ZERO EMISSION TRANSIT FUND

The GHG+ PLUS Guidance Modules

Infrastructure Canada

Canada

DISCLAIMER

This document is intended to be a climate change and air pollutant guidance document for project developers applying to Infrastructure Canada's Zero Emission Transit Fund. The GHG and air pollutant quantification approach presented in this document is to ensure consistency and comparability of estimates between projects.

The scope of the GHG and air pollutant sources presented here is not purported to be a comprehensive life-cycle analysis of the project. Such an exercise can only be done credibly ex-post and with a large amount of information. This guidance describes an approach to estimate air emissions ex-ante, when minimal information and resources are available. In addition, the methodologies proposed in this document are intended to capture the most significant of emission sources only.

Finally, the guidance in this document is evergreen – meaning it will be periodically updated to remain aligned with advancing assessment methodologies. Please ensure you consult the Infrastructure Canada website to ensure you have the most recent version of this guidance before undertaking a Climate Change and Air Pollutant Assessment.

INTRODUCTION

This GHG+ PLUS Guidance Module provides information to help quantify greenhouse (GHG) emission and air pollutant reductions from the implementation of new zero emission buses (ZEBs), which run on either electricity or hydrogen fuel. Emission reductions are mainly based on the difference between the combustion of fossil fuels (gas/diesel) in existing or conventional bus fleets (the baseline) and the use of electricity or hydrogen in the new ZEB fleets (the project). This Module also provides guidance on assessing the adaptation and resilience of the ZEB project to a changing climate.

The GHG+ PLUS Guidance Modules provide a simple, sector-specific approach to assessing GHG emissions and air pollutants, as well as the adaptation and resilience of various projects across Canada. They are intended to be used by qualified professionals with expertise related to the project and preferably some level of GHG and air pollutant accounting experience. Each GHG+ PLUS Guidance Module is based on international standards[1] and sets out a pre-determined set of technical elements (i.e. baselines, activities and variables) and other considerations, required to assess the climate change and air pollutant impacts from a specific project type or sector.

The GHG+ PLUS Guidance Modules are built upon the following 3 principles:

1. Integrity – the guidance provides an approach to ensure GHG assessments are developed according to specific standards to ensure they are consistent, comparable and transparent to allow intended users to make decisions with reasonable confidence.

2. Rationality – the process is as simple and logical to administer as possible, while ensuring a rigorous commitment to the environmental reliability of the system.

3. Legacy – the process builds on experience and tools gained from existing project-based programs in other jurisdictions across Canada, international standards and methodologies and existing Canadian projects.

DEFINITIONS:

Fuel: includes a form of energy that is combusted or transformed to generate usable energy or provides motive force to a mechanical process. Examples of fuel include fossil fuels (oil/gas/diesel), electricity or hydrogen.

Zero-Emission Buses: Mobile fleets used in public transport that operate on clean forms of energy such as electricity or hydrogen.

[1] The GHG Modules are based upon the ISO 14064-2: Specification with guidance at the project level for quantification, monitoring, and reporting of GHG emissions reductions or removal enhancements and the World Resource Institute (WRI) GHG Protocol.

GHG EMISSION REDUCTIONS

The GHG assessment for ZEB projects provides an estimation of the GHG emissions and reductions resulting from the implementation of the zero-emission buses and all supporting infrastructure. The assessment includes important information related to the quantification process such as the scope of the assessment, relevant sources and sinks, calculations and assumptions. All information should be provided in a clear and organized format, to ensure the principles of GHG quantification have been carefully followed and GHG estimates can be easily validated. The GHG assessment is composed of the following main sections:

Project Overview:

The project overview provides a brief description of the project activities including the product or service provided by the project and any supporting infrastructure that will be developed. In addition, it includes the project location and the timeline (start and end dates) of the various phases of the project.

Upfront GHG Emissions:

This section quantifies the GHG emissions associated with the upfront (upstream and before the project) GHG emissions. This includes emissions associated with the production of materials (embodied carbon), the transport of the zero-emission buses and the GHGs related to the main construction activities associated with the supporting infrastructure.

Operational GHG Emissions:

Project Operational Scenario

The GHGs from all project operational activities are identified and quantified in this section. This Module has identified all the relevant GHG activities and sources that are to be quantified according to the step-by-step instructions for the operation of the project.

Baseline Operational Scenario

The Baseline Scenario is the “business as usual” or hypothetical reference case against which the GHG performance of the project is measured. The GHGs from all baseline activities are identified and quantified in this section. This Module has identified all the relevant GHG activities and sources that are to be quantified according to the step-by-step instructions for the operation of the baseline.

Total Operational GHG Reductions

The total GHG reductions resulting from the operation of the ZEB project are presented in this section, which includes estimated annual reductions and cumulative reductions for the lifetime of the project.

GHG PRINCIPLES

When developing any type of GHG assessment or inventory, developers should follow relevant GHG standards, guidance documents and methodologies suggested by the specific program authority. However, as the process of GHG quantification has inherent flexibility and room for interpretation, developers of GHG assessments will still be faced to make specific decisions that are outside the scope of any guidance document. On these occasions, developers should make decisions based on the overarching objectives of integrity and credibility. To achieve these objectives, developers should follow a set of common GHG quantification principles, found throughout the many GHG standards, protocols and guidance documents worldwide. The following principles have been adapted from the ISO 14064:2 Standard and should be followed when developing a GHG assessment of a project:

RELEVANCE	Selected sources (activities) of GHG emissions, data and methodologies must be appropriate to the project and the needs of the intended user.
COMPLETENESS	Include all relevant GHG emission sources. Include all relevant information to support program criteria and the GHG emission estimates.
CONSISTENCY	Developers should apply estimation methods and assumptions consistently across all aspects of the project and for all individual GHG emission sources. In other words, developers should maintain the same “quantification rules” throughout the GHG assessment.
TRANSPARENCY	All assumptions, methods, calculations, and associated uncertainties should be provided in order to allow intended users to make decisions with reasonable confidence and allow for successful validation and verification of the results.
ACCURACY	Estimates and calculations should be unbiased, and uncertainties should be reduced as far as practical. Calculations should be conducted in a manner that minimizes uncertainty.
CONSERVATIVENESS	Where there are uncertainties, the values used to quantify GHG emissions should err on the side of underestimating potential reductions.

GHG BASICS

BASELINE SCENARIO: The baseline scenario is the "business as usual" or hypothetical reference case against which the GHG performance of the project is measured. A variety of baseline approaches are available to quantify GHG emissions from a project, although not all approaches are applicable to any given project type. The baseline is the single most important aspect to GHG quantification, and pending the choice of a baseline, can result in varying estimates of GHG emissions.

PROJECT SCENARIO: The project scenario consists of the project activities, which include the GHG mitigation measures that go beyond standard codes and practice and are aimed to reduce energy and GHG emissions. The performance of the project and its mitigation measures are compared to an alternative hypothetical reference case with average energy and GHG performance (i.e. the baseline scenario).

SOURCES & SINKS: Under ISO 14064:2, a source is any process or activity that releases a greenhouse gas into the atmosphere, whereas a sink is any process, activity or mechanism that removes a greenhouse gas from the atmosphere. Although there are numerous sources and/or sinks related to a project or baseline scenario, only a few relevant activities are typically selected for quantification, as they are likely to result in significant amounts of GHG emissions.

ELEMENTS: GHG sources and sinks can be further broken down into the specific elements which are responsible for completing the activity and result in GHG emissions. For example, for the activity of heating a building, the associated element will be the stationary combustion unit such as a boiler or furnace. The specifications of an element, including how it operates, are important factors to identify and state in a GHG assessment, as they impact the overall quantity of emissions released and/or sequestered.

END VARIABLE: An end variable is the annual input/output or activity level of an element (i.e. the amount of fuel combusted in one year in a boiler) and estimated for each year of the project lifetime. End variables are generally calculated using specific data from an element or activity and gathered from various sources. Examples of end variables include: litres (L) of fuel, kWh of electricity and tonnes of hydrofluorocarbons (HFCs).

EMISSION FACTOR: An emission factor is a representative value that relates the quantity of GHGs released with a specific level or output of an activity. Emission factors are based on the unique characteristics of elements or processes, and can also be specific to the location where an activity is placed. A common equation used to estimate GHG emissions from a project or baseline activity involves an end variable and a relevant emission factor, which is typically found in Canada's National Inventory Report. The equation is structured in the following way: GHG Emissions = End Variable (EV) × Emission Factor (EF).

EX ANTE ESTIMATION: The estimation of GHG emissions prior to the development and operation of a project and actual generation of GHG emissions. As no actual data has yet been generated by the project at this stage, project proponents must look to comparable sources of data such as the following: similar projects completed by the proponent in the past; similar projects completed by others in the surrounding area; contracts, work plans or estimates for the project provided by third party contractors involved; any modeling work performed by project developers, energy consultants, etc.; and estimates developed to the best of the proponent's ability.

GHG SOURCES

Table 2.0 below provides the main GHG activities and sources throughout the implementation of a zero emission bus project. The main stages include fuel and material production, construction and transportation, operation and decommissioning. Currently under this Module, activities related to decommissioning of the project are not quantified.

GHG emissions from the transportation sector result mainly from the combustion of petroleum-based products, like diesel or gasoline, in internal combustion engines. The majority of GHG emissions emitted during fuel combustion are carbon dioxide (CO_2)emissions, but small amounts of methane (CH_4) and nitrous oxide (N_2O) are also emitted. In addition, a small amount of hydrofluorocarbons (HFC) emissions are also released from the use of mobile air conditioners.

Table 2.0 Main GHG Sources of a new Zero Emission Bus Project

Project Stage	Main Components of a Zero Emission Bus Project (hydrogen or electric)		
	Fuel	Buses	Infrastructure: Charging Stations/ Storage Facility
Upstream - Production	Fuel production (hydrogen)	Bus manufacturing (includes fuel cell/battery production)	Production of infrastructure material (embodied carbon)
Construction & Transport	NA	Transport of buses to project site (location of service)	Construction vehicles and equipment Transport of materials and construction equipment
Operation	Combustion of fuel Leakage of hydrogen Transport of hydrogen to fueling station(s)	Operation, maintenance and repairs of the buses Operation of diesel engine heaters (auxiliary power) Fugitive emissions Waste generation	Operation, maintenance and repairs of infrastructure Fugitive emissions Waste generation
Downstream-Decommissioning	NA	Vehicle scrapping and disposal (including batteries/fuel cells) Transport of vehicle waste	Infrastructure dismantling and disposal Transport of infrastructure waste

* Sources in grey are not quantified under this Module.

STEP-BY-STEP INSTRUCTIONS

This section provides step-by-step instructions for completing a GHG assessment for the replacement or purchase of a new zero emission buses. Annexes A and B provide a list of GHG sources and relevant information to be used along with these step-by-step instructions. For additional supporting information, please refer to the references in Annex F.

PART 1.0 : Project Overview

1.1 Project Description

The project description lays out the foundation for the types of activities that may release or sequester GHGs from the project, and that will need to be quantified in the assessment.

KEY ACTIONS

- *Document a brief description of the new zero emission buses and services they will be providing.*
- *Identify if the ZEB(s) will be replacing existing fleet, adding capacity or both.*
- *Identify fuel source (electric or hydrogen). If hydrogen, identify the type and source of hydrogen.*
- *Record the number of new vehicles that will be purchased and maximum passenger or freight capacity.*
- *Identify if any supporting infrastructure will be implemented (charging stations, storage facility, renewable energy, etc.)*
- *Identify any typical maintenance/repairs that will be needed throughout the operational lifetime of the buses and supporting infrastructure.*

1.2 Project Location & Service Area

The identification of the project site is important as many data values will need to be sourced and obtained from the local area, including emission factors. Validators need to be able to assess if the proper values representing the area were used or not in the quantification of the GHG emissions, and to ensure all GHG sources or sinks have been properly accounted for in the assessment.

KEY ACTIONS

- *Record the address and/or GPS coordinates of the project.*
- *Identify the service location of the new mobile fleet and delineate the boundaries of the service area on a map if possible.*
- *Identify locations of storage facility and charging stations (if applicable).*

1.3 Project Timeline

It is important to know when the project will be implemented and in full operation, including if and when GHG emission reductions will start taking place and for how long. Other important dates are the maintenance and repair schedules which will result in downtimes and interruptions in service, which will also impact any emission reductions.

KEY ACTIONS

- *Record a detailed project timeline outlining the timing of operational activities. Specifically, the following estimated dates are required:*
  - *Construction start and end date (of supporting infrastructure if applicable)*
  - *Operational start and end dates*
  - *Dates of any major maintenance/repairs/refurbishments expected*
  - *Expected lifetime of project (service life of the new fleet)*
- *Identify any risks that could substantially affect the project's operational timelines.*

PART 2.0: GHG EMISSIONS

2.1 Upstream Material Production

The overview provides a description of the type of and amount of materials used for the construction of the supporting infrastructure of the project. Currently under this Module, the main materials that are evaluated include cement, asphalt, steel and wood.

The three primary tactics to reduce life-cycle assessment impacts related to materials include 1) Reducing resource use 2) Selecting resources with lower impact intensities (impacts per unit resource) and 3) Choosing resources that are local to reduce transport GHG emissions.

KEY ACTIONS

- *Identify the various infrastructure components that will be constructed for the public transit system.*
- *Record the type and amount of each material that will be used for each component identified above. Information on the amount of each material to be used can be obtained from the project design or construction plans or can be estimated from similar projects that have been completed in the past.*
- *Information can be presented in a table such as the one below:*

Type of Infrastructure	Name or Section	Types of Materials used	Total tonnes of Concrete	Total tonnes of Asphalt	Total tonnes of Steel-Rebar	Total tonnes of Wood
Road						
Tunnel						
Shelter						
Station						
Terminal						
		TOTAL				

- *Identify the appropriate global warming potentials (GWPs) for each of the materials identified above. GWPs can be obtained from the Environmental Product Declarations (EPDs) for each material found in the [CSA Group EPD Registry]() or the [CSSBI website]().*
- *For each component of the transit system, multiply the appropriate GWPs with the amount of each material used to obtain the GHG emissions associated with the materials used for all components. The following is a sample calculation for concrete:*

  Total Concrete (tonne) x Concrete global warming potential (tonnes CO2e/MT)= Emissions tonnes CO2e/year

- *For each component, add the GHG emissions associated with each material to obtain total embodied carbon for the component.*
- *For each material, add all the GHG emissions from all the components to obtain the total GHG emissions associated with each material for the project.*
- *Provide all GWPs used in the calculations.*
- *Ensure all values are presented in a table such as the one below or other legible format.*

Type of Infrastructure	Name or Section	Concrete tonnes CO2e	Asphalt tonnes CO2e	Steel-Rebar tonnes CO2e	Wood tonnes CO2e	Total tonnes CO2e
Road						
Tunnel						
Shelter						
Station						
Terminal						
	TOTAL					

- ➢ *For each component, evaluate the amount of materials that will be required and the associated GHG emissions – are there any design options or mitigation measures that can be implemented to decrease the GHG impact from using these materials? Identify and describe any potential mitigation measures associated with the use of materials in the public transit system that will be implemented. If not possible, provide justification as to why not.*
- ➢ *Identify at least one other alternative and provide a comparison of the GHG emissions to the chosen material for the transit system. Provide justification as to why the alternative material was not chosen.*

2.2 Project Construction Emissions

The overview of the construction of the project should provide the general phases of the construction process (ex. site preparation, component installation and site restoration) and a brief description of the major construction activities.

KEY ACTIONS

- *Provide an overview of the general construction process of the project including the various phases of the construction process.*

- *Identify the phases or activities (or % of project) being constructed by the Applicant's own resources or if a third party is being contracted to build the project.*
- *Provide a timeline for the different phases of the construction process (ex. site preparation, installation, site restoration).*

Identification of Construction GHG Activities & Elements

In this section, all the relevant activities (i.e. GHG sources and sinks) for each phase of the construction process are identified.

KEY ACTIONS

- *Using the table Construction Activities in Annex E, identify the activities related to the various phases of the construction process. The information in the table is provided as a sample only, and Applicants can add or remove activities to ensure the most appropriate fit for their project.*
- *Identify and provide details for all elements required to complete the selected activities.*
- *Ensure all information is presented in a table or other legible format.*
- *Include a list of assumptions regarding the performance/use of the elements (ex. A dump truck operating at full load, 8 hours/day, 50-50 mix city/highway).*

Construction Activity 1: Vehicles

KEY ACTIONS

- *Identify the type and amount of fuel (L/Kwh) expected to be used for the operation of all construction vehicles for each construction phase.*
- *Vehicles include those that will be operated on site and used to transport material, workers, equipment, fuel and waste to and from the project location.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the vehicles by the expected vehicle kilometers travelled, which can be based on expected work or past similar projects. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in the [Fuel Consumption Guide by Natural Resources Canada]() or from the fleet manufacturer's specification. The following calculation can be used:*

  Fuel Efficiency (L/kms) x kms travelled = L of fuel

- **<u>If the vehicles are electric:</u>** *Obtain the provincial/territorial electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of provincial/territorial (P/T) grids in future years. P/T Emission intensities can be found in Annex C. To quantify GHG emissions, apply the following calculation:*
  Energy (MWh) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e

- **<u>If the vehicles are using gas/diesel/LPG/CNG</u>*:*** *Obtain the relevant emission factors from Annex D or [Canada's National Inventory Report (Annex 6),]() and apply the following calculation:*
  Fuel (L) x Specific mobile fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e

- *The fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the operation of the construction vehicles.*

Construction Activity 2: Electricity (Energy, Heating & Cooling, Equipment)

KEY ACTIONS

- *Identify the amount of electricity (MWh) expected to be used during each phase of the construction process.*
- *Estimated electricity use should be available from expected work requirements, or obtained from similar past projects.*
- *Obtain the provincial/territorial (P/T) electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of P/T grids in future years. P/T Emission intensities can be found in Annex C. For remote communities not connected to a P/T grid, use the emission factor (found in [Canada's National Inventory Report (2019)](#)) for the type of energy used to generate electricity in that location (ex. Diesel generators).*
- *To quantify GHG emissions, apply the following calculation:*

  Energy (MWh/year) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e

  Note: If replacing diesel or other fuel, substitute the P/T emission intensity for the respective fuel emission factor.

- *The energy use, emission intensities and the associated GHG emissions should be presented in a table or other legible format.*
- *Document all assumptions and references used to calculate the electricity consumption for the construction of the project and the associated GHG emissions.*

Construction Activity 3: Heating & Cooling - Fuel

KEY ACTIONS

- *Identify the amount of fuel (m^3/L/kg) of each type expected to be used for heating and cooling for each phases of the construction process.*
- *Estimated consumption of fuel(s) for heating and cooling should be available from expected work requirements, or obtained from similar past projects.*
- *Obtain the relevant emission factors for your fuel type and combustion equipment. Emission factors can be obtained from [Canada's National Inventory Report (2019)](#). Note that emission factors are presented for each of the three main gases: CO_2, CH_4 and N_20. To obtain an emission factor in units of CO_2e, multiply each emission factor for CO_2, CH_4 and N_2O by their respective 100 year global warming potentials (1, 25 and 298 respectively) and add all three values together.*
- *To quantify GHG emissions, apply the following calculation:*

  Fuel (m^3) x Specific fuel combustion emission factor (tonnes/m^3) = Emissions tonnes CO_2e
  (Fuel may be in either L or m^3- ensure the units are consistent with the appropriate emission factor)

- *The fuel use, emission factors and the associated GHG emissions should be presented in a table or other legible format.*
- *List all assumptions and references used to calculate the fuel consumption of the construction process and the associated GHG emissions and include any relevant equipment specifications.*

Construction Activity 4: Generators- Fuel

KEY ACTIONS

- *Identify the amount of fuel (m^3/L/kg) expected to be used for any generators on site during the construction process.*
- *Estimated consumption of fuel should be available based on expected work requirements, or obtained from similar past projects.*
- *Obtain the relevant emission factors for your fuel type and generator equipment. Emission factors can be obtained from [Canada's National Inventory Report (2019)](). Note that emission factors are presented for each of the three main gases: CO_2, CH_4 and N_20. To obtain an emission factor in units of CO_2e, multiply each emission factor for CO_2, CH_4 and N_2O by their respective 100 year global warming potentials (1, 25 and 298 respectively) and add all three values together.*
- *To quantify GHG emissions, apply the following calculation:*

  Fuel (m^3) x Specific fuel combustion emission factor (tonnes/m^3) = Emissions tonnes CO_2e
  (Fuel may be in either L or m^3- ensure the units are consistent with the appropriate emission factor)

- *The fuel use, emission factors and the associated GHG emissions should be presented in a table or other legible format.*
- *List all assumptions and references used to calculate the fuel consumption for generator use during the construction process and the associated GHG emissions and include any relevant equipment specifications.*

Construction Activity 5: Equipment - Fuel

KEY ACTIONS

- *Identify the type and amount of fuel (L) expected to be used for the operation of all construction equipment and machinery for each construction phase.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the equipment by the expected hours in operation, which can be based on expected work or past similar projects. The most appropriate fuel efficiency value can be found in the manufacturer's specification of the equipment. The following calculation can be used:*

  Fuel Efficiency (L/hour of operation) x hours of operation = L of fuel

- *Obtain the relevant emission factors from [Canada's National Inventory Report (Annex 6),]() and apply the following calculation:*
  Fuel (L) x Specific equipment fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e

- *The fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the operation of the construction equipment.*

Total Construction GHG Emissions

KEY ACTIONS

- *For each construction phase, sum together the tonnes of CO2e from all activities and present data in a Table such as the one below.*
  Activity 1 + Activity 2 + Activity 3 + Activity 4 + Activity 5 = Total Construction Emissions tonnes CO_2e

Table 2.2 Total Construction Emissions (in tonnes of CO_2e)							
Construction Phase	Year(s)	**Activity 1 Construction Vehicles**	**Activity 2 Electricity**	**Activity 3 Heating & Cooling- Fuel**	**Activity 4 Generators- Fuel**	**Activity 5 Equipment - Fuel**	**Total Construction Emissions**
	2021						
	2022						
	2023….						
	TOTAL						

Construction Mitigation Measures

KEY ACTIONS

Identify any potential mitigation measures that will be implemented during the construction phase of the project. Potential mitigation measures include:

- Sizing construction machinery and vehicles accordingly to the job.
- Using energy efficient vehicles and equipment, or those that use cleaner forms of fuel. Keep equipment maintained in good working order.
- Educate operators of machinery/equipment on energy saving practices, such as reducing idling if possible.
- Ensure waste materials are properly sorted and recycled.
- Encourage carpooling of all construction workers.

2.3 Transport of Zero-Emission Buses

GHG emissions related to the transportation of the buses to the site of service. GHG Emissions are related to mode of transport used, distance travelled and the type of fuel combusted.

KEY ACTIONS

- *Identify the location of the manufacturing facility of the buses.*
- *Determine the distance (km) from the manufacturing facility to the project location. This can be completed by accessing Google maps or by reviewing transportation logs. If more than one mode of transport will be used to bring the buses to the project site, divide the total distance by each of the modes of transport.*
- *Identify the type and amount of fuel (L/Kwh) expected to be used for the transport of the new buses to the project location (by each mode of transport if applicable).*
- *The amount of fuel can be estimated by multiplying the fuel efficiency of the transport vehicle by the expected vehicle kilometers travelled. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in the [Fuel Consumption Guide by Natural Resources Canada]() or the fleet manufacturer's specification. The following calculation can be used (adjust metrics to relate to appropriate fuel type):* ***Fuel Efficiency (L/kms) x kms travelled = L of fuel***

- **<u>If the transport vehicle is electric:</u>** *Obtain the provincial/territorial electrical grid emission intensity for the fueling origin of the transport vehicle. Emission intensities should be dynamic and reflect cleaning of provincial/territorial (P/T) grids in future years. P/T Emission intensities can be found in Annex C. To quantify GHG emissions, apply the following calculation:*
Energy (MWh/year) x PT Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e/year

- **<u>If the transport vehicle is using gas/diesel/LPG/CNG:</u>** *Obtain the relevant emission factors from Annex D or [Canada's National Inventory Report (Annex 6),]() and apply the following calculation:*
Fuel (L) x Specific mobile fuel combustion emission factor (tonnes/L)= Emissions tonnes CO2e/year

- *Document all assumptions and references used to calculate the amount of fuel associated with the transport of the ZEBs to the project site.*

2.4 Total Upfront Project Emissions

KEY ACTIONS

- *For each project activity, input the associated GHG emissions into a Table such as the one below.*
- *Calculate the total tonnes CO_2e per year using the following equation:*
Material Production + Construction + Transport = Total Project Emissions (tonnes CO_2e /year)

Table 2.4 Total Upfront Project Emissions
(in tonnes of CO_2e)

Year	Material Production	Construction	Transport	Total Emissions
2021				
2022				
2024				
2025…				
TOTAL				

PART 2.0: OPERATIONAL GHG EMISSIONS & REDUCTIONS

2.5 Project Operation

In this section, all the relevant activities for the operation of the project are identified, including all elements.

The most common sources of GHGs related to the implementation of a new transit system fleet is the combustion of fuel from the operation of the new buses, as well as any electricity and fuels combusted for operation of supporting infrastructure (charging stations, storage facilities, etc.). In addition, GHG emissions resulting from the maintenance and repairs of the buses and supporting infrastructure are also included. Fugitive emissions (GHG emissions resulting from air conditioning units/refrigeration, maintenance and leaks/spills of fuels and other maintenance products) and any emissions from waste generated by the buses and infrastructure are currently not included under this Module.

KEY ACTIONS

- *Using the table in Annex A as a guide, select all activities related to the project and document a brief description of each activity.*

Project Activity 1: Upstream Fuel Production

GHG emissions related to the extraction and production of the fuel used in the buses is quantified in this section. Note that for electric buses, the emissions associated with the production of electricity is accounted for under the operation emissions section.

Hydrogen can be produced in a variety of different processes that are commonly distinguished by their feedstock (e.g. water or natural gas) and associated carbon intensity. There are three main types of hydrogen, which are commonly referred to as grey, blue and green hydrogen. When using natural gas as a feedstock (i.e. to make grey and blue hydrogen), methane and carbon dioxide (CO_2) emissions from extraction and processing will affect the total carbon intensity of the product.

Characteristics of the different types of Hydrogen:

Grey Hydrogen	Blue Hydrogen	Green Hydrogen
Produced from natural gas through steam methane reforming.	Produced the same as grey hydrogen but with the incorporation of carbon capture and storage.	Produced by running an electric current through water using low-carbon sources of electricity (solar or wind)
Carbon Intensity: 11.3-12.1 kg CO_2e/kg H_2	Carbon Intensity: 2.3-4.1 kg CO_2e/kg H_2	Carbon Intensity: 0-0.6 kg CO_2e/ kg H_2

KEY ACTIONS

- *Identify the type (grey, blue or green) and amount of hydrogen fuel (kg) expected to be used for the operation of the new buses on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the buses by the expected vehicle kilometers travelled, which can be based on historical kms travelled from the operation of an existing bus fleet or based on new transportation modelling scenarios. An average of the last three years of kms travelled from internal records should be used, and any year with kms travelled that is out of the ordinary due to extraordinary circumstances, should be discarded. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found from the bus manufacturer's specification. A typical hydrogen-fueled bus requires ~ 15.5 kg H_2/100 km. The following calculation can be used:*

  Fuel Efficiency (kg H_2/100 km) x km travelled/year = kg of H_2 fuel/year

- *Obtain the relevant emission factors from the Table above and apply the following calculation:*
  Fuel (kg) x Emission Intensity for Type of Hydrogen (Grey, Blue or Green) kg CO_2e/kg H_2 = Emissions kg CO_2e/year

- *Convert all values to tonnes CO2e/year.*
- *The yearly GHG emissions from Hydrogen fuel production should be presented in a table such as the one below.*
- *Document all assumptions and references used to calculate the upstream emissions associated with Hydrogen fuel production.*

Project Activity 2: Operation of Buses (Fuel Combustion)

KEY ACTIONS

- *Identify the type and amount of fuel (L/kWh) expected to be used for the operation of the new transit vehicles or cars on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the new mobile fleet by the expected vehicle kilometers travelled, which can be based on new transportation modelling scenarios. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in the Fuel Consumption Guide by Natural Resources Canada or from the fleet manufacturer's specification. The following calculation can be used:*

  Fuel Efficiency (L/kms) x kms travelled/year = L of fuel/year

- **<u>If the new mobile fleet is electric:</u>** *Obtain the provincial/territorial electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of provincial/territorial (P/T) grids in future years. P/T Emission intensities can be found in Annex C. To quantify GHG emissions, apply the following calculation:*
  Energy (MWh/year) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e/year

- **<u>If the new mobile fleet is using gas/diesel/LPG/CNG</u>:** *Obtain the relevant emission factors from Annex D or [Canada's National Inventory Report (Annex 6)](), and apply the following calculation:*
  Fuel (L) x Specific mobile fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e/year

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the operation of the new transit vehicles / cars.*

Project Activity 3: Infrastructure Electricity Use

KEY ACTIONS

- *Identify the amount of electricity (MWh) expected to be used in all the related transit facilities (shelters / terminals, storage) on a yearly basis.*
- *Estimated electricity use should be available from energy modelling results, or obtained from similar projects in operation. Standard energy use for a similar type of facility can be used if no energy modelling information is available.*
- *Obtain the provincial/territorial (P/T) electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of P/T grids in future years. P/T Emission intensities can be found in Annex C. For remote communities not connected to a P/T grid, use the emission factor (found in [Canada's National Inventory Report (2019)]()) for the type of energy used to generate electricity in that location (ex. Diesel generators).*
- *To quantify GHG emissions, apply the following calculation:*

  Energy (MWh/year) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e /year

  Note: If replacing diesel or other fuel, substitute the P/T emission intensity for the respective fuel emission factor.

- *The yearly energy use, emission intensities and the associated GHG emissions should be presented in a table or other legible format.*
- *Document all assumptions and references used to calculate the electricity consumption of the transit facilities and the associated GHG emissions.*

Project Activity 4: Infrastructure Heating & Cooling - Fuel

KEY ACTIONS

- *Identify the amount of fuel (m^3/L/kg) of each type expected to be used in the transit facilities for heating and cooling on a yearly basis.*
- *Estimated consumption of fuel(s) for heating and cooling should be available from energy modelling results, or obtained from similar projects in operation. Standard fuel use for a similar type of facility can be used if no energy modelling information is available.*

- *Obtain the relevant emission factors for your fuel type and combustion equipment. Emission factors can be obtained from [Canada's National Inventory Report (2019)](). Note that emission factors are presented for each of the three main gases: CO_2, CH_4 and N_20. To obtain an emission factor in units of CO_2e, multiply each emission factor for CO_2, CH_4 and N_2O by their respective 100 year global warming potentials (1, 25 and 298 respectively) and add all three values together.*
- *To quantify GHG emissions, apply the following calculation:*

  Fuel (m^3) x Specific fuel combustion emission factor (tonnes/m^3) = Emissions tonnes CO_2e/year
  (Fuel may be in either L or m^3- ensure the units are consistent with the appropriate emission factor)

- *The yearly fuel use, emission factors and the associated GHG emissions should be presented in a table or other legible format.*
- *List all assumptions and references used to calculate the fuel consumption of the transit facilities and the associated GHG emissions and include any relevant equipment specifications.*

Project Activity 5: Maintenance and Repair Equipment

KEY ACTIONS

- *Identify the type and number of all maintenance and repair equipment and machinery that will be used in the transit system operations.*
- *Identify the type and amount of fuel (L) expected to be used for the equipment and machinery on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the equipment by the expected hours in operation, which can be based on expected work or past similar projects or projects in operation. The most appropriate fuel efficiency value can be found in the manufacturer's specification of the equipment. The following calculation can be used:*

  Fuel Efficiency (L/hour of operation) x hours of operation = L of fuel

- *Obtain the relevant emission factors from [Canada's National Inventory Report (Annex 6),]() and apply the following calculation:*
  Fuel (L) x Specific equipment fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the maintenance and repair equipment and machinery of the transit facility.*

Project Activity 6: Maintenance and Repair Vehicles

KEY ACTIONS

- *Identify the type and number of all maintenance and repair vehicles that will be used in the transit system operations.*
- *Identify the type and amount of fuel (L/Kwh) expected to be used in the maintenance and repair vehicles of the new transit system on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the maintenance and repair vehicles by the expected vehicle kilometers travelled, which can be based on expected work or similar past projects or project in operation. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in the [Fuel Consumption Guide by Natural Resources Canada](#) or from the vehicle manufacturer's specification. The following calculation can be used:*

  Fuel Efficiency (L/kms) x kms travelled/year = L of fuel/year

- **If the vehicles are electric:** *Obtain the provincial/territorial electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of provincial/territorial (P/T) grids in future years. P/T Emission intensities can be found in Annex C. To quantify GHG emissions, apply the following calculation:*
  Energy (MWh/year) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e/year

- **If the vehicles are gas/diesel/LPG/CNG:** *Obtain the relevant emission factors from Annex D or [Canada's National Inventory Report (Annex 6),](#) and apply the following calculation:*
  Fuel (L) x Specific mobile fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e/year

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the operation of the maintenance and repair vehicles.*

Total Project Operational GHG Emissions

KEY ACTIONS

- *For each project activity, input the associated GHG emissions into a Table such as the one below.*
- *Calculate the total tonnes CO_2e per year using the following equation:*
  Activity 1 + Activity 2 + Activity 3 + Activity 4 + Activity 5 = Activity 6 = Total Operational Emissions (tonnes CO_2e /year)
- *Sum all the years to obtain the cumulative tonnes CO_2e over the project lifetime*

Table 2.5 Total Project Operational Emissions (in tonnes of CO_2e)

Year	Activity 1 Fuel	Activity 2 Operation of Buses	Activity 3 Infrastructure - Electricity	Activity 4	Activity 5 M&R	Activity 6 M&R	Total Operational Emissions

	Production (Hydrogen)			Infrastructure - Heating & Cooling- Fuel	Equipment -Fuel	Vehicles - Fuel	
2021							
2022							
2023…							
2030							
2031…							
2050							
TOTAL							

2.6 Baseline Operation

The Baseline Scenario is the "business as usual" or hypothetical reference case against which the GHG performance of the project is measured. Under this GHG Guidance Module, the most appropriate baseline scenario for the implementation of a new mobile fleet would be the following:

The continued operation of the current mobile fleet or the purchase of a conventional gas or diesel-based mobile fleet with average fuel efficiency.

The baseline must also follow these requirements:

- Level of service or capacity (ex. # of passengers or tonnes of freight transported) must be equal to the level of service anticipated in the project scenario. The level of output or services provided must be the same in the project as in the baseline, to ensure that the project is not reducing GHG emissions solely by providing fewer services.

- Travel routes will be of the same length in the baseline as in the project scenario. All other travel variables, such as terrain and vehicle speeds, are also assumed to be the same in the baseline as in the project scenario.

- Adjustments for future anticipated changes in refurbishment/ replacement of the baseline mobile fleet must be included. For vehicles equipment efficiency levels, the current performance level may be applied until the natural end of the lifetime of the vehicles. After this date, the vehicle efficiency level must reflect any refurbishments set to occur or reflect the current regulated performance level for the **vehicles or** the current standard efficiency for its replacement. **Simply ending the services provided by the mobile service is not an acceptable alternative when the vehicles are no longer operational.**

KEY ACTIONS

- *Document a description of the baseline scenario, including the current mobile fleet characteristics, level of services, type of fuel used and sources of fuel.*
- *Document the maximum passenger or freight capacity of the current mobile fleet.*

- *Include all assumptions under the baseline scenario as applicable.*
- *Using the table in Annex A as a guide, select all activities related to the baseline and document a brief description of each activity.*
- *Ensure all information is presented in a table or other legible format.*

Baseline Activity 1: Upstream Fuel Production

KEY ACTIONS

- *Identify the type and amount of diesel fuel (L) that would be required for the operation of the alternative buses on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the buses by the expected vehicle kilometers travelled, which can be based on historical kms travelled from the operation of an existing bus fleet or based on new transportation modelling scenarios. An average of the last three years of kms travelled from internal records should be used, and any year with kms travelled that is out of the ordinary due to extraordinary circumstances, should be discarded. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in the [Fuel Consumption Guide by Natural Resources Canada]() or from the bus manufacturer's specification. The following calculation can be used:*

Fuel Efficiency (L/kms) x kms travelled/year = L of fuel/year

- *Using the following equation, calculate the amount of GHG emissions associated with the upstream production of diesel:*

Fuel (L) x Emission Intensity of Diesel Extraction & Production (0.4117 kg CO2e/L) = Emissions kgs CO_2e/year

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions and references used to calculate the upstream emissions associated with diesel fuel production.*

Baseline Activity 2: Operation of Diesel Buses

KEY ACTIONS

- *Identify the type and amount of fuel (L) that is currently being combusted on a yearly basis in the existing fleet or that would be used in a new conventional mobile fleet of average fuel efficiency.*
- *The amount of fuel used annually can be obtained one of two ways:*
  1. *Amount of fuel used annually can be obtained by looking at historical internal fuel purchase records and assuming the same amount of fuel will be used in the future. An average of the last three years of fuel records should be used, and any year with fuel use that is out of the ordinary due to extraordinary circumstances, should be discarded.*
  2. *Amount of fuel can be estimated by multiplying the fuel efficiency of the mobile fleet by the expected vehicle kilometers travelled, which can be based on historical kms travelled from the operation of the*

existing mobile fleet or based on new transportation modelling scenarios. An average of the last three years of kms travelled from internal records should be used, and any year with kms travelled that is out of the ordinary due to extraordinary circumstances, should be discarded. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in [the Fuel Consumption Guide by Natural Resources Canada] or from the fleet manufacturer's specification. The following calculation can be used:

Fuel Efficiency (L/kms) x kms travelled/year = L of fuel/year

- *To obtain the yearly GHG emissions from the conventional mobile fleet, identify the relevant emission factors from Annex D or [Canada's National Inventory Report (Annex 6)] and apply the following calculation:*

  Fuel (L) x Specific mobile fuel combustion emission factor (tonnes CO_2e/L)= Emissions tonnes CO_2e/year

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions and references used to calculate the amount of fuel associated with the operation of the existing or conventional mobile fleet.*

Baseline Activity 3: Infrastructure Electricity

KEY ACTIONS

- *Identify the amount of electricity (MWh) expected to be used in all the related transit facilities (shelters / terminals, storage) on a yearly basis.*
- *Estimated electricity use should be available from energy modelling results, or obtained from similar projects in operation. Standard energy use for a similar type of facility can be used if no energy modelling information is available.*
- *Obtain the provincial/territorial (P/T) electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of P/T grids in future years. P/T Emission intensities can be found in Annex C. For remote communities not connected to a P/T grid, use the emission factor (found in [Canada's National Inventory Report (2019)]) for the type of energy used to generate electricity in that location (ex. Diesel generators).*
- *To quantify GHG emissions, apply the following calculation:*

  Energy (MWh/year) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e /year

  Note: If replacing diesel or other fuel, substitute the P/T emission intensity for the respective fuel emission factor.

- *The yearly energy use, emission intensities and the associated GHG emissions should be presented in a table or other legible format.*
- *Document all assumptions and references used to calculate the electricity consumption of the transit facilities and the associated GHG emissions.*

Baseline Activity 4: Infrastructure Heating & Cooling

KEY ACTIONS

- *Identify the amount of fuel (m^3/L/kg) of each type expected to be used in the transit facilities for heating and cooling on a yearly basis.*
- *Estimated consumption of fuel(s) for heating and cooling should be available from energy modelling results, or obtained from similar projects in operation. Standard fuel use for a similar type of facility can be used if no energy modelling information is available.*
- *Obtain the relevant emission factors for your fuel type and combustion equipment. Emission factors can be obtained from [Canada's National Inventory Report (2019)]. Note that emission factors are presented for each of the three main gases: CO_2, CH_4 and N_20. To obtain an emission factor in units of CO_2e, multiply each emission factor for CO_2, CH_4 and N_2O by their respective 100 year global warming potentials (1, 25 and 298 respectively) and add all three values together.*
- *To quantify GHG emissions, apply the following calculation:*

  Fuel (m^3) x Specific fuel combustion emission factor (tonnes/m^3) = Emissions tonnes CO_2e/year
  (Fuel may be in either L or m^3- ensure the units are consistent with the appropriate emission factor)

- *The yearly fuel use, emission factors and the associated GHG emissions should be presented in a table or other legible format.*
- *List all assumptions and references used to calculate the fuel consumption of the transit facilities and the associated GHG emissions and include any relevant equipment specifications.*

Baseline Activity 5: Maintenance and Repair Equipment

KEY ACTIONS

- *Identify the type and number of all maintenance and repair equipment and machinery that will be used in the transit system operations.*
- *Identify the type and amount of fuel (L) expected to be used for the equipment and machinery on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the equipment by the expected hours in operation, which can be based on expected work or past similar projects or projects in operation. The most appropriate fuel efficiency value can be found in the manufacturer's specification of the equipment. The following calculation can be used:*

  Fuel Efficiency (L/hour of operation) x hours of operation = L of fuel

- *Obtain the relevant emission factors from [Canada's National Inventory Report (Annex 6),] and apply the following calculation:*
  Fuel (L) x Specific equipment fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the maintenance and repair equipment and machinery of the transit facility.*

Baseline Activity 6: Maintenance and Repair Vehicles

KEY ACTIONS

- *Identify the type and number of all maintenance and repair vehicles that will be used in the transit system operations.*
- *Identify the type and amount of fuel (L/Kwh) expected to be used in the maintenance and repair vehicles of the new transit system on a yearly basis.*
- *Amount of fuel can be estimated by multiplying the fuel efficiency of the maintenance and repair vehicles by the expected vehicle kilometers travelled, which can be based on expected work or similar past projects or project in operation. The combined fuel efficiency value can be used (50-50 mix of highway and city) or the most appropriate fuel efficiency value can be selected for the operational scenario and can be found in the [Fuel Consumption Guide by Natural Resources Canada]() or from the vehicle manufacturer's specification. The following calculation can be used:*

  Fuel Efficiency (L/kms) x kms travelled/year = L of fuel/year

- **<u>If the vehicles are electric:</u>** *Obtain the provincial/territorial electrical grid emission intensity for your location. Emission intensities should be dynamic and reflect cleaning of provincial/territorial (P/T) grids in future years. P/T Emission intensities can be found in Annex C. To quantify GHG emissions, apply the following calculation:*
  Energy (MWh/year) x P/T Emission Intensity (tonnes CO_2e/MWh) = Emissions tonnes CO_2e/year

- **<u>If the vehicles are gas/diesel/LPG/CNG:</u>** *Obtain the relevant emission factors from Annex D or [Canada's National Inventory Report (Annex 6),]() and apply the following calculation:*
  Fuel (L) x Specific mobile fuel combustion emission factor (tonnes/L)= Emissions tonnes CO_2e/year

- *The yearly fuel use, emission factors and the associated GHG emissions is most useful when presented in a table or other legible format.*
- *Document all assumptions made to obtain/calculate the amount of fuel associated with the operation of the maintenance and repair vehicles.*

Total Baseline Operational GHG Emissions

KEY ACTIONS

- *For each baseline activity, input the associated GHG emissions into a Table such as the one below.*
- *Calculate the total tonnes CO_2e per year using the following equation:*
  Activity 1 + Activity 2 + Activity 3 = Activity 4 + Activity 5+ Activity 6 = Total Baseline Emissions (tonnes CO_2e /year)

- *Sum all the years to obtain the cumulative tonnes CO_2e over the baseline lifetime.*

Table 2.6 Total Baseline Operational Emissions (in tonnes of CO_2e)							
Year	**Activity 1 Fuel Production (Diesel)**	**Activity 2 Operation of Buses**	**Activity 3 Infrastructure-Electricity**	**Activity 4 Infrastructure - Heating & Cooling- Fuel**	**Activity 5 M&R Equipment -Fuel**	**Activity 6 M&R Vehicles-Fuel**	**Total Operational Emissions**
2021							
2022							
2023…							
2030							
2031…							
2050							
TOTAL							

2.7 Total GHG Reductions

The general equation for calculating total GHG emission reductions is:

Baseline Emissions - Project Emissions = Total GHG Emission Reductions

Emission reductions are calculated per year of the project lifetime, by subtracting the project emissions from the baseline emissions. Then all emission reductions for the given years are summed to obtain the total estimated emission reductions from the implementation of the Project.

KEY ACTIONS

- *Input the project and baseline emission values into a table (sample provided below).*
- *Calculate the total GHG emission reductions by subtracting project emissions from the baseline emissions.*

Table 2.7 Total GHG Reductions (in tonnes of CO_2e)			
Year	**Baseline Emissions**	**Project Emissions**	**Total GHG Reductions**
2020			
2021			
2022….			
2030			
2031….			
2050			
TOTAL			

AIR POLLUTANTS

Air pollution has major adverse impacts on the environment and the health of Canadians. Public transport vehicles running on conventional fossil fuels emit various air pollutants including volatile organic compounds (VOCs), nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), nonmethane hydrocarbons (NMHCs) and sulphur oxides (SO_x). Emissions of these substances to the atmosphere is known to affect human health and contribute to ground level ozone, smog, and acid rain.

When determining the emission rate of pollutants, key variables are vehicle speed and engine load. These relationships are neither linear nor consistent between pollutants- for example, emissions rates for VOCs generally decrease with increasing vehicle speed, whereas emission rates for nitrogen oxides initially drop as speed increases, and then rise again at higher speeds. An overview of the most common pollutants are found below:

NOx

-Highly reactive family of gases formed from burning of nitrogen in fossil fuels and nitrogen compounds in air.
- increase with increasing engine temperature
- adverse effects on respiratory systems and vegetation, precursor to ground level ozone and acid rain.
- Nitrogen dioxide (NO2) most common; Nitrogen oxide (NO) creates the brown haze of smog.

SOx

- Product of the combustion of fossil fuels that contain sulphur.
- can impact both human health and the environment.
- SO2 can cause irritation to the respiratory system, respiratory diseases and cancer.
- SO2 dissolves in water vapour to form acids (e.g., acid rain) and interacts with other gases and particles to form sulphates and other detrimental products.

CO

- A toxic gaseous product of incomplete combustion of gasoline and diesel fuel (especially in poorly maintained vehicles).
- CO emissions increase at lower temperatures .
- interferes with the bloods ability to carry oxygen to the brain, heart, and other tissues; slows reflexes and causes fatigue, headache, confusion, nausea, and dizziness.

AIR POLLUTANTS FROM TRANSPORTATION

NMHCs

-Products of incomplete combustion process which can occur during operation of the internal combustion engine.
– include pollutants such as acetylaldehyde and formaldehyde.
– contribute to ground-level ozone or smog.
– can have negative health impacts and irritate eyes, skin and the respiratory tract.

VOCs

- large group of carbon-containing gases and vapours that are products of gasoline combustion.
- have been identified as toxic and/or carcinogenic to humans.
- although usually found at low concentrations, these substances are also precursors to ground-level ozone and PM2.5.

PM

- mixture of small particles and droplets including acids, organic chemicals, metals, soil or dust.
- can be a primary pollutant *or* a secondary pollutant from HCs, NOx, and SO2.
- two size ranges: PM2.5 and PM10
-potential to cause aggravated cardiac and respiratory diseases.
- can have adverse effects on vegetation and visibility, can remain suspended in air for days or weeks.

STEP-BY-STEP INSTRUCTIONS

This section provides step-by-step instructions for completing an air pollutant assessment for the replacement or purchase of new zero emission buses. For additional supporting information, please refer to the references in Annex F.

3.1 Quantification of Air Pollutants

Fuel Type	Emission Factors: Criteria Air Contaminants (in g/km)				
	CO	NO2	SO2	PM	VOC
Diesel	0.23	0.50	0.04	0.02	0.33
Gas	0.47	0.34	0.03	0.01	1.07
EV	0.00	0.00	0.00	0.00	0.00
Hydrogen	0.00	0.00	0.00	0.00	0.00

Source: GHGenius (www.ghgenius.ca)

KEY ACTIONS

- *Identify the annual kms travelled by the existing conventional buses or the expected kms that will be travelled.*
- *The annual kms travelled can be based on historical kms travelled from the operation of the existing mobile fleet or based on new transportation modelling scenarios. An average of the last three years of kms travelled from internal records should be used, and any year with kms travelled that is out of the ordinary due to extraordinary circumstances, should be discarded.*
- *To obtain the yearly air pollutants, identify the relevant emission factors from the table above and apply the following calculation:*

Kms travelled (in one year) x Specific air pollutant emission factor (g/km)= Emissions g/year

(Values should be converted to kg)

- *The annual km travelled, emission factors and the associated air pollutant emissions are most useful when presented in a table or other legible format.*
- *Document all assumptions and references used to calculate the amount of fuel associated with the operation of the existing or conventional mobile fleet.*

3.2 Total Net Change in Air Pollutants

KEY ACTIONS

- *Input the project and baseline emission values into a table such as the one below.*
- *Calculate the total air pollutants and/or reductions by subtracting project emissions from the baseline as shown in the following calculation:*

Baseline air emissions – Project air emissions = Net change in air emissions

Table 3.0 Total Net Change in Air Pollutants (in kgs)															
Year	**CO**			**NO2**			**SO2**			**VOCs**			**PM**		
	Base	**Project**	**Net**	**Base**	**Project**	**Net**	**Base**	**Project**	**Net**	**Base**	**Project**	**Net**	**Base**	**Project**	**Net**
2021															
...															
...															
2050															
TOTAL															

ADAPTATION & RESILIENCE

This guidance provides information to help undertake a climate resilience assessment for the implementation of new zero emission buses (ZEBs). This is a risk assessment that includes an analysis of future climate conditions and proposes risk treatment measures, and is composed of the following:

Scope, Boundaries and Timescale of the Assessment

The assessment is designed to support better decision-making during the project's planning and design stages. This first requires understanding what exactly is under assessment. The scope and boundaries of the assessment should consider the full spectrum of project design choices being made (e.g., location, materials used, construction methods etc.). The assessment should also consider the vulnerabilities and climate risks to the electrical grid where appropriate. The timescale of the assessment should also match the lifespan of the asset, unless there is an appropriate justification for using a different timeframe.

Risk Management Framework

The assessment is a risk assessment that includes the analysis of future climate conditions and risk treatment for the proposed project. The objective of this exercise is to identify, evaluate and manage risks. Risk management could involve doing nothing or implementing risk treatment strategies, to reduce the risk to an acceptable level. This process helps identify best solutions.

Determining the Level of Risk Analysis

Depending on the project and the types of hazards and risks identified, further analysis may be required. Assessments will be undertaken across different geographies and climate zones, under different climate hazards.

Identification and Assessment of Climate Change Risks

Each climate change hazard and impact may have several consequences and it is important that these risks be identified separately. This will allow each risk to be rated separately to reflect any potential differences in priority. Risk identification should include consideration of impacts from extreme events (e.g., increased storm intensity, heat waves, etc.) impacts resulting from incremental or slow onset events (e.g., sea-level rise, etc.), and consideration of cascading and cumulative impacts.

Analysis of Risk, Consequence, Likelihood and Vulnerability

The assessment should identify the magnitude of the consequence of an event and its likelihood of occurring. The consequence and likelihood should be considered in the context of the climate change scenario(s) being considered and the existing controls to manage the risk.

Risk Treatment or Adaptation Measures to be taken

Once climate risks are identified, the next step is to identify which risk treatments or adaptation measures (e.g. changes to location, design or build, operations and maintenance etc.) can be implemented to address the risks. This can also include an analysis of the anticipated residual risk or the risk treatment measures as well as cost considerations for taking these measures.

RESILIENCE PRINICPLES

A Climate Change Resilience Assessment is a risk assessment that includes an analysis of future climate conditions and proposes risk treatment measures for the proposed project. When developing any type of Climate Resilience assessment, developers should follow relevant standards, guidance documents and methodologies suggested by the specific program authority. However, as the process of assessing climate risks has inherent flexibility and room for interpretation, developers of Resilience assessments will still be faced to make specific decisions that are outside the scope of any guidance document. On these occasions, developers should make decisions based on the overarching objectives of integrity and credibility. To achieve these objectives, developers should follow a set of common climate resilience principles.

PROPORTIONATE ASSESSMENT	The level of effort and detail in assessing risk and identifying solutions should reflect: The project cost and scope, how vulnerable the asset is to climate impacts, and how important the asset is to providing or protecting essential services (criticality of asset).
SYSTEMIC ANALYSIS OF RISK	A holistic approach should assess climate hazards according to likelihood and consequence, based on best available science and data (including historical data and future climate projections), asset vulnerability, and also consider infrastructure interdependencies. A network perspective considers dependencies and interdependencies, when appropriate. An impact to a single asset can result in significant damage on a city-wide, regional, national or even international scale. Priority-setting of possible measures should, should consider redundancy, prioritize no-regrets options and avoid locking-in costly decisions that narrow future options.
PURSUIT OF MULTIPLE BENEFITS	Opportunities should be maximized to provide many benefits, e.g., considering synergies with greenhouse gas emissions reduction. Adaptation initiatives that are not GHG-intensive should be strongly considered. Increasing emissions to address climate impacts (e.g., use of fossil-fuel powered air conditioning to counter extreme heat) may be avoided through a detailed assessment of different options to clarify potential GHG impacts of adaptation actions. Consider natural infrastructure.
AVOIDANCE OF UNINTENDED CONSEQUENCES	Seeking to avoid risk transference from one asset to others, preserving decision-making flexibility over the long-term (to accommodate new technologies and information), and pursuing no-regrets approaches and first-order solutions.

STEP-BY-STEP INSTRUCTIONS

This section provides step-by-step instructions for completing a climate resilience assessment for the replacement or purchase of new zero emission buses.

PART 1.0 : Project Overview

1.4 Project Description

The project description lays out the foundation for the types of activities that will occur on the project site. The type of technologies/project materials that will be used can also be described here. The project description lays out the foundation for understanding the types of risks climate change may pose to the project, and that will need to be assessed.

KEY ACTIONS

- *Document a brief description of the new zero emission buses, all of the project components and services they will be providing.*
- *Identify if any supporting infrastructure will be implemented (charging stations, storage facility, renewable energy, etc.)*
- *If relevant, describe any resilience considerations that have already been considered/ included in the project.*

1.5 Establish scope and boundaries of the assessment

The scope and boundaries of the assessment must be clearly described and include the full spectrum of project design choices being made (location, materials used, construction methods/standards etc.). Considerations of climate risks during the construction phase as well as changes in climate risks during the planned operation and maintenance phases should be included.

KEY ACTIONS

- *Describe all of the infrastructure components included in the assessment.*
- *Describe the location and boundaries of the assessment*
- *If relevant describe what is excluded from the analysis and why.*
- *Identify potential immediate upstream and downstream impacts of the project.*

1.6 Project Timeline

It is important to know when the project will be implemented and in full operation, and the full lifespan of the asset. The timescale of the assessment must match the intended lifespan of the asset, unless there is an appropriate justification for a different timeframe. For longer-lifespan assets, both shorter-term and longer-term climate change impacts must also be examined, and different emissions scenarios.

KEY ACTIONS

- *Identify the lifespan of the new zero emission buses and all of the project components, and the timescale of the resilience assessment to match.*

PART 2.0: Risk Identification

2.1 Identify Climate Change Parameters

The first step in assessing the potential impacts of climate change is to understand the interactions of historical climate conditions with your geographical area of interest, (i.e., where your project will be located), both in terms of trends in key climate variables (e.g., precipitation or temperature) and records of extreme events (e.g., heat waves, floods). Understanding this historical record can help identify areas of vulnerability and provide a baseline of climate conditions to compare against projected future changes in the climate.

Risk identification should include, as appropriate, consideration of impacts from extreme events (e.g., increased storm intensity, heat waves, etc.) as well as impacts resulting from incremental or slow onset events (e.g., increased drought, sea-level rise, permafrost thaw, etc.).
Risk identification should also include, as required, consideration of cascading and cumulative impacts.

KEY ACTIONS

- *Identify climate change parameters that are relevant to your project. Be sure to include any climate change parameters that could impact the electrical grid if the project is reliant on and/or vulnerable to interruptions of the electrical grid , in order to answer* ***Application Question 46****.*
- *Collect baseline information for each climate parameter.*
- *Identify any risks which present a minimal or no level of risk that may be removed from further consideration.*
- *Identify existing control measures and describe preliminary thoughts about potential additional adaptation or control measures.*
- ***List the climate parameters identified as part of the Application Question 45.b)***

2.2 Collect Required Climate Data

This is the beginning of the risk assessment process. The sequence of risk events and/or slow climate onset events resulting from climate change impacts are carefully assessed and given a preliminary examination.

ECCC provides climate model projections for a range of emission scenarios, also called Representative Concentration Pathways (RCPs). These are a set of emission scenarios that range from a low emission scenario characterized by active GHG mitigation (RCP 2.6), through intermediate scenarios (RCP 4.5), to a high emission scenario (RCP 8.5).

KEY ACTIONS

- *Begin to collect both historic, and current data for your climate change hazards.*
- *For projects with longer lifespans identify both shorter term and longer term climate impacts and different emission scenarios (RCPs) should be used in the analysis.*

- *Per best practice in climate science consult multiple climate models (i.e, multi-model ensembles that group results from multiple climate models together) that project future changes across a range of greenhouse gas emission scenarios to assess the potential impacts of climate change.*
- *Identify both the current and projected climate change impacts and the associated potential risks to the asset, system and surrounding environment.*
- ***Record the climate data sources used as part of the Application Question 45.b)***

Climate Data and Sources

The following is a list of resources to support proponents with selecting data to support their climate resilience assessment. It includes references to national and regional climate service providers, climate data portals, and other sources of climate data and information across the country.

Please note that this list is not exhaustive and that the inclusion of a resource does not mean it is current or the best available information available. For example, local governments may have more detailed flood maps that should be used.

Canada Centre for Climate Services

The CCCS has developed a suite of data portals that are useful for Canadians looking for an entry-level understanding of climate change trends, informed decision-makers that need high-resolution data, and researchers with climate science backgrounds looking to collaborate and share information. These portals include:

- Climate Atlas of Canada
- ClimateData.ca
- Platform for the Analysis and Visualization of Climate Science

The CCCS also helps guide Canadians in their understanding and use of climate data by providing direct access to climate experts through the Climate Services Support Desk. The Support Desk can be reached by phone at 1-833-517-0376, by email at info.cccs-ccsc@canada.ca, or through the CCCS website. Please check the CCCS website on a regular basis as new tools and resources become available.

Climate Resilient Buildings and Core Public Infrastructure (CRBCPI) report: an assessment of the impact of climate change on climatic design data in Canada

The National Research Council, in collaboration with Environment and Climate Change Canada and other partners, has released a forward-looking set of climate data that aligns with design information used in the National Building Code of Canada and Canadian Highway Bridge Design Code. This data, which must be used following guidance provided in the associated report, is available here: https://climate-scenarios.canada.ca/?page=buildings-report-overview

Environment and Climate Change Canada Climate Datasets

- Canadian Climate Data and Scenarios: http://climate-scenarios.canada.ca/?page=main

- Canadian Gridded Temperature and Precipitation Anomalies (CANGRD): https://open.canada.ca/data/en/dataset/3d4b68a5-13bc-48bb-ad10-801128aa6604
- Adjusted and Homogenized Canadian Climate Data (AHCCD): https://open.canada.ca/data/en/dataset/9c4ebc00-3ea4-4fe0-8bf2-66cfe1cddd1d
- Canadian Climate Normals and Averages: http://climate.weather.gc.ca/climate_normals/
- Canadian Historical Climate Data : http://climate.weather.gc.ca/historical_data/search_historic_data_e.html
- Engineering Climate Datasets: http://climate.weather.gc.ca/prods_servs/engineering_e.html

The CANGRD and AHCCD datasets, climate normals, and daily historical climate data from select weather stations can also be viewed through an interactive map and downloaded from the CCCS website.

ClimateData.ca also provides interactive access to daily historical climate data, and intensity-duration-frequency (IDF) curves available under Engineering Climate Datasets.

Natural Resources Canada Datasets

- Federal Geospatial Platform: https://gcgeo.gc.ca/en/index.html
- Canadian Forestry Service: https://cfs.nrcan.gc.ca/projects/3

Other national datasets

- Climate Change Hazards Information Portal (CCHIP): http://cchip.ca/
- Future-Looking Climate Data-NRC CRBCPI: https://climate-scenarios.canada.ca/?page=buildings-report

Regional Climate Data

- Atlantic Climate Adaptation Solutions Association: https://atlanticadaptation.ca/
- Canadian Climate Data and Scenarios: http://climate-scenarios.canada.ca/?page=main
- Climate West: https://climatewest.ca/
- New Brunswick's Future Climate Data: http://acasav2.azurewebsites.net/
- Newfoundland and Labrador, Climate Data and Tools: http://www.turnbackthetide.ca/tools-and-resources/climate-data-and-tools.shtml
- Ontario Climate Risk Institute: https://climateriskinstitute.ca/climate-data/
- Ouranos (Québec): https://www.ouranos.ca/
- Pacific Climate Impacts Consortium (British Columbia): https://www.pacificclimate.org/
- Prairie Climate Centre: http://prairieclimatecentre.ca/

Provincial and Territorial Flood Maps

- British Columbia: http://www.env.gov.bc.ca/wsd/data_searches/fpm/reports/index.html
- Alberta: https://floods.alberta.ca/
- Manitoba: https://www.gov.mb.ca/mit/floodinfo/floodoutlook/watersheds_data_maps.html
- Ontario: https://www.ontario.ca/law-and-safety/flood-forecasting-and-warning-program
- Quebec: https://www.cehq.gouv.qc.ca/zones-inond/carte-esri/index.html

- New Brunswick: http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/flood/flood_maps.html
- Newfoundland and Labrador: http://www.mae.gov.nl.ca/waterres/flooding/frm.html

Federal Flood Mapping Guidelines
These are a series of evergreen guidelines that will help advance flood mapping activities across Canada. The publication of these documents will contribute to better addressing overland flooding – Canada's costliest hazard – by strengthening flood mapping across the country.

- Federal Flood Mapping Framework (Version 2.0): https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=308128
- Federal Airborne LiDAR Data Acquisition Guideline (Version 2.0): https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=308382
- Bibliography of Best Practices and References for Flood Mitigation (Version 2.0): https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=308380

Case Studies on Climate Change in Floodplain Mapping (Version 1.0): https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=306436

PART 3.0: RISK ANALYSIS

3.1 Assessment of Likelihood/ Consequence

In this section, The assessment must identify the magnitude of the consequence of an event and its likelihood of occurring. The consequence and likelihood should be considered in the context of:

- the climate change scenario(s) being considered; and
- the existing controls to manage the risk.

KEY ACTIONS

- *Identify estimates of likelihood and consequence of risk events and opportunities, including risk events to the electrical grid if the project is reliant on and/or vulnerable to interruptions of the electrical grid.*
- *Tables 3.1 provides an example of how to calculate estimates of likelihood of risks.*
- *Table 3.2 below provides an example of how to calculate estimates of consequences of risks.*

Table 3.1 Estimates of Likelihood of Risks

Probability Range Type of Event	Very low	Low	Moderate	High	Very High
Event(s)	Not likely to occur in period	Likely to occur once between 30 and 50 years	Likely to occur once between 10 and 30 years	Likely to occur at least once a decade	Likely to occur once or more annually
On-going/ Cumulative Occurrence	Not likely to become critical/ beneficial in period	Likely to become critical/ beneficial in 30-50 years	Likely to become critical/ beneficial in 10-30 years	Likely to become critical/ beneficial in a decade	Will become critical/ beneficial within several years

Table 3.2 Estimates of Consequences

	People				Economic			Environment			
Factor Degree	Health & Safety	Displacement	Loss of Livelihood	Reputation	Infrastructure Damage	Financial Impact on Proponent	Financial Impact on Stakeholders	Air	Water	Land	Eco-system
Very low											
Low											
Moderate											
High											
Very High											

3.2 Risk Ranking

In this step a process for comparing or ranking each risk event is developed. This is done by confirming the overall likelihood and consequence rating that was carried out in Step 3.1, including costs, benefits and acceptability.

In this step you should identify unacceptable risks and rank them for risk reduction or control measures.

KEY ACTIONS

- *Risks are evaluated in terms of likelihood, consequence, and with some sense of cost and benefits.*
- *Risks are ranked and prioritized.*
- *Unacceptable risks are identified.*
- *Tables 3.3 provides a suggested risk evaluation matrix.*
- ***To answer Question 45 A) Note down and describe in as much detail as possible any risks that present a medium or high risk (e.g. increased precipitation is a medium risk and can cause electrical damage to the ZEB Charging Station)***
- ***To answer***

Table 3.3 Risk Evaluation Matrix

Consequences	Very High	Moderate Risk	High Risk	High Risk	Extreme Risk	Extreme Risk
	High	Low Risk	Moderate Risk	High Risk	High Risk	Extreme Risk
	Moderate	Low Risk	Low Risk	Moderate Risk	High Risk	High Risk
	Low	Negligible Risk	Low Risk	Low Risk	Moderate Risk	Moderate Risk
	Very Low	Negligible Risk	Negligible Risk	Low Risk	Low Risk	Low Risk
		Very Low	Low	Moderate	High	Very High
	Likelihood					

Extreme Risk (Red): Immediate controls required
High Risk (Orange): High Priority control measures required
Moderate Risk (Yellow): Some controls required to reduce risks to lower levels
Low Risk (Blue): Controls likely not required
Negligible Risk (Green): Risk events do not require further consideration

PART 4.0: RISK TREATMENT AND ADAPTATION

4.0 Identifying Risk Treatments

In this step risk treatment or adaptation measures will be identified to reduce the unacceptable risks identified in Part 4 to acceptable levels of risk. During this step the effectiveness of the risk treatment or adaptation measure will be evaluated.

KEY ACTIONS

- *Identify risk treatment or adaptation measures for all Moderate, High and Extreme risk, including any risks to the electricity grid in order to reduce unacceptable risks to acceptable levels.*
- *Examine the feasibility and effectiveness of Risk treatment or adaptation measures, including the costs, benefits and associated implementation risks.*
- *You may wish to consult this guidance for considerations on climate resilience and the electrical grid: Guidance: CSA-RR_CEC-ClimateChange.pdf (csagroup.org)*
- ***Identify any risk reduction measures and/or strategies that are in place in case a climate-influenced natural hazards affects the electricity grid as part of the answer to Question 46 a)***

ANNEX A

GHG Activities Checklist for a Zero-Emission Bus Project

PROJECT PHASE	ACTIVITIES	PROJECT		BASELINE	
		Hydrogen	Electricity	Diesel	Other
Production	Extraction and production of fuel		NA		
Production	Production of supporting infrastructure materials				
Transport	Combustion of fuel in vehicles used to transport new buses to service site				
Construction	Electricity used in construction of supporting infrastructure				
Construction	Combustion of fuel for heating & cooling during construction				
Construction	Combustion of fuel in construction vehicles				
Construction	Combustion of fuel in construction equipment				
Construction	Combustion of fuel in vehicles used to transport construction materials and equipment to site				
Operation	Combustion of fuel in buses				
Operation	Electricity used in the operation and maintenance of supporting infrastructure.				
Operation	Combustion of fuel for heating and cooling in supporting infrastructure				
Operation	Combustion of fuel for maintenance and repair vehicles				
Operation	Combustion of fuel for maintenance and repair equipment				
Operation	Generation of renewable electricity for use on site				

Note: Fugitive emissions (GHG emissions resulting from air conditioning units/refrigeration, maintenance and leaks/spills of fuels and other maintenance products) is not included at this time.

Annex B

Mobile Fleet GHG Activities and Related Information

ACTIVITY	DESCRIPTION	ELEMENT	DATA REQUIRED	SOURCES OF DATA	END VARIABLES
Operation of Mobile Sources	Emissions from the combustion of fuels used in the mobile source.	Mobile sources i.e. vehicle fleets, buses	Type of mobile source Number of mobile sources Type of fuel Age (for existing fleets) and technical life of mobile sources Fuel efficiency Capacity of mobile source	Equipment specifications Internal records Fuel purchase records Local survey data, Fuel Consumption Guide, NRCAN Modeling analysis	Fuel (L/Kwh)
ACTIVITY	DESCRIPTION	ELEMENT	DATA REQUIRED	SOURCES OF DATA	END VARIABLES
Transportation of Buses to Project Site	Emissions from the combustion of fuel in vehicles used to transport buses to facilities.	Vehicles	Type/# of vehicles (make/model) Fuel type Distance travelled Fuel efficiency of vehicle	Operational logs (kms) Fuel Consumption Guide, NRCAN Fuel purchase records	Fuel (L/Kwh)
ACTIVITY	DESCRIPTION	ELEMENT	DATA REQUIRED	SOURCES OF DATA	END VARIABLES
Operation of Supporting Infrastructure	Emissions resulting from electricity use and from heating cooling of supporting infrastructure	Electricity	kWh consumed on site	Metering/ energy bills Internal records	Electricity (kWh)
		Heating units Air conditioners, Generators	Type/# of equipment/units Fuel Type Efficiency of equipment Hours of operation	Fuel purchase records Equipment specifications	Fuel (L, m3)
ACTIVITY	DESCRIPTION	ELEMENT	DATA REQUIRED	SOURCES OF DATA	END VARIABLES
Maintenance and Repairs	Emissions resulting from the maintenance and repairs of the buses and supporting infrastructure	Equipment/tools Machinery	Types/# of equipment/tools (makes/models) Fuel Type Efficiency of equipment Hours of operation	Equipment specifications Operational logs Fuel purchase records Invoices	Fuel (L, m3, kWh)
		Vehicles	Type/# of vehicles	Fuel purchase records	Fuel (L)

			Fuel Type Distance travelled Fuel efficiency of vehicle	Operational logs Fuel Consumption Guide, NRCAN Internal records	
Other requirements: • As a default, use the combined fuel efficiency values in calculations (50-50 mix of highway and city). • Travel routes will be of the same length in the baseline as in the project scenario. All other travel variables, such as terrain and vehicle speeds, are also assumed to be the same in the baseline as in the project scenario. • Ensure annual service provided remains functionally equivalent between the project and the baseline. A performance standard can be used to ensure functional equivalency (tonnes CO_2e/passenger, tonnes CO_2e/lb freight, etc.).					

ANNEX C

Average P/T Grid Electricity Emission Intensities (tonnes/MWh)*

Region	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Alberta	0.75	0.76	0.74	0.69	0.68	0.66	0.63	0.55	0.51	0.47	0.44	0.43	0.40	0.40	0.39	0.38	0.28	0.27	0.27	0.27	0.27
British Columbia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manitoba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Brunswick	0.27	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.27	0.27	0.27	0.27	0.27	0.27
Newfoundland	0.14	0.22	0.22	0.18	0.18	0.17	0.07	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Northwest Territories	0.39	0.23	0.22	0.23	0.23	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Nova Scotia	0.64	0.67	0.67	0.66	0.66	0.59	0.55	0.55	0.55	0.54	0.52	0.50	0.50	0.50	0.50	0.43	0.43	0.43	0.42	0.42	0.42
Nunavut	0.66	0.66	0.65	0.66	0.44	0.45	0.45	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Ontario	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Prince Edward Island	0.27	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.27	0.27	0.27	0.27	0.27	0.27
Quebec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saskatchewan	0.77	0.76	0.75	0.74	0.73	0.64	0.61	0.61	0.61	0.61	0.61	0.60	0.60	0.54	0.54	0.41	0.41	0.42	0.42	0.42	0.42
Yukon Territory	0.04	0.11	0.13	0.14	0.14	0.05	0.08	0.07	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.05

Notes:

1. Grid Emissions intensity is defined as: (utility generation emissions) + (industrial net sales to grid by sector)*(industrial electricity generation emissions factor) *divided by* electricity consumption from the grid,
2. Prince Edward Island: The emission intensities for PEI generation use New Brunswick emission intensity as PEI generation is non-dispatchable wind and balance is imported.
3. BC, Manitoba and Quebec: The electricity grids in B.C., Manitoba and Quebec are zero emitting. Residual emitting generation is not considered relevant.

Source: ECCC's 2017 Reference Case GHG Emissions Case, Published December 2017 in Canada's 7th National Communications to the UNFCC

*** Emission Intensities will be updated periodically. Please check the <u>INFC Climate Lens website</u> for the most up-to-date version of the Average P/T Grid Electricity Emission Intensities Table.**

ANNEX D

Emission Factors for Mobile Combustion Sources

			Emission Factor			
Transport Mode	Fuel Type	Units (kg/L or kg/kg)	CO_2	CH_4	N_2O	CO_2e
Light-duty vehicle	Gasoline (E5)	kg/L	2.200	0.00023	0.00047	2.346
	Diesel (B4)	kg/L	2.582	0.000051	0.00022	2.649
	Propane	kg/L	1.515	0.00064	0.000028	1.539
	Natural Gas	kg/kg	2.738	0.013	0.000086	3.089
Light-duty truck (includes SUV and minivan)	Gasoline (E5)	kg/L	2.200	0.00024	0.00058	2.379
	Diesel (B4)	kg/L	2.582	0.000068	0.00022	2.650
	Propane	kg/L	1.515	0.00064	0.000028	1.539
	Natural Gas	kg/kg	2.738	0.013	0.000086	3.089
Heavy-duty	Gasoline (E5)	kg/L	2.200	0.000068	0.00020	2.262
	Diesel (B4)	kg/L	2.582	0.00011	0.000151	2.630
	Natural Gas	kg/kg	2.738	0.013	0.000086	3.089
Motorcycle	Gasoline (E5)	kg/L	2.200	0.00077	0.000041	2.232

Source: Canada's National Inventory Report (2019)

Annex E

Construction GHG Activities and Related Information

PHASE 1	EXAMPLES OF ACTIVITIES	ELEMENTS	DATA REQUIRED	SOURCES OF DATA	END VARIABLES
Site Preparation	• Tree & vegetation removal • Site grading, clearing, excavation • Drilling/blasting/dredging • Installation of site services- fencing, lighting, security systems • Construction of temporary site access roads, linkages to roadways • Changes to existing infrastructure (e.g. relocation of pipelines) • Transportation of material to site • Removal of waste from site	Vehicles (light/heavy duty/off-road)	Type/# of vehicles Fuel Type Distance travelled Fuel efficiency of vehicle	Fuel purchase records Operational logs Fuel Consumption Guide, NRCAN Internal records	Fuel (L)
		Electricity	kWh consumed on site	Metering/ energy bills Internal records	Electricity (kWh)
		Heating units Air conditioners, Generators	Type/# of equipment/units Fuel Type Efficiency of equipment Hours of operation	Fuel purchase records Equipment specifications	Fuel (L, m3)
		Equipment/tools Machinery Lights Fans/Blowers	Types/# of equipment/tools (makes/models) Fuel Type Efficiency of equipment Hours of operation	Equipment specifications Operational logs Fuel purchase records Invoices	Fuel (L, m3, kWh)
PHASE 2	**EXAMPLES OF ACTIVITIES**	**ELEMENT**	**DATA REQUIRED**	**SOURCES OF DATA**	**END VARIABLES**
Installation and Construction	• Transport of project components to site • Construction of buildings, facilities, structures • Installation of project components • Paving/asphalt of roadways • Removal of waste from site	Vehicles (light/heavy duty/off-road)	Type/# of vehicles Fuel Type Distance travelled Fuel efficiency of vehicle	Fuel purchase records Operational logs Fuel Consumption Guide, NRCAN Internal records	Fuel (L)
		Electricity	kWh consumed on site	Metering/ energy bills Internal records	Electricity (kWh)
		Heating units Air conditioners, Generators	Type/# of equipment/units Fuel Type Efficiency of equipment	Fuel purchase records Equipment specifications	Fuel (L, m3)

			Hours of operation		
		Equipment/tools Machinery Lights Fans/Blowers	Types/# of equipment/tools (makes/models) Fuel Type Efficiency of equipment Hours of operation	Equipment specifications Operational logs Fuel purchase records Invoices	Fuel (L, m3, kWh)
PHASE 3	**EXAMPLES OF ACTIVITIES**	**ELEMENT**	**DATA REQUIRED**	**SOURCES OF DATA**	**END VARIABLES**
Site Restoration	• Removal of temporary site services • Landscaping • Planting new vegetation/trees • Transport of restoration material to site • Removal of waste from site	Vehicles (light/heavy duty/off-road)	Type/# of vehicles Fuel Type Distance travelled Fuel efficiency of vehicle	Fuel purchase records Operational logs Fuel Consumption Guide, NRCAN Internal records	Fuel (L)
		Electricity	kWh consumed on site	Metering/ energy bills Internal records	Electricity (kWh)
		Heating units Air conditioners, Generators	Type/# of equipment/units Fuel Type Efficiency of equipment Hours of operation	Fuel purchase records Equipment specifications	Fuel (L, m3)
		Equipment/tools Machinery Lights Fans/Blowers	Types/# of equipment/tools (makes/models) Fuel Type Efficiency of equipment Hours of operation	Equipment specifications Operational logs Fuel purchase records Invoices	Fuel (L, m3, kWh)

Notes:

- GHG emissions per year of construction will be required.
- Examples of Vehicles/Equipment include: Graders, excavators, scrapers, dozers, packers, loaders, haulers, dump trucks, cranes
- Fugitive emissions, such as refrigerant leaks, natural gas leaking from compressors or vented from compressor engine start-ups and shutdowns, are not required to be quantified under this module, but can be included if sufficient data is available.
- GHG sequestration in plants/trees is currently not a requirement, but can be included if sufficient data is available.
- Alternative sources: internal records, utilities, local survey data, Statistics Canada, Comprehensive Energy Use Database, Office of Energy Efficiency, Natural Resources Canada, etc.
- Sources of supporting information*: Bill of sale, invoices, contracts of service, engineering drawings, energy audits, energy modeling, electricity permits, building permits, energy bills.*

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