Surrey Community Energy and Emissions Plan (CEEP) Supporting Document:

Detailed Modelling Methodology

Table of Contents

Modelling Methodology Overview

Purpose

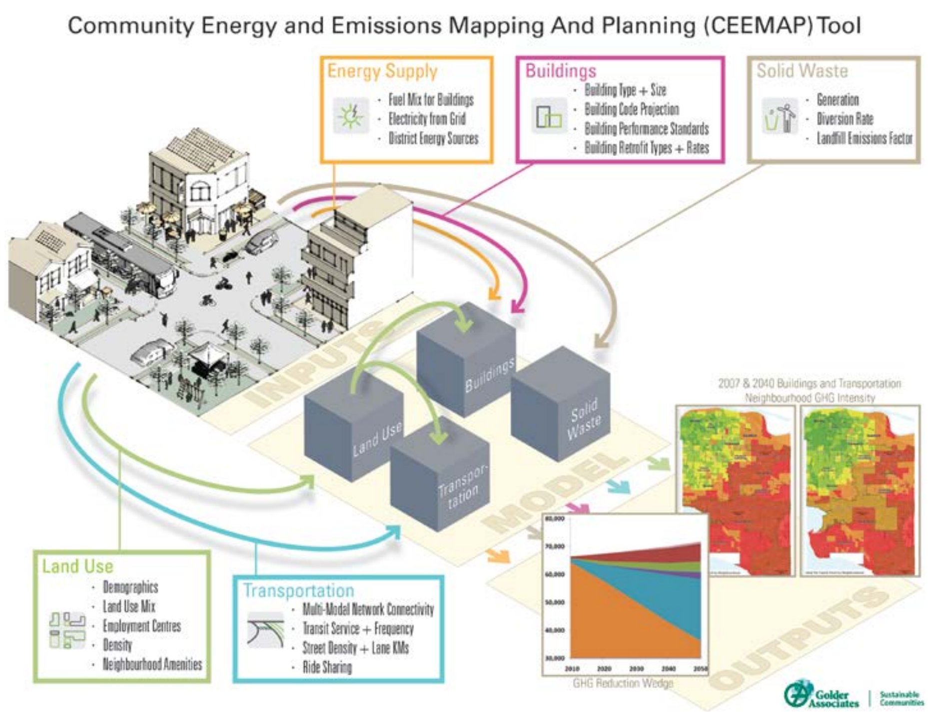
Golder Sustainable Communities Group projects future energy use and greenhouse gas (GHG) emissions using a dynamic model called the *Community Energy and Emissions Modeling and Planning* tool—CEEMAP. CEEMAP was created to assist local governments with the task of GHG goal setting and policy development. CEEMAP is comprised of five integrated modules: land use, transportation, buildings, solid waste, and energy costing. Within these modules, spreadsheets and ArcGIS are used to analyze the effect of various land use, urban form, and transportation changes and green building policies on energy consumption, GHG emissions, and energy costs.

Forecasting future emissions is challenging due to the number of factors that influence GHG emissions, the interrelationships between factors, and the difficulty in estimating how they will change over time. For example, GHG modelling is complicated by the fact that long-term emissions reductions usually occur in the context of population and economic cycles, an aging building stock, varying rates of building replacement and renovation, and improvements in technological efficiency. Further complicating the task is considerable uncertainty about the introduction of federal and provincial policy and legislative changes as well as regional transportation investments. In other words, forecasting energy and emissions should not rely on static assumptions. Rather, it should take into account dynamic changes over long periods. This is CEEMAP's approach.

CEEMAP Modules

CEEMAP's five modules are connected through common inputs and a linear interconnection between module outputs and inputs. Figure 1 (below) illustrates these connections. The land use module is the backbone of CEEMAP, as it generates outputs that are used in the transportation, buildings, and costing modules. These outputs include a variety of spatially specific land use elements that are explained in more detail below.

Figure 1 – CEEMAP Schematic Diagram



Inputs and Outputs

CEEMAP's modules are configured using diverse data sources and expert input from City staff and key stakeholders. Figure 1 lists the high level data input categories for the four most commonly used CEEMAP modules. Some of these data are obtained from aggregated regional or national data while other data are specific to the community. The Land Use module, in turn, produces outputs that are used as inputs by the other modules. Land use module outputs such as future build-out by building type, allocation of non-residential sector square-footage, and residential population are particularly important for the buildings and transportation modules.

Example Inputs

- Socio Economic Data (e.g. residential and employment population)
- Land Use & Community Design (e.g. location and density of non-residential and residential buildings)
- Transportation Technology & Patterns (e.g. number and type of automobiles, transit routes and frequency)
- Building Type & Performance (e.g. single detached or multi family home type, building energy efficiency rating, retrofit rate)
- Heat & Electricity Supply (e.g. electricity from grid or other sources, specific district energy technology)
- Solid Waste Management (e.g. waste composition and mass, management practices)

Example Outputs

- Energy Use and Greenhouse Gas Emissions, by
  - Sector
  - Energy type
  - Neighbourhood, Census dissemination area and/or other planning areas
  - Household
  - Per-capita
- Building Retrofit Rate
- District Energy Service Areas
- Vehicle Kilometres Traveled
- Transit Passenger Kilometres Traveled
- Landfilled Solid Waste

Process

The modeling process typically involves the following stages:

1. Data gathering
2. CEEMAP setup and configuration
3. Enhanced energy and emissions baseline
4. Business As Usual (BAU) energy and emissions forecast
5. Exploration of energy and emission strategies, policies, and actions
6. Definition of one or more possible futures (comprised of strategies, policies, actions, and performance assumptions)
7. CEEMAP setup to model future scenario(s) based on different policy and performance assumptions
8. Initial energy and emission model outputs
9. Adjustment of strategies, policies, and actions
10. Final energy and emission model outputs

These steps can be adjusted to meet the objectives of each project. For more nuanced results, sensitivity analysis of specific policies and actions can be conducted. For a more streamlined approach, steps can be eliminated.

Key Terminology

Archetype – A grouping of units with similar functions or characteristics. For example, light passenger vehicles manufactured between 1980 and 1990 may be placed in one archetype as they have similar energy consumption characteristics (i.e. mileage).

Indicator – A metric that is useful for monitoring energy use and greenhouse gas emissions. The most useful indicators are those that can be easily tracked through existing or new data collection processes and that can be obtained without complex modeling. As a rule of thumb, good indicators are those that can be tracked every 2-3 years so that they can inform planning decisions.

Model Input – Data that is required to run the model. “Model input” is synonymous with “variable” or “model variable.”

Model Output – Data or graphics that are produced from running the model.

Scenario – A collection of strategies, policies, actions, and performance assumptions created to represent a specific future development path.

Variable – Shorthand term used to refer to model “independent variables” (model inputs that typically are adjusted for each community) and “dependent variables” (model outputs that change based on the value of the model inputs/independent variables).

Land Use Module

Land use is one of the main drivers of community-based energy use and emissions. Land use enables or restricts changes to the built environment, such as the size and type of dwellings or the distance and access to services.

Key Variables and Inputs

Three key variables influence land use changes:

1. Changes to the **building stock** in terms of type, size, and other characteristics;
2. **Land-use regulations**, especially those related to density (expressed either as dwellings or square meters of building area per hectare); and
3. **Growth** in residential population and employment.

The land use module within CEEMAP requires the following inputs:

1. Current building stock, preferably sourced from the local assessment authority, although census data may be used in some cases
2. Current and future land use planning designations (i.e. zoning)
3. Planning areas used by the community to inform planning decisions; these can be neighbourhoods, districts, regions, villages or any combination thereof provided there is no overlap between areas
4. Geographic constraints to development - these typically take the form of existing infrastructure, environmentally sensitive areas, rivers, lakes, or any other area that would prohibit development
5. Key growth assumptions concerning future building stock - these are typically related to dwelling size, population per dwellings, jobs per structure, and retrofit rates for key structural alterations (such as energy efficiency, onsite renewables and district energy connections)

Outputs and Module Process

CEEMAP generates one key output: a future version of a community's building stock. The module first creates a baseline of the current building stock by:

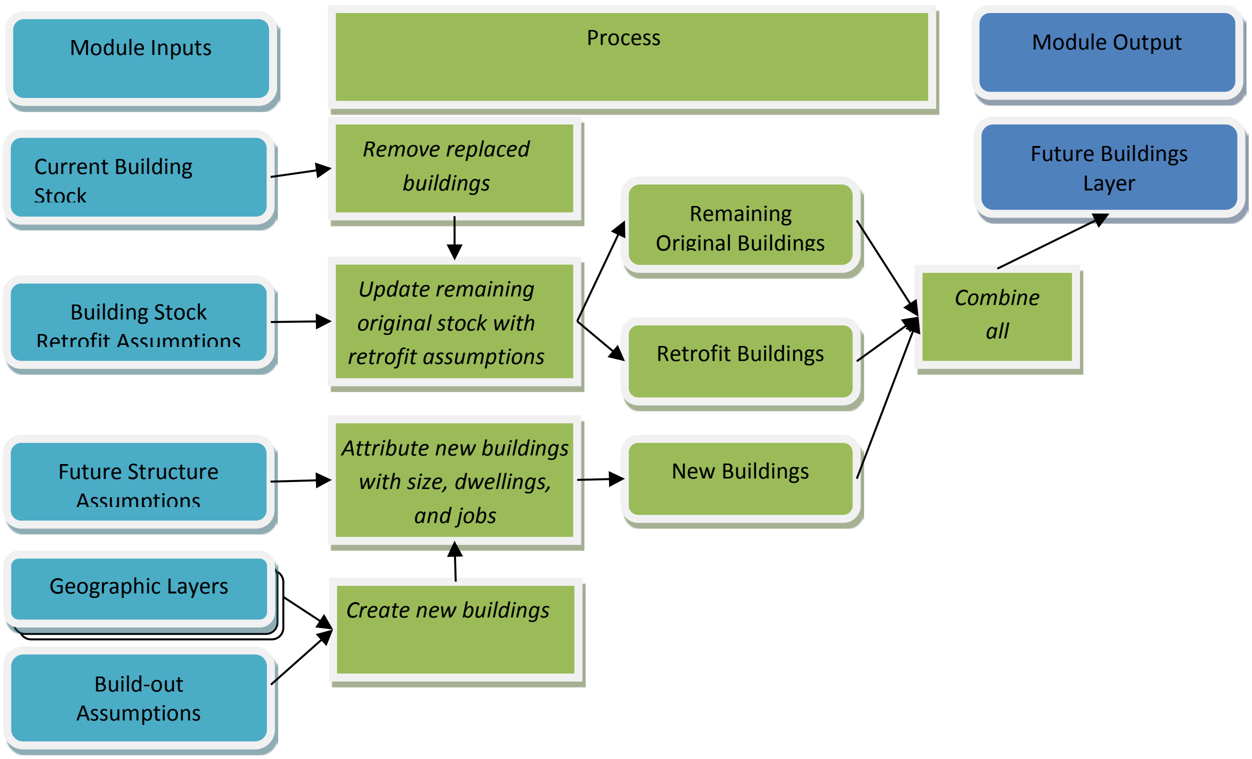
1. Creating a snapshot of current building stock consisting of all buildings in the community categorized by type, year of construction, and size;
2. Creating archetypes by a combination of building age and structural class;
3. Adding planning area boundaries determined by the community onto the snapshot;
4. Generating charts, graphs, tables, and maps to describe the baseline.

CEEMAP then models the future building stock by:

1. Entering data on future development and growth (population, number of dwellings, number of employees, and total area of built space by archetype) gathered from community land-use plans and engagement with local planning staff;
2. Generating new building points in each planning area;
3. Removing buildings as necessary from the baseline snapshot if they have been replaced by another structure (due to redevelopment) or if there is negative growth;
4. Combining the new buildings and remaining baseline buildings to generate the future building stock for each milestone year; and
5. Generating charts, graphs, tables, and maps to describe the future building stock.

The figure below illustrates the process described above.

Figure 2: Process Flowchart for Land Use



Data Sources

1. City of Surrey *Residential Land and Buildings Inventory*, 2011
2. City of Surrey *Commercial and Industrial Land and Buildings Inventory*, 2011
3. 2006 Census of Canada Data
4. City of Surrey *Residential, Commercial, Industrial, and Institutional Floorspace Projections*, 2011

Buildings Module

Key Variables and Inputs

Variables that influence changes to building energy use and emissions are the same as the inputs required by the building module. These include:

1. Building characteristics such as type, size, and age;
2. Building energy intensity, expressed as gigajoules per square meter or kilowatt-hours per square meter;
3. Building fuel mix, which refers to the type and source of energy consumed (e.g. natural gas, electricity, solar, etc.); and
4. The emissions factor for each fuel type, expressed as tonnes CO_2e per unit of energy.

Outputs and Formulas

The building module generates two outputs: future energy use in buildings and future emissions from buildings. Building energy use and emissions are calculated for each building archetype by dissemination area using the following formulas:

- Annual Energy Use = [Building Floor Area] x [Building Energy Intensity]
- Annual Building Emissions = [Building Floor Area] x [Building Energy Intensity] x [Fuel Mix] x [Emissions Factor]

Module Process

The module first creates a baseline of current building energy and emissions by:

1. Creating building archetypes based on energy consumption patterns and using NEUD energy consumption data from the NEUD. This includes estimates of energy consumption by era of construction, represented as energy consumed per square meter per year[1];
2. Entering the location, type, and average size of each existing building from the land use module into the building module;
3. For each building, multiplying the energy intensity (e.g. energy consumed per square meter) by the building size to generate building energy use;
4. For each building, calculating building emissions using building fuel mix and associated emissions factors; and
5. Calibrating the above results with data from the Community Energy and Emissions Inventory.

CEEMAP then projects future building energy use and emissions by:

1. Estimating changes in building energy intensity and fuel mix using a combination of Building Code projections and demand forecasting assumptions by local electrical and natural gas utilities;
2. Consulting peer-reviewed literature and case studies to estimate the energy and emissions impacts of specific building-related strategies;
3. Calculating future building energy and emissions using the estimated impact of policies, the future building stock from the land use module, and estimated changes in building energy intensity and fuel mix;
4. Generating charts, graphs, tables, and maps.

Data Sources

1. Baseline and future building characteristics from the land use module;
2. Natural Resources Canada, *Comprehensive Energy Use Database* (NEUD), British Columbia, August 2010;
3. Environment Canada *Electricity Intensity Tables*, 2010;

[1] This data is calibrated to local weather patterns and, where available, local utility consumption data

4. BC Ministry of the Environment, *City of Surrey Updated 2007 Community Energy and Emissions Inventory,* 2010;
5. BC Hydro: Power Smart Sustainable Communities Group *District Energy Assumptions,* 2011 (for low-rise and high-rise apartment building energy performance after 2008); and
6. BC Hydro *Electric Load Forecast 2010-2030*, 2010 (for trends in plug loads).

Transportation Module

The effect of land use features—such as where people live, work, shop, and play—and the characteristics of local and regional transportation patterns—including the type of cars on the road, how much people drive, walk, cycle, and take transit, and the incentives and disincentives for doing each—all combine to determine the amount of energy used and the GHG emissions emitted by the transportation sector. Research from communities across North America has quantified the relationships between these numerous variables. The development of the CEEMAP transportation module took these relationships into consideration.

Key Variables and Formulas

Transportation-related energy use and emissions are the result of:

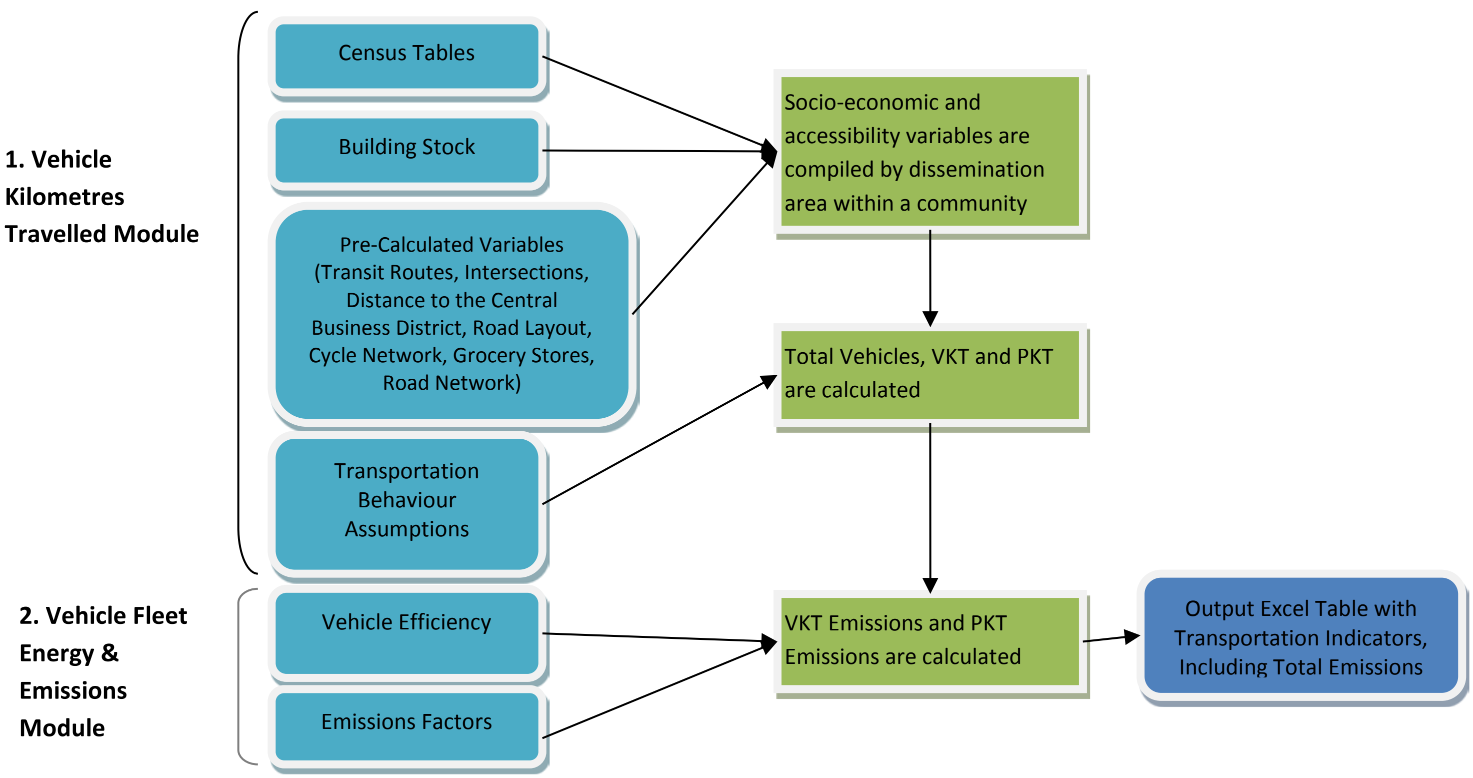
1. The distance that vehicles travel, expressed in terms of annual Vehicle Kilometres Traveled (VKT) and Passenger Kilometres Traveled (PKT); and
2. The fuel efficiency of vehicles on the road and the emissions factors associated with fuel type.

In its most simple form the transportation-related energy use and emissions are calculated according to the formulas:

- Annual Energy Use = [Total Annual Vehicle Kilometres Traveled] x [Average Vehicle Fuel Consumption Rate (litres of fuel/km)]
- Annual Emissions = [Annual Energy Use] x [Emissions Factors]

The following figure and sections explain these two sub-modules in detail.

Figure 3: **Process Flowchart for the Transportation Module and its two Sub-Modules, the VKT Sub-Module and the Transportation Fleet Energy & Emissions Sub-Module**



Transportation Module: Vehicle Kilometres Travelled Sub-Module

Key Variables, Inputs, and Formulas

This sub-module estimates future Vehicle Kilometers Traveled (VKT) and Passenger Kilometers Traveled (PKT) by dissemination area. Two key variables influence VKT and PKT:

1. Socio-economic and accessibility characteristics of the community, reflecting factors such as current and planned infrastructure, growth, employment, and land-use data; and
2. Transportation behaviour assumptions and formulas, such as the effect on an individual's driving when there is (or isn't) a grocery store within easy walking distance from their home.

This sub-module requires the following inputs:

1. Employment and demographic variables;
2. The current and future building stock and locations;
3. Accessibility characteristics, such as kilometres of roads and cycle routes, distance to rapid transit and commercial areas, and connectivity;
4. Transportation behaviour assumptions (such as % trip by car vs. % trip by transit); and
5. Total vehicles per household.

The simplified formula for calculating total VKT and PKT for each dissemination area (once variables for socio-economic, accessibility, and total vehicles have been determined) is as follows:

Average VKT and PKT = [Population in a Dissemination Area] x [Behaviour Assumptions]

Process

The module first creates a baseline of current VKT and PKT by:

1. Generating a layer of socio-economic variables for each dissemination area in the community using socio-economic variables, information on the building stock, and other community data;
2. Importing the transportation behaviour assumptions into the model;
3. Joining the dissemination area layer with the transportation assumptions;
4. Calculating the total vehicles per household and per non-residential building for each dissemination area; and
5. Calculating daily VKT and PKT per dwelling using multiple variables from the dissemination areas layer, figures for total vehicles, and relevant variables from the transportation assumptions (which includes specific assumptions for VKT and for PKT).

CEEMAP then projects future VKT and PKT by:

6. Calculating total annual VKT and PKT for each dissemination area by multiplying daily VKT and PKT per dwelling by an assumed growth factor and by the total number of dwellings ; and
7. Summarizing the final indicators for transportation (daily VKT and PKT, annual VKT and PKT, and total VKT and PKT emissions) from the dissemination areas table in charts, graphs, tables, and maps and as inputs for the Vehicle Fleet Energy & Emissions Sub-Module described below

Data Sources

1. Employment and demographic variables were taken from Census Canada reports and community data.
2. The current and future building stock and locations were drawn from the Land Use Module.

3. Accessibility characteristics, such as kilometres of roads and cycle routes, distance to rapid transit and commercial areas, and connectivity were drawn primarily from community plans and the local transit authority.
4. Transportation behaviour assumptions were derived from a variety of sources, including peer-reviewed journals, existing models, and community-specific data provided by the community's transportation planners.
5. Total vehicles per household (used for calculating VKT and PKT only) were drawn from the other key input data, local transportation authorities, vehicle insurance corporations, or the local transportation planning authority.

Transportation Module: Vehicle Fleet Energy & Emissions Sub-Module

Key Variables, Inputs, and Formulas

The Vehicle Fleet Energy & Emissions Sub-Module calculates vehicle energy use and emissions using the VKT and PKT numbers generated in the previous module.

Vehicle energy use is driven primarily by vehicle efficiency while emissions are driven by fuel type. Vehicle efficiency and fuel type are primarily influenced by fuel costs, technological change, senior government policies that set limits on vehicle tailpipe emissions, and as personal preference. City policies and programs have a lesser impact. Vehicle energy use and emissions are influenced by four major variables:

1. The vehicle stock for existing vehicles by vehicle class and age and trends in consumer choice for different vehicle types;
2. Vehicle efficiency as determined by senior government efficiency standards and trends, estimated energy prices, and technological change, expressed as energy consumed (gigajoules) per vehicle-kilometer travelled[2];
3. Vehicle fuel mix or distribution of vehicle type, especially electric vehicles, as determined by predicted vehicle efficiency, energy prices, and consumer trends; and
4. Vehicle kilometres travelled, as determined by the VKT Sub-Module.

CEEMAP requires four inputs for projecting vehicle energy use and emissions:

1. Vehicle registration data from regional agencies;
2. Locally available community energy and emissions inventory reports;
3. Vehicle efficiency by vehicle class and age as determined by empirical data from Natural Resources Canada; and
4. Available projections of future efficiency by vehicle type and age from a combination of regional or federal tailpipe efficiency standards, historical efficiency trends, and third-party projections.

The following formula is used to calculate energy use and greenhouse gas emissions from passenger vehicles, commercial vehicles, and public transit for each vehicle archetype, dissemination area, and milestone year:

- Energy Use = [Number of Vehicles (in a particular archetype)] x [Average VKT] x [Vehicle Efficiency (energy of fuel used per kilometre travelled)]
- Emissions = [Energy Use] x [Fuel Emissions Factors]

Process

The module first creates a baseline of current vehicle energy use and emissions by:

1. Categorizing the existing vehicle stock into archetypes by vehicle age and class;
2. Calculating vehicle kilometres traveled by archetype, sector (i.e. passenger, commercial, or public transit), and dissemination area by assigning vehicles, depending on vehicle type and sector, to residential and non-residential buildings;
3. Calculating the energy use by fuel type by multiplying the vehicle efficiency by archetype and dissemination area by kilometres driven from the Vehicle Kilometres Travelled sub-model;
4. Calculating emissions by multiplying energy use by fuel type by emissions factors; and
5. Calibrating the energy use and emissions results with data from local energy and emissions inventories.

[2] This is influenced by the Average Vehicle Tailpipe Emission Rate (expressed in terms of grams CO_2e / kilometre) calculated by the government of Canada and vehicle manufacturers in order to comply with national and state/provincial legislation.

CEEMAP then projects future vehicle energy use and emissions by:

1. Entering the baseline vehicle stock composition by archetype (e.g. % of trucks for personal vehicles) into the model for each sector;
2. Applying average improvements in vehicle efficiency relative to baseline year (generally expressed as a percentage value) to the vehicle archetypes at each milestone;
3. Calculating the vehicle fuel mix based on the proportion of the vehicle stock with alternative fuels (largely driven by the uptake of electric vehicles);
4. Calculating energy use by vehicle sector by multiplying vehicle efficiency by VKT and fuel mix;
5. Calculating emissions by vehicle sector by multiplying fuel consumed by emissions factors for each fuel type; and
6. Generating charts, graphs, tables and maps to describe future vehicle energy use and emissions.

Data Sources

1. Natural Resources Canada, *Fuel Consumption Ratings*
2. BC Ministry of the Environment, *City of Surrey Updated 2007 Community Energy and Emissions Inventory,* 2010
3. Environment Canada, *Key Features of Canada's Proposed Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations,* 2011
4. BC Hydro *Electric Load Forecast 2010-2030,* Appendix 4: Electric Vehicles, 2010
5. 2010 City of Surrey *Transportation Datasets*, 2011
6. Translink *South of Fraser Area Transportation Plan*, 2007

Waste Module

Consumption of food, goods, and materials and use of services by residents and businesses generate solid waste. Organic waste from kitchen scraps, back yards, and restaurants that ends up in the landfill often decomposes anaerobically (i.e. without oxygen) and generates methane, a potent greenhouse gas. The amount of methane generated can be greatly reduced by diverting organic waste to composting. In addition, methane gas can be captured and combusted at the landfill with appropriate equipment, reducing the amount that is released to the atmosphere.[3]

Key Variables and Inputs

This module estimates GHG emissions associated with solid waste. In general, emissions from solid waste account for only a small fraction of total community emissions. Energy consumed in transporting and processing waste is not calculated directly.

CEEMAP uses the Waste Commitment Method to calculate waste-related emissions. Waste emissions are determined by two main variables:

1. The volume and composition of waste disposed, measured in tonnes or tonnes per capita; and
2. The greenhouse gas emissions factor associated with waste disposal or processing, measured in tonnes CO_2e per tonne of solid waste[4].

CEEMAP requires three inputs for forecasting waste emissions:

1. Baseline waste composition, with a high-level estimate of the proportion that is organics[5];
2. Diversion and landfill gas capture[6] rates drawn from a combination of reports, plans, and discussions with staff; and
3. Quantity of waste disposed, from Surrey's Community Energy and Emissions Inventory.

Outputs and Formulas

The waste module generates one output: total annual emissions from solid waste. Emissions from waste being disposed at the landfill are calculated using the following formula:

- Total Annual Emissions from Solid Waste (Tonnes CO_2e) = [Total Annual Waste Sent to Landfill (tonnes)] x [Emissions Factor (CO_2e per tonne)] – [Percentage of Landfill Gas that is Captured (%)]

Process

The module first creates a baseline of current waste emissions by:

1. Entering the total amount of waste generated, the amount of waste diverted, and amount of waste sent to the landfill into the model; and
2. Calculating the emissions using appropriate emissions factors.

[3] Note that emissions from landfill occur gradually, often for decades after the organic waste is placed in the landfill. However, in keeping with common GHG accounting practices, these emissions are assumed to occur in the year in which the waste is placed in landfill.

[4] This differs based in disposal type; waste-to-energy is significantly different from landfilling.

[5] In most communities this is only available at a regional scale. The data is generally sourced from a sampling of waste sent to landfill, combined with the volume of waste diverted to recycling, composting, and other programs. Empirical data from Metro Vancouver was used to develop baseline waste composition estimates for Surrey.

[6] Landfill gas capture rates estimated based on best practices and precedents, and any available regulations or data reported by the landfill operator

CEEMAP then projects future waste emissions by:

1. Adjusting the per capita baseline waste emissions based on policy assumptions, plans, and through discussions with staff;
2. Applying the percentage of organic waste that will be diverted based on above policy assumptions, plans, and staff conversations (this reduces the amount of organic waste being sent to landfill and reduces landfill gas generation);
3. Applying the percentage of landfill gas that will be captured based on above policy assumptions, plans, and staff conversations (this reduces the amount of methane emissions generated by landfills);
4. Calculating the emissions factors for landfill and waste-to-energy facilities based on assumptions about technology and waste composition;
5. Calculating total emissions by multiplying the total amount of waste sent to the landfill and, if relevant, to waste-to-energy facilities by the appropriate emissions factors; and
6. Generating charts, graphs, tables and maps

Key Data Sources for Solid Waste Energy & Emissions Calculation

1. Technology Resource Inc, *Solid Waste Composition Study,* 2008
2. Metro Vancouver, *Integrated Solid Waste and Resource Management Plan*, 2010
    - Used as a basis for future targets and diversion assumptions.
3. BC Ministry of the Environment, *City of Surrey Updated 2007 Community Energy and Emissions Inventory,* 2010
4. Environment Canada, *Greenhouse Gas Calculator for Waste Management*, 2010
5. US Environmental Protection Agency *Waste Reduction Model* (WARM), 2010
    - Used for emissions factors by material type (excluding landfill gas capture)

Energy Cost Module

Individuals and businesses spend a significant amount of money on energy to operate buildings and vehicles. In general, reductions in energy spending can stimulate local re-spending.[7] Hence, a means to calculate the cost savings from policy implementation are important for effective decision-making. This module calculates baseline energy spending and potential reductions in energy spending based on the results of policy projections from previous modules.

Key Variables and Inputs

Energy costs are influenced by two key variables:

1. The energy consumed in each sector and sub-sector (calculated in the previous modules); and
2. Projected energy costs (expressed as $ per gigajoule).

The energy cost module requires the following inputs:

- Fixed energy costs, such as delivery charges;
- Energy costs for baseline year, based on empirical data;
- Forecasted energy costs from third-party estimates from regional or federal agencies (these differ depending on the fuel type);
- Where necessary, a growth/trend projection from the final year for which third-party estimates are available to additional milestone years;
- Sales tax; and
- Carbon tax (if applicable).

The costs of capital (equipment within buildings or vehicle ownership costs) are not factored in the energy cost analysis. Baseline gasoline, natural gas, and electricity prices were drawn from Natural Resources Canada, FortisBC, and BC Hydro respectively. Future projections are based on estimated % price increases from the US Energy Information Association (gasoline, natural gas) and BC Hydro (electricity). Carbon taxes were not assumed to increase after 2012.

In general the time-frame used for the model exceeds existing available third-party cost projections. Hence, the projections should be considered increasingly uncertain over longer time-frames. Unless otherwise specified, all prices are expressed in real rather than nominal units and are inflation-adjusted to the baseline year.

Outputs and Formulas

The energy cost module calculates one output: the total annual amount spent on energy. In its most simple form, this is calculated according to the following formula for each sector and fuel:

- Total Annual Spending on Energy ($) = [Energy Used Annually (Gigajoules) x [Energy Cost (Dollars per Gigajoule Consumed)]

Some fuels are combined to simplify the calculation and results (e.g. diesel fuel and gasoline are both expressed in equivalent units of gasoline-energy). Unless otherwise stated, figures are inflation-adjusted to the base year.

Process

The module first creates a baseline of current energy spending by:

1. Entering energy price data for the baseline year into the model; and

---

[7] A significant body of literature exists on “economic multipliers” in relation to energy efficiency measures. See, for example, US Department of Energy, *The Jobs Connection: Energy Use and Local Economic Development*, 1996, available at http://www.localenergy.org/pdfs/Document%20Library/The%20Jobs%20Connection.pdf

2. Calculating energy spending by multiplying the energy consumption by sector and fuel-type for the baseline year with energy prices by sector and fuel-type.

CEEMAP then projects future energy spending by:

1. Inputting forecasted energy consumption calculated from the other modules into the model;
2. Project future energy prices by multiplying energy prices by sector and fuel-type from the baseline year by the percentage increases in energy costs per gigajoule by sector and fuel-type;
3. Adding sales and carbon taxes to the projected future energy prices;
4. Calculating future energy spending by multiplying forecasted energy consumption by sector and fuel type with project energy prices by sector and fuel-type; and
5. Generating charts, graphs, tables and maps.

Key Data Sources for Energy Cost Calculations

1. Natural Resources Canada, *Average Retail Prices for Gasoline,* 2007
2. US Energy Information Administration (EIA) *Annual Energy Outlook* 2010
3. US Energy Information Administration (EIA) *Annual Energy Outlook* 2011
4. Natural Resources Canada, *Natural Gas Outlook to 2020*, 2011
5. BC Hydro *LTAP*, 2008
6. BC Hydro *Long-Term Rate Forecast*, 2010, from 2011 IRP Technical Advisory Committee Meeting