GHG Estimation Overview

Introduction

The Low Carbon Innovation Fund will require Applicants to estimate the GHG impacts of their innovative technology and describe the estimation methodology used to determine these impacts. The description of the method must be set out with sufficient detail for reviewers to understand the unique variables of the technology that will impact net greenhouse gas (GHG) impacts, such as the rate or extent of market penetration and adoption.

This document provides high-level guidance to assist LCIF Applicants to calculate verifiable Greenhouse Gas (GHG) emissions impacts resulting from their innovation. It assumes that Applicants have a basic level of knowledge on GHG estimation methodology, and reviews key principles and concepts necessary to consider in the GHG estimation process in relation to the project being evaluated for the program.

To evaluate the applications, reviewers must know how Applicants have calculated the GHG impacts of their technologies. For example, which impacts have been included, which emission factors have been used, and how have the applicants derived their impacts? The "National Inventory Report (NIR) 1990-2015: Greenhouse Gas Sources and Sinks in Canada" is the key resource recommended for emission factors. This is the foundation document used nationally to report to the United Nations Framework Convention on Climate Change.

Key Concepts

Key steps to GHG emission calculations for technology commercialization include:

1. Developing a Business – as – Usual (BAU) baseline scenario
2. Calculating project GHG reductions relative to the incumbent technology Baseline; and
3. Establishing the novel Technology Rate of Adoption to estimate impact.

Establishing a Baseline

A baseline must be established before the innovation's impact can be estimated. For LCIF applications separate GHG impacts will need to be calculated for both the Project stage and its duration, and for the subsequent commercialization period from 2020 through to 2030. For this reason, Applicants must define the baseline for the incumbent technology to compare it with the innovation in the proposed project.

Establishing a baseline involves two key steps:

1. Characterizing the status quo/ industry standard for existing technology; and,
2. Defining the elements of the incumbent technology contributing to GHG emissions.

In the absence of market specific data on the incumbent solution, use currently available commercialized technology as the baseline. Emission factors of the baseline must be referenced or estimated (see emission factors in Appendix 1).

Calculating GHG reductions from the Baseline

GHG impacts for a novel technology can be quantified by comparing the project estimate to the baseline, and applying the relevant emission factors (see Appendix 1).

Below are key principles that should be considered when calculating GHG impacts.

1. Applicants should take a *conservative approach* when calculating estimates, to ensure they do not overstate the anticipated emission reductions.
2. Estimates relative to the baseline must be made in accordance with the principle of *functional equivalence.* Functional equivalence is the concept that the baseline scenario must provide an equivalent type or level of product or service or use the same underlying activity level parameter as the project, in order to ensure a proper comparison of project conditions to baseline scenario conditions (see Appendix 1, Functional Unit).
3. When explaining GHG estimation methodology, applicants should describe and quantify negative impacts if applicable. This is as important as including environmental benefits. For example:
    - It may take more energy to increase quality, reduce waste and create marketable by- products.
    - Using a new catalyst to increase yield by 20% and purity by 15% requires an increase in reaction temperature by 50°C - using 5% more natural gas.
    - The compact fluorescent lamp (CFL) uses 1/5 to 1/3 of electric power and lasts 8-15 times longer but contains toxic mercury, which complicates its' disposal.

Establishing the Technology Rate of Adoption to estimate impact

GHG impacts of the novel technology can be calculated on a per-unit basis, and then forecasted in aggregate through market roll-out scenarios over time. To do this, Applicants must estimate the market adoption rate. Overall GHG impacts from 2020-2030 can then be calculated by multiplying the net GHG reductions identified per unit of the novel technology with the number of units anticipated in the roll-out scenario.

Standardized reporting of GHGs

LCIF projects may address a wide range of GHGs. No matter which GHG is attributable to the technology, all impacts must be converted to the international unit, which is carbon dioxide equivalent in tonnes or:

- Long form - tonnes -CO_{2e}
- Short form - tCO_{2e}

GHG calculation example expressed in tCO_{2e}: A vehicle consuming 10,000 litres of diesel fuel releases 26.90 tonnes of carbon dioxide ($C0_2$), 0.0011 tonnes of methane (CH_4), and 0.0015 tonnes of nitrous oxide (N_20). Using the GWPs from Table 1, Appendix 1, quantities can be multiplied by their GWPs and summed to estimate the total GHG emissions.

CO_2	26.90 x 1	=26.90 tonnes-$C0_{2e}$
CH_4	0.0011 x 25	= 0.03 tonnes-$C0_{2e}$
N_20	0.0015 x 298	= 0.45 tonnes-$C0_{2e}$
Total GHG		=27.38 tonnes-$C0_{2e}$

(See http://climatechangeconnection.org/emissions/CO_2-equivalents and Glossary Terms)

LCIF Project and commercialization estimates

LCIF Project GHG estimates require that applicants describe and quantify the GHG impacts of the manufacturing, installation or operation of the technology solution generated during the course of the project. Applicants must also calculate the net GHG estimates of one technology installation relative to baseline.

The LCIF technology commercialization GHG estimate is based on the forecasted technology adoption rate over the commercialization period (2020-2030), relative to the baseline forecast. The estimate is aimed at quantifying potential reductions anticipated through the commercialization of the innovation. Knowing the average GHG impacts of one plant, project or technology installation, the longer-term effects can be estimated based on projections with respect to baseline forecast and market penetration.

Other Environmental Benefits

Applicants should also describe other environmental impacts such as atmospheric emissions (clean air), water quality and soil impacts. Impacts may not be a direct result of the technology itself but may derive from the use of the product or service, enabling another technology or service to displace a more environmentally damaging product or service.

APPENDIX 1

Glossary of Terms

Baseline
A scenario that represents future decisions described as "business as usual". A realistic baseline considers legislation mandating certain activities and choices, as well as economic and other drivers that favour certain outcomes. The baseline describes what would most likely occur in the absence of the project activity (and the introduction of the new technology). The competing technology to be replaced is usually what defines the baseline against which the innovation's impacts are to be measured.

Criteria Air Contaminants (CAC)
CAC, or criteria pollutants, are a set of air pollutants that cause smog, acid rain, and other health hazards. The most recognized CACs are:

- Ozone (O_3)
- Particulate matter:
  - PM10up to 10 µm in size
  - PM2.5, fine particles: 2.5 µm in size or less
- Carbon monoxide (CO)
- Sulfur oxides (SOx)
- Nitrogen oxides (NOx)
- Volatile organic compounds (VOC)
- Ammonia (NH_3)

CO_{2e}
Carbon Dioxide Equivalent is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally 100 years).

Emission factors
Factors are expressed in units of CO_2 equivalent (CO_{2e}) so as to encompass the global warming effects of all relevant GHGs. (Example: National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada, Part 2, Pg. 233, Annex 6, Emission Factors and Part 3, Pg. 99, Table A13-7 Electricity Generation and GHG Emission Details for Ontario).

<u>Common GHG Emission Factors</u>

The table below includes a list of common GHG emission factors that can be used by default for project quantification and reporting:

Fuel	Emission factor (in kg) divide by 1,000 for tCO2e/
Stationary sources	
Electricity	0.05 kgCO2e / kWh
Natural gas	1.899 kgCO2e / m3
Propane	1.548 kgCO2e / L
Heating oil	2.755 kgCO2e / L
Mobile sources	
Diesel	2.754 kgCO2e / L
Gasoline	2.462 kgCO2e / L

Functional unit
The unit used to quantify GHG emissions. For the purposes of GHG calculations, this unit needs to represent what is produced by a process (e.g. litre of fuel, MWh of electricity) or what is avoided (e.g. a tonne of input material or one GJ of heat energy). The functional unit defines how all impacts are quantified (tCO_{2e} reduced per functional unit; CAC emissions per functional unit; tonne of waste per functional unit; tonne of water, etc.). The functional unit should be an energy or mass/volume unit whose value may have to be derived from other calculations, such as based on kms driven by a typical vehicle and corresponding fuel use and savings, or the impact of an innovation on a typical application.

GHG
Greenhouse Gas is a gas that absorbs and emits radiation within the thermal infrared range. This is the fundamental cause of the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

GWP
Global Warming Potential is a relative measure of how much heat a greenhouse gas traps in the atmosphere and is calculated over a specific time interval, commonly 100 years.

Table 1: GHG & Global Warming Potentials (GWP)

GHG Name	Chemical formula	Lifetime (years)	Global warming potential (GWP) for given time horizon		
			20-yr	**100-yr**	**500-yr**
Carbon dioxide	CO_2	30–95	1	1	1
Methane	CH_4	12	72	25	7.6
Nitrous oxide	N_2O	114	289	298	153
CFC-12	CCl_2F_2	100	11 000	10 900	5 200
HCFC-22	$CHClF_2$	12	5 160	1 810	549
Tetrafluoromethane	CF_4	50 000	5 210	7 390	11 200
Hexafluoroethane	C_2F_6	10 000	8 630	12 200	18 200
Sulfur hexafluoride	SF_6	3 200	16 300	22 800	32 600
Nitrogen trifluoride	NF_3	740	12 300	17 200	20 700

Leakage
When quantifying GHG impacts, the concept of leakage addresses unintended consequences of an emission reduction activity. For example, making a vehicle more energy efficient may encourage drivers to pay less attention to energy efficient driving styles, partially undoing the efficiency benefits. Sequestering CO_2 into existing oil wells may reduce the cost of producing extra oil, leading to lower oil prices and possible, increased market uptake (and higher emissions). Such consequences are sometimes hard to quantify but should be discussed where relevant.

NIR
Environment and Climate Change Canada is responsible for preparing Canada's official national annual greenhouse gas (GHG) inventory report covering anthropogenic emissions by sources and removals by sinks. The National Inventory Report (NIR) contains Canada's annual GHG emission estimates dating back to 1990.