Greenhouse Gas Emissions Calculation Methods

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February 2017

Research Questions:

1) How did the Government of Prince Edward Island and Environment Canada calculate the greenhouse gas generation for our province on a yearly basis? Are these figures exact or are they estimated?
2) Can you please provide a breakdown of the formula used, what source data went into the formula, and attribute where that data originated from?
3) Are there any exact figures reported to Environment Canada for any GHG emissions on PEI?

Emissions Measurement and Formulas

National greenhouse gas emissions figures are estimates, as it is not possible to accurately measure emissions from every source. There is always a degree of uncertainty in the emissions figures which are disclosed in Canada's National Inventory Report, submitted annually to the United Nations Framework Convention on Climate Change (UNFCCC). In 2014, the most recent year for which data is available, Canada emitted 738 megatonnes (Mt) of carbon dioxide equivalent (CO_2e), not including emissions and removals from land use, land use changes and forestry. The uncertainty range for this figure is ±4%, meaning that the actual figure could be between 706 and 771 Mt of CO_2e.[1] Although emissions and removals in the land use, land use changes and forestry sector (LULUCF) are tracked and reported in the National Inventory, the figure is excluded from the national total for several reasons. For one, it is extremely difficult to accurately measure emissions and removals in this category, which includes activities such as logging, forest land management, the conversion of forest to cropland, and certain agricultural activities such as the adoption of conservation tillage practices. This sector is also significantly affected by natural disturbances which can drastically increase emissions, such as large forest fires and infestations of destructive insects, and the resulting large fluxes in emissions make it difficult to measure the impact of human activities in this area.

Canada follows the estimation guidelines produced by the Intergovernmental Panel on Climate Change (IPCC) when making its emissions reports to the UNFCCC. Emissions are measured in units of carbon dioxide equivalent (CO_2e). This is a way to compare the global warming potentials of various gases, such as carbon dioxide, methane, and nitrous oxide. Global warming potential (GWP) is measured in terms of the amount of warming caused by a tonne of a given gas compared to that caused by a tonne of CO_2 over a given period of time.[2] Because it is used as the reference, the GWP of CO_2 is 1. Methane (CH_4) has a GWP of 28-36 over a 100-year period; it has a shorter lifespan in the atmosphere than carbon dioxide, but it also absorbs much more energy, and so a tonne of methane causes 28-36 times as much warming as does a tonne of CO_2 over the same period of time. Nitrous Oxide (NO_2) has a GWP of 265-298, while

chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) can all have a GWP in the thousands or tens of thousands.[3] Emissions are broken down into the following categories: Energy; Industrial Processes and Product Use; Agriculture, Forestry and Other Land Use; Waste; and Other.

The general formula used for estimating greenhouse gas emissions is "*Emissions = activity data x emission factor*". Activity data is the level of emissions generated by a human activity over a given period of time. When estimating annual emissions caused by fuel consumption, for example, the activity data would be the total amount of fuel burned in a year. The emission factor is the estimated amount of pollution caused by each source. Under the IPCC guidelines, there are three "tiers" used to estimate emissions. Each tier varies in complexity and level of technological detail, but all three follow the general structure outlined above. The selection of which estimation methodology to use is affected by the overall importance of the emissions category as well as the availability of enough reliable data. To use fuel combustion as an example, a Tier 1 calculation would take into account the amount of fuel combusted and use a default emissions factor (level of pollution per unit of fuel) provided by the IPCC. A Tier 2 calculation would consider the amount of fuel combusted together with a country-specific emissions factor, developed using data on variables such as the carbon content of the specific fuel and level of technological development in the country. To use a Tier 3 approach, data would be required on factors used in Tier 2 in addition to information on operating conditions, control technology, quality of maintenance, and the age of the equipment used to burn the fuel.[4] Examples of formulas used in Canada's estimation of GHG emissions have been included in Appendix 1. Additionally, Canada periodically revises its emissions estimates for previous years as more reliable data becomes available and estimation methods improve.[5]

Any facility which emits 50 kilotonnes (kt) of CO_2e per year must file a report with Environment and Climate Change Canada under the GHG Emissions Reporting Program. The department's website states that:

> "This threshold is expected to apply to over 500 facilities across Canada, in all sectors. Facilities that do not meet the reporting threshold are encouraged to report voluntarily. Major industrial facilities that produce electricity, heat or steam on site using fossil fuels are those that would typically emit more than 50 kt of GHGs per year. These could include power generation facilities, integrated steel mills, facilities involved in smelting and refining metals, petroleum refineries, and chemical production facilities. Other operations, such as large landfills and incinerators, could also be subject to this mandatory reporting."[6]

The emissions reported by these large facilities accounted for 36% of Canada's total 2014 emissions.[7]

Environment and Climate Change Canada has numerous agreements with other federal agencies to share emissions statistics and information. Statistics Canada provides ECCC with much of the data used to track emissions in both the Energy and Industrial Processes and

Product Use categories. Statistics Canada collects this information through its annual *Report on Energy Supply and Demand in Canada*[8], as well as the *Annual Industrial Consumption of Energy Survey*[9]. The agency also collects information related to mining activities, chemical and petrochemical production, and agriculture. Natural Resources Canada and Agriculture and Agri-food Canada are jointly responsible for tracking emissions and removals in the Land Use, Land Use Changes and Forestry category. Natural Resources also provides information for the Energy category, as well as data on mineral production, and tracks emissions by vehicles in conjunction with Transport Canada.[10]

Emissions Data for PEI

Prince Edward Island's greenhouse gas emissions in 2014, as reported in Canada's National Inventory Report, were 1,800 kt of CO_2e, or 1.8 megatonnes. 1,250 kt of the total came as a result of energy production, 43.1 kt from industrial processes and product use, 380 kt from agricultural activity, and 130 kt from waste disposal. A more detailed breakdown of the province's emissions data, in the form of tables on PEI's 2014 Emissions Summaries as provided in the National Inventory Report, is available in Appendix 2.[11] As noted earlier, these figures are estimates, not exact data. However, one unnamed facility in PEI did meet the 50 kt threshold for mandatory emissions disclosure, and reported 55 kt of emissions in 2014.[12] Thirteen facilities on PEI also report emissions data for various air pollutants to Environment and Climate Change Canada each year. The facilities are:

- Air Canada – Charlottetown International Airport;
- BioVectra Inc. – Douglas J. Hennesy Biochemical Centre;
- BioVectra Inc. – Regis & Joan Duffy BioPharmaceutical Centre;
- Cavendish Farms Corporation – Cavendish Farms;
- City of Charlottetown – Pollution Control Plant;
- City of Charlottetown – East Royalty Lagoon;
- Elanco Canada Limited – Victoria;
- Elanco Canada Limited – 37 McCarville;
- Irving Oil Commercial G.P. – Charlottetown;
- Maritime Electric Co. Limited – Charlottetown Thermal Generating Station;
- PEI Agromart Ltd.;
- Veresen Energy Infrastructure Inc. – UPEI boiler; and
- Veresen Energy Infrastructure Inc. – PEI Energy Systems.[13]

Further information on emissions from these facilities is available through the link attached to this document's 13th reference. However, the emissions data is not limited to greenhouse gases, and is therefore not recorded in CO_2e units.

APPENDIX 1 – EMISSIONS CALCULATION FORMULAS

Formula used to estimate the level of contribution and importance of a given source or sink of emissions:

$$L_{x,t} = \frac{|E_{x,t}|}{\sum_y |E_{y,t}|}$$

where:

$L_{x,t}$	=	level assessment for source or sink *x* in latest inventory year (year *t*)
$\|E_{x,t}\|$	=	the absolute value of emission or removal estimate of source or sink category *x* in year *t*
$\sum_y \|E_{y,t}\|$	=	total contribution, which is the sum of the absolute values of emissions and removals in year *t* calculated using the aggregation level chosen by the country for key category analysis; because both emissions and removals are entered with positive sign, the total contribution/level can be larger than a country's total emissions less removals

Formula used to estimate fuel consumption, using an IPCC Tier 3 and Tier 2 approach:

$$E_{Category,G} = FC_{F,R} * EF_{G,F,R,T}$$

where:

$E_{Category,G}$	=	GHG emissions by source category and by GHG (CO_2, CH_4 or N_2O)
$FC_{F,R}$	=	Quantity of fuel consumed (in physical units, such as kg, L, or m^3) by fuel type (i.e. natural gas, sub-bituminous coal, kerosene, etc.) and by region
$EF_{G,F,R,T}$	=	Country-specific emission factor (in physical units) by GHG, by fuel type, by region (where available) and by technology (for non-CO_2 factors)

Table A11–4 1990–2014 GHG Emission Summary for Prince Edward Island

Greenhouse Gas Categories		1990	2000	2005	2010	2011	2012	2013	2014
	kt CO_2 equivalent								
TOTAL		**1 960**	**2 150**	**2 070**	**1 990**	**2 050**	**2 060**	**1 770**	**1 800**
ENERGY		**1 430**	**1 550**	**1 450**	**1 480**	**1 540**	**1 530**	**1 280**	**1 250**
a.	Stationary Combustion Sources	736	726	614	650	725	671	535	470
	Public Electricity and Heat Production	104	53	4.76	1.59	1.23	10.8	3.92	4.96
	Petroleum Refining Industries	-	-	-	-	-	-	-	-
	Mining and Upstream Oil and Gas Production	0.89	7.53	x	x	0.16	x	x	x
	Manufacturing Industries	55.2	136	144	171	142	187	114	103
	Construction	11.1	6.68	x	x	x	x	x	x
	Commercial and Institutional	160	179	120	47.6	86.4	74.2	75	61.5
	Residential	387	312	311	380	454	379	327	287
	Agriculture and Forestry	18.5	31.9	24	29.5	30.5	17.5	12.5	11.5
b.	Transport[1]	695	828	840	833	819	859	746	779
	Domestic Aviation	17	11	14	18	16	19	20	19
	Road Transportation	522	602	625	660	554	659	632	623
	Light-Duty Gasoline Vehicles	262	238	229	226	170	216	205	194
	Light-Duty Gasoline Trucks	120	196	228	248	198	262	253	253
	Heavy-Duty Gasoline Vehicles	42.4	28.6	22	23.6	18.7	24.4	24.2	23.1
	Motorcycles	0.47	0.63	0.55	1.01	0.79	0.99	x	x
	Light-Duty Diesel Vehicles	2.42	1.89	x	x	3.19	x	3.29	3.3
	Light-Duty Diesel Trucks	0.85	1.41	1.75	1.17	1.08	1.03	1.03	0.93
	Heavy-Duty Diesel Vehicles	92.6	135	140	158	162	151	144	148
	Propane and Natural Gas Vehicles	1.1	0.77	x	x	-	x	x	x
	Railways	-	-	-	-	-	-	-	x
	Domestic Navigation	80	76	90	96	130	85	63	x
	Other Transportation	75	140	110	60	120	96	32	51
	Off-Road Gasoline	32	55	77	41	x	x	x	x
	Off-Road Diesel	43	84	x	x	74	51	24	45
	Pipeline Transport	-	-	x	x	x	x	x	x
c.	Fugitive Sources	-	-	0.0	-	0.0	-	-	-
	Coal Mining	-	-	-	-	-	-	-	-
	Oil and Natural Gas	-	-	0.0	-	0.0	-	-	-
d.	CO_2 Transport and Storage	-	-	-	-	-	-	-	-
INDUSTRIAL PROCESSES AND PRODUCT USE		**4.49**	**19.3**	**26.5**	**37.8**	**40.2**	**41.1**	**41.2**	**43.1**
a.	Mineral Products	0.34	0.71	0.91	0.69	0.73	0.63	0.58	0.59
	Cement Production	-	-	-	-	-	-	-	-
	Lime Production	-	-	-	-	-	-	-	-
	Mineral Products Use	0.34	0.71	0.91	0.69	0.73	0.63	0.58	0.59
b.	Chemical Industry[2]	-	-	-	-	-	-	-	-
	Adipic Acid Production	-	-	-	-	-	-	-	-
c.	Metal Production	-	-	-	-	-	-	-	-
	Iron and Steel Production	-	-	-	-	-	-	-	-
	Aluminum Production	-	-	-	-	-	-	-	-
	SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-
d.	Production and Consumption of Halocarbons, SF_6 and NF_3[3]	-	14	23	35	37	38	39	41
e.	Non-Energy Products from Fuels and Solvent Use	3.3	2.4	1.3	0.99	1.3	0.85	0.99	0.56
f.	Other Product Manufacture and Use	0.83	1.9	1.6	1	1.1	1.2	1.2	1.2
AGRICULTURE		**410**	**440**	**460**	**340**	**340**	**370**	**320**	**380**
a.	Enteric Fermentation	150	150	140	120	120	120	120	120
b.	Manure Management	60	61	60	44	44	44	44	44
c.	Agriculture Soils	190	230	250	170	180	200	150	210
	Direct Sources	160	180	200	140	150	160	130	170
	Indirect Sources	30	40	50	30	30	30	30	40
d.	Field Burning of Agricultural Residues	0.09	0.2	0.2	0.1	0.1	0.2	0.2	0.2
e.	Liming, Urea Application and Other Carbon-containing Fertilizers	5	5	5	3	3	2	2	2
WASTE		**120**	**140**	**140**	**130**	**130**	**130**	**130**	**130**
a.	Solid Waste Disposal	96	110	110	110	110	100	100	100
b.	Biological Treatment of Solid Waste	3	4	3	3	3	3	3	3
c.	Wastewater Treatment and Discharge	6.2	8	8.1	8	8.1	8.2	8.4	8.4
d.	Incineration and Open Burning of Waste	11	12	12	12	12	12	12	12

Notes:
1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from the Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use within the provincial/territorial tables as CO_2 eq values.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.

- Indicates no emissions
0.0 Indicates emissions truncated due to rounding
x Indicates data has been suppressed to respect confidentiality
Estimates for the latest year (2014) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.
Provincial/Territorial GHG emissions allocated to Canadian economic sectors are provided in Annex 12 of this report

Table A11–5 2014 GHG Emission Smmary for Prince Edward Island

Greenhouse Gas Categories	Greenhouse Gases									
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs[4]	PFCs[4]	SF_6	NF_3	TOTAL
Global Warming Potential			25		298			22 800	17 200	
Unit	kt	kt	kt CO_2 eq.	kt	kt CO_2 eq.	kt CO_2 eq.	kt CO_2 eq.	kt CO_2 eq.	kt CO_2 eq.	kt CO_2 eq.
TOTAL	**1 210**	**11**	**290**	**0.88**	**260**	**41**	**0.01**	**0.03**	**-**	**1 800**
ENERGY	**1 190**	**1.4**	**35**	**0.07**	**20**	**-**	**-**	**-**	**-**	**1 250**
a. Stationary Combustion Sources	432	1	30	0.02	6	-	-	-	-	470
Public Electricity and Heat Production	4.9	0.0	0.0	0.0	0.03	-	-	-	-	4.96
Petroleum Refining Industries	-	-	-	-	-	-	-	-	-	-
Mining and Upstream Oil and Gas Production	x	x	x	x	x	-	-	-	-	x
Manufacturing Industries	102	0.0	0.07	0.0	0.55	-	-	-	-	103
Construction	x	x	x	x	x	-	-	-	-	x
Commercial and Institutional	61.1	0.0	0.02	0.0	0.3	-	-	-	-	61.5
Residential	249	1	30	0.02	5	-	-	-	-	287
Agriculture and Forestry	11.5	0.0	0.0	0.0	0.05	-	-	-	-	11.5
b. Transport[1]	763	0.07	1.6	0.05	14	-	-	-	-	779
Domestic Aviation	19.1	0.0	0.01	0.0	0.2	-	-	-	-	19
Road Transportation	613	0.05	1	0.03	8.4	-	-	-	-	623
Light-Duty Gasoline Vehicles	191	0.02	0.42	0.01	2.3	-	-	-	-	194
Light-Duty Gasoline Trucks	249	0.02	0.57	0.01	3.1	-	-	-	-	253
Heavy-Duty Gasoline Vehicles	22.5	0.0	0.02	0.0	0.56	-	-	-	-	23.1
Motorcycles	x	x	x	x	x	-	-	-	-	x
Light-Duty Diesel Vehicles	3.22	0.0	0.0	0.0	0.08	-	-	-	-	3.3
Light-Duty Diesel Trucks	0.91	0.0	0.0	0.0	0.02	-	-	-	-	0.93
Heavy-Duty Diesel Vehicles	146	0.01	0.2	0.01	2	-	-	-	-	148
Propane and Natural Gas Vehicles	x	x	x	x	x	-	-	-	-	x
Railways	x	x	x	x	x	-	-	-	-	x
Domestic Navigation	x	x	x	x	x	-	-	-	-	x
Other Transportation	45.9	0.01	0.2	0.02	5	-	-	-	-	51
Off-Road Gasoline	x	x	x	x	x	-	-	-	-	x
Off-Road Diesel	40.4	0.0	0.06	0.02	5	-	-	-	-	45
Pipeline Transport	x	x	x	x	x	-	-	-	-	x
c. Fugitive Sources	-	-	-	-	-	-	-	-	-	-
Coal Mining	-	-	-	-	-	-	-	-	-	-
Oil and Natural Gas	-	-	-	-	-	-	-	-	-	-
d. CO_2 Transport and Storage	-	-	-	-	-	-	-	-	-	-
INDUSTRIAL PROCESSES AND PRODUCT USE	**1.35**	**-**	**-**	**0.0**	**1.0**	**41**	**0.01**	**0.03**	**-**	**43.1**
a. Mineral Products	0.59	-	-	-	-	-	-	-	-	0.59
Cement Production	-	-	-	-	-	-	-	-	-	-
Lime Production	-	-	-	-	-	-	-	-	-	-
Mineral Products Use	0.59	-	-	-	-	-	-	-	-	0.59
b. Chemical Industry[2]	-	-	-	-	-	-	-	-	-	-
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
c. Metal Production	-	-	-	-	-	-	-	-	-	-
Iron and Steel Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production	-	-	-	-	-	-	-	-	-	-
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	-	-	-
d. Production and Consumption of Halocarbons, SF_6 and NF_3[3]	-	-	-	-	-	41	0.01	-	-	41
e. Non-Energy Products from Fuels and Solvent Use	0.56	-	-	-	-	-	-	-	-	0.56
f. Other Product Manufacture and Use	0.2	-	-	0.0	1	-	0.0	0.03	-	1.2
AGRICULTURE	**2**	**5.6**	**140**	**0.79**	**240**	**-**	**-**	**-**	**-**	**380**
a. Enteric Fermentation	-	4.8	120	-	-	-	-	-	-	120
b. Manure Management	-	0.75	19	0.08	30	-	-	-	-	44
c. Agriculture Soils	-	-	-	0.7	210	-	-	-	-	210
Direct Sources	-	-	-	0.58	170	-	-	-	-	170
Indirect Sources	-	-	-	0.1	40	-	-	-	-	40
d. Field Burning of Agricultural Residues	-	0.01	0.1	0.0	0.04	-	-	-	-	0.2
e. Liming, Urea Application and Other Carbon-containing Fertilizers	2	-	-	-	-	-	-	-	-	2
WASTE	**10**	**4.5**	**110**	**0.02**	**5.7**	**-**	**-**	**-**	**-**	**130**
a. Solid Waste Disposal on Land	-	4.2	100	-	-	-	-	-	-	100
b. Wastewater Handling	-	0.07	2	0.01	1	-	-	-	-	3
	-	0.23	5.7	0.01	3	-	-	-	-	8.4
c. Waste Incineration	10	0.0	0.0	0.01	1	-	-	-	-	12

Notes:
1. Emissions from ethanol and biodiesel are included in the Transport categories using gasoline and diesel respectively.
2. Emissions from the Ammonia Production, Nitric Acid Production and Petrochemical Production and Carbon Black categories are included in Non-Energy Products from Fuels and Solvent Use within the provincial/territorial tables as CO_2 eq values.
3. HFC and PFC consumption began in 1995; HFC emissions occurring as a by-product of HCFC production (HCFC-22 exclusively) only occurred in Canada from 1990–1992 and PFC emissions prior to 1995 are the result of by-product CF_4 emissions from the use of NF_3.
4. IPCC's *Fourth Assessment Report* provides global warming potentials (GWPs) for the various species of HFCs and PFCs. Chapter 1, Table 1-1 of this report provides a list of GWPs used.

- Indicates no emissions
0.0 Indicates emissions truncated due to rounding
x Indicates data has been suppressed to respect confidentiality
Estimates for the latest year (2014) are based on preliminary energy data; these data, though the best available information at the time of publication, are subject to revision in the next submission year.
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