COMMUNITY CLIMATE ACTION PLAN

Energy and Emissions Modelling Methodology - Full Version

City of Kamloops

June 2021

Community-scale energy and emissions modelling was completed to understand the greenhouse gas (GHG) and energy implications of future emissions scenarios based on existing City, provincial, and federal policies and plans as well as the emissions reductions that could result from the actions specified within the Community Climate Action Plan (CCAP). This document provides an overview of the methodology and key datasets used for modelling the three key community emissions source sectors (transportation, buildings, and waste) and for developing land use scenarios that were subsequently utilized within transportation and buildings emissions modelling. The reference year for all baseline modelling data was 2017. All future emissions scenarios based on existing City, provincial, and federal policies and plans and the CCAP's Big Moves were modelled out to 2050.

Land Use

Land use modelling for the CCAP involved an estimation of the location, type, and scale of future development in the city under differing land use scenarios. While emissions from land use were not modelled outright, outputs from growth modelling directly influenced two key emissions source sectors: transportation and buildings. All land use modelling prepared for this project involved theoretical outcomes based on assumed development patterns and best available information to develop scenarios that can be used to evaluate emissions outcomes.

Key datasets:

- Municipal datasets such as land use plan designation polygons, zoning polygons, recent building and demolition permits
- Growth modelling completed for the City's Official Community Plan (OCP)
- Employment and population projections produced for the Transportation Master Plan (TMP)
- BC Assessment data (specifically, information pertaining to the actual use of parcels and commercial and residential floor areas)

Baseline Modelling	Future emissions scenarios based on existing City, provincial, and federal policies and plans	Alternate scenarios to model Big Moves emissions reductions
Create a baseline model of population, employment, and buildings in the city. This involved the development of a parcel-based dataset that describes the conditions of buildings in the city comprising floor areas from BC Assessment along with assumed occupancies for population, employment and unit counts. This highly granular dataset was used as an input for baseline transportation and buildings modelling, which is discussed in their respective sections below.	Fundamentally, this effort resulted in a model of future structures in the city by 2050. To create this buildout, housing and employment projections were assigned to traffic analysis zones (TAZ) and modelling rules involving developable lands, assumed densities, penetration of secondary suites, unit typology mixes, and demolition rates were developed to guide the creation of future structures. The output of this work was a projected dataset with the theoretical location of structures that was used for modelling the impact of existing policies and plans for transportation and buildings.	To construct these theoretical alternate buildouts, assumptions around projections were altered to meet the intent of various Big Move strategies. For example, assumptions with regards to the 10-Minute City strategy involved positioning new growth in highly walkable areas of the community. These alternate projections were then applied to the modelling rules discussed above to create new buildout scenarios for the community.

Transportation

Transportation modelling for this plan involved an estimation of fossil fuels combusted by on-road vehicles registered in the City of Kamloops, including light-duty vehicles such as passenger cars, SUVs, and light-duty trucks and medium- and heavy-duty vehicles such as transit vehicles, delivery trucks, and long-haul trucks. The development of the baseline model and forecasting was guided by the Federation of Canadian Municipalities and ICLEI Canada's (2014) PCP Protocol: *Canadian Supplement to the International Emissions Analysis Protocol* and, where needed, the World Resources Institute's (2018) *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories: An Accounting and Reporting Standard for Cities*.

Key datasets:

- Transportation modelling previously completed for the OCP and the TMP and land use modelling completed earlier in this project
- 2007 trip diary study prepared for the City of Kamloops
- Provincial Community Energy and Emissions Inventory (CEEI) from 2007, 2010 and 2012
- Extracts from Climate Action Secretariat’s provincial fleet model
- Fleet information from BC Transit
- Emissions factors from BC Ministry of Environment's (2018) *B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions*

Baseline Modelling	Modelling future emissions based on existing City, provincial, and federal policies and plans	Modelling Big Moves emissions reductions
Develop a baseline fleet model (vehicles per household). The baseline model of light-, medium-, and heavy-duty on-road vehicles was projected using CEEI data and provincial fleet extracts. For modelling purposes, the fleet was assumed to be composed of passenger vehicles such as small and large passenger cars, light-duty trucks, SUVs and vans, motorhomes, transit vehicles, and medium- and heavy-duty trucks. Fuels modelled included gasoline and diesel as well as electricity as a power source for registered electric vehicles.	**Forecast fleet size and composition**. Using the vehicles per household model developed for the baseline model, land use inputs were altered based on the land use model to determine future counts of vehicles in the city at the TAZ level. These counts were then disaggregated into vehicle classes and, crucially, divided into electric- and fossil fuel-powered vehicles based on the electric vehicle sales targets per the BC *Zero-Emission Vehicles Act* as well as an assumed vehicle turnover rate in the city (average vehicle age is expected to hover around nine years old with a retirement profile that assumes 95% turnover by 20 years). Additional	**Develop alternate modelling inputs for the Big Moves**. Depending on the type of actions contemplated under each Big Move in the CCAP, alternate modelling inputs (such as VKT-affecting land use inputs or fleet-affected technology inputs) were qualitatively developed to encompass potential changes in the community. - For Big Move 1: Low-Carbon Development, strategy 1A repositions growth in the community, reducing light- and heavy-duty VKT significantly. Strategies 1B and 1C diversify housing stock and modestly reposition growth, thereby modestly reducing VKT.

Develop a baseline VKT model. The baseline vehicle kilometres travelled (VKT) model was derived from transportation modelling work completed for the TMP, which included estimations of origin-destination trips and distances at the TAZ levels. These trips were then transformed into origin-based household and per vehicle VKT by each traffic zone. Land use factors, such as density, transit service provision, housing mix, intersection density, and demographic factors like household size and composition, were correlated against light-duty VKT and vehicles per household to develop simple coefficients that could be used for baseline and forecasting purposes. Total community VKT was then calculated from a summary of the TAZ-level data and disaggregated to vehicles by type based on proportions developed in the CEEI. Transit kilometres travelled were sourced from BC Transit. Heavy-duty kilometres travelled were projected from CEEI data without modification.

Calculate emissions from fuel consumption. Emissions were calculated by vehicle type by multiplying VKT per vehicle by assumed fuel economies from NRCan's National Energy Use Database (2019) to generate total volumes of fuel consumed (gasoline and diesel). Each of these volumes was then transformed into an emissions total by applying litres-to-tCO_2e emissions factors sourced from *B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions*. improvements to tailpipe efficiency of new passenger vehicles were completed per US Department of Transportation's Corporate Average Fuel Economy (2017) standards (i.e. approximately 30% improvement in overall fleet fuel economy by 2050 over 2017 levels).

Forecast VKT. As with the fleet, VKT was forecast using the coefficients developed in the baseline model along with new land use inputs representing Kamloops in 2050 under existing policies and Kamloops-specific plans (i.e. OCP and TMP). At the time of modelling, no relevant senior government policies were identified that would significantly impact community VKT. As such, community VKT are expected to increase from 1.1 billion kilometres travelled in 2017 to 1.6 billion in 2050. VKT per vehicle is assumed to remain static over the same timeframe. That is to say, based on the modelling, vehicle ownership is expected to rise in accordance with overall community VKT.

Calculate forecast emissions scenario based on existing policies and plans of City, provincial and federal governments. As with the baseline, emissions were calculated through a multiplication of VKT, fuel economy, and emissions factors. Due to uncertainty in the provincial low-carbon fuel standard at the time of modelling, improvements to tailpipe emissions factors were modestly assumed to increase by 4% over 2017 levels.

- For Big Move 2: Car-Light Community, all strategies address behavioral determinants of travel, resulting in VKT and fleet size reductions that range from modest to significant. Strategies 2B and 2E result in increasing transit usage, which in turn reduces VKT. Emissions from transit usage increase correspondingly though at a reduced pace due to the anticipated decarbonization of the transit fleet.
- For Big Move 3: Zero-Emissions Transportation, strategy 3A further accelerates the transition to zero-emissions light-duty vehicles by 2050. Strategies 3B and 3C facilitate a potential transition to zero-emissions vehicles for heavy-duty fleets by 2050 and further reduce heavy-duty VKT modestly.

Model Big Moves in sequence and calculate emissions reductions. Big Moves strategies were modelled in an order of operation that takes into account fleet size reductions first, VKT reductions second, and changes to fleet composition third. As such, emissions reductions for strategies that concern zero-emissions vehicles are slightly lower than they would appear if the order of operations was changed to prioritize changes to fleet composition first.

Calculate forecast emissions for the Big Moves scenario. As mentioned above, emissions reductions for Big Moves were calculated in sequence and referenced against the scenario based on existing policies and plans.

Buildings

Buildings modelling involved using building archetypes with typical energy use intensity (EUI) in kWh/m² for different sectors. These archetypes were applied to current building floor areas to determine total consumption, which was aligned with community-wide utility data. Changes in floor area and EUI for different sectors could then be projected for future years. Emissions were determined using standard emissions factors for the energy types being used.

Key datasets:

- Community-wide utility electricity and natural gas consumption data obtained through the provincial CEEI initiative
- Floor area projections (see Land Use section above)
- Building archetype EUIs developed by BC Hydro
- Emissions factors from the *B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions*

Baseline Modelling	Modelling future emissions based on existing City, provincial, and federal policies and plans	Modelling Big Moves emissions reductions
Develop baseline energy consumption. This was determined by applying archetype EUIs to the existing floor area by sector. The sector consumption was then adjusted to match utility data, accounting for weather variation. **Calculate emissions.** GHG emissions were calculated by applying the appropriate emissions factor to the consumption data.	The buildings modelling was done in BC Hydro's Policy Impact Estimator (PIE) Excel-based software with modifications. This model projected building floor areas and energy consumption through 2050, and policies were applied to adjust archetype EUIs over time. For the projection of the impact of existing policies and plans only, the Province's adoption schedule for the BC Energy Step Code was applied to projected new construction through to 2032. No changes to existing buildings were incorporated, although there was a slight decline in floor area due to demolition.	Initial modelling of reduction scenarios was done in PIE by accelerating the adoption rate of Step Code construction and incorporating a mix of modest- and higher-impact retrofits for existing buildings. For the Big Moves, emissions reductions were applied based on reductions determined through extensive Metro Vancouver modelling of near-zero GHG requirements for buildings.

Solid Waste

Waste modelling was based on the US Environmental Protection Agency's (EPA) Landgem model, which models methane generation from the characterization of waste and mass of waste disposed over time. The model was adapted to allow for changes to waste characterization, in order to calculate the impact of waste reduction policies. Further spreadsheet analysis was performed on the Landgem results to determine the impact of landfill gas collection and calculate GHG emissions.

Key datasets:

- Population data and projections from BC Stats and the City of Kamloops
- City of Kamloops landfill disposal rates
- TNRD Solid Waste Management Plan
- City of Kamloops Solid Waste Composition Study (2006)
- Landfill gas collection rate from City of Kamloops
- Landfill decomposition parameters
- Golder landfill inventory report (2008)

Baseline Modelling	Modelling future emissions based on existing City, provincial, and federal policies and plans	Modelling Big Moves emissions reductions
Calculate baseline methane generation. This was based on the mass of waste disposed by year and parameters for the Mission Flats landfill. The analysis was performed in the US EPA's Landgem model. The land fill gas (LFG) collection rate was then applied to the calculated methane.	Future disposal rates were based on population growth projections and current estimated composition. This was modelled in Landgem to determine methane generation through to 2050. The LFG collection rate was assumed to remain the same.	Reduction in mass of waste disposed was calculated by applying estimated reductions by material type proposed in the Solid Waste Management Plan by year. The revised waste tonnages and composition were then modelled in Landgem to determine methane generation. Increases in the LFG collection rate were then applied to determine final emissions.