residential	Wood	109,280	2,085
Buildings	Commercial/Small-Medium Industrial	Electricity	175,232	56
Buildings	Commercial/Small-Medium Industrial	Natural Gas	241,106	12,025
Buildings	Commercial/Small-Medium Industrial	Propane	1,361	83

Appendix 3 – Citizen Survey on Climate Change Results

The following indicates the results from the Citizen Survey on Climate Change conducted by the City of Nelson in 2020, and was used to populate wood, heating oil, and propane residential data:

Q8. What type of fuel do you use to heat/cool your home? Check all that apply.									
Answer Choices	Natural Gas	Electricity (Hydro)	Wood	Heating Oil	Alternative energy sources (solar, wind etc.)	Propane	Don't know	Other (please specify)	Total
Q6: Fully detached house	299	286	171	1	8	9	0	13	465
Q6: Semi-detached house/duplex	19	28	4	0	0	0	1	2	36
Q6: Townhouse/row house	10	4	1	0	0	1	1	0	14
Q6: Condo/apartment/secondary suite	24	49	0	0	1	0	1	1	63
Q6: Prefer not to answer	2	4	4	1	0	0	1	0	8
Total	354	371	180	2	9	10	4	16	586
Percentage								Answered	586
								Skipped	0

Appendix D: Co-Benefits of Focus

Co-benefits are the universal pay-offs or improvements that can arise from action taken to mitigate or adapt to climate change - above and beyond the numerous benefits expected to result from a more stable climate. Climate initiatives with co-benefits result in 'win-win' scenarios for the environment and the community, and can often save money and time when planned and implemented integratively.

The co-benefits to climate action that have been focused on throughout the process of Nelson Next's development have been informed by community engagement and best practice research, and they are as follows[1]:

Sustainable Behaviour: lifestyle changes that improve health benefits through more active mobility and changes in diet, reduced material consumption and waste, low carbon energy use
Improved Resource Efficiency: meeting needs with better use of water food and energy sources, circular economy sees more resume and recycling of local goods, reduce waste and consumption
Enhanced Resilience: improved food security, healthy natural ecosystems, emergency preparedness, energy self-sufficiency and backup power, protecting local buildings, roads, and other infrastructure from climate impact
Public Health: improved access to clean air, indoor air quality, healthy local food, safe and healthy homes, nature, safe walking and cycling routes, safer streets, human health and well-being
Economic Growth: increasing tax base, secure new jobs, value of goods and services, ingenuity, sustainable business opportunities, more locally owned businesses, builds shared wealth
Community Cohesion: increased neighborhood vibrancy, collective response to disruptions, increased access to transit and mobility, traditionally excluded groups are engaged to strengthen social bonds, vulnerable populations have increased security, protecting quality of life for future generations
Cost Savings: lower cost of home energy bills, car maintenance, and necessary goods, reduced energy poverty, reduced energy consumption associated with green building and retrofitting strategies
Biodiversity: Protection and preservation of local ecosystems and species at risk, clean, natural water sources, connectivity of green spaces, habitat protection, nature education, increased capacity of local soil, forests and wetlands to sequester carbon

[1] List informed by: Simon Fraser University, ACT Team. 2019. *Low Carbon Resilience Interventions: Case Studies.* Accessed 2020. https://act-adapt.org/wp-content/uploads/2020/04/ACT-LCR-Interventions.pdf & Carbon Discolsure Project. 2020. T*he Co-Benefits of Climate Action: Accelerating City-Level Ambition.* Accessed 2020. https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/005/329/original/CDP_Co-benefits_analysis.pdf?1597235231#:~:text=What%20is%20a%20co%2Dbenefit,through%20expansion%20of%20green%20spac e