CARBON OFFSET EMISSION FACTORS HANDBOOK

Version 1.0 **March 2015**

Specified Gas Emitters Regulation

Alberta Government

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Disclaimer

The information provided in this directive is subject to revisions as learnings and new information come forward as part of a commitment to continuous improvement. Emission factors provided in this directive must be used when referenced in approved quantification protocols.

This document is not a substitute for the legal requirements. Consult the Specified Gas Emitters Regulation and the legislation for all purposes of interpreting and applying the law. In the event that there is a difference between this document and the Specified Gas Emitters Regulation or legislation, the Specified Gas Emitters Regulation or the legislation prevails.

This directive is subject to periodic review as deemed necessary by the Department, and will be re-examined at a minimum of every five years from the original publication date to ensure methodologies and science continue to reflect best-available knowledge and best practices. Any updates to this directive as a result of the reviews will apply at the end of the credit duration period. Project extensions will be required to follow the current directive.

Any comments or questions regarding the content of this document may be directed to:

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Introduction

The Carbon Offset Emission Factors Handbook contains a listing of common emission factors used in the Alberta carbon offset system as well as common quantification methodologies.

Common emission factors, provided in section 1, are intended as inputs to formulae provided in approved quantification protocols.

Common quantification methods, provided in section 2, are commonly used formulae for quantification of greenhouse gas offsets in Alberta. This section includes both quantification methods and factors required for greenhouse gas offset quantification.

Emission factors and methodologies are subject to periodic updates. Updated values are immediately applicable for use in new offset projects. Current projects will be required to transfer to updated factors if they receive a crediting period extension. The project developer is responsible for ensuring the most current version is used for annual project reporting.

1.0 Common Emissions Factors

1.1 Global Warming Potential

The Global Warming Potentials (GWP) of specified gases is listed in the Specified Gas Emitters Regulation (AR139/2007). Alberta uses the 2007 GWPs as published by the International Panel on Climate Change. Global warming potentials are effective for 2014 vintage credits forward as per a MEMO released by ESRD on January 23, 2014.

Table 1. Intergovernmental Panel on Climate Change (IPCC) Global Warming Potentials - 100 Year Time Horizon

Specified Gas	Formula	100-year GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
Sulphur Hexafluoride	SF_6	22,800
Perfluoromethane	CF_4	7,390
Perfluoroethane	C_2F_6	12,200
Perfluoropropane	C_3F_8	8,830
Perfluorobutane	C_4F_{10}	8,860
Perfluorocyclobutane	c-C_4F_8	10,300
Perfluoropentane	C_5F_{12}	9,160
Perfluorohexane	C_6F_{14}	9,300
Hydrofluorocarbons-23	CHF_3	14,800
Hydrofluorocarbons-32	CH_2F_2	675
Hydrofluorocarbons-41	CH_3F	92
Hydrofluorocarbons-43-10mee	$C_5H_2F_{10}$ (structure:$CF_3CHFCHFCF_2CF_3$)	1,640
Hydrofluorocarbons-125	C_2HF_5	3,500
Hydrofluorocarbons-134	$C_2H_2F_4$ (structure: CHF_2CHF_2)	1,100
Hydrofluorocarbons-134a	$C_2H_2F_4$ (structure: CH_2FCF_3)	1,430
Hydrofluorocarbons-143	$C_2H_3F_3$ (structure: CHF_2CH_2F)	353
Hydrofluorocarbons-143a	$C_2H_3F_3$ (structure: CF_3CH_3)	4,470
Hydrofluorocarbons-152a	$C_2H_4F_2$ (structure: CH_3CHF_2)	124
Hydrofluorocarbons-227ea	C_3HF_7 (structure: CF_3CHFCF_3)	3,220
Hydrofluorocarbons-236fa	$C_3H_2F_6$ (structure: $CF_3CH_2CF_3$)	9,810
Hydrofluorocarbons-245ca	$C_3H_3F_5$ (structure: $CH_2FCF_2CHF_2$)	693

2007. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Adapted from Table 2.14, IPCC Fourth Assessment Report, 2007

1.2 Electricity Grid Use and Displacement Factors

Below the are grid factors applicable in the Alberta carbon offset system for projects that are displacing grid electricity with renewable electricity or reducing grid electricity usage and projects resulting in additional electricity usage from the Alberta electrical grid. These factors are set by Alberta Environment and Sustainable Resources Development (ESRD) and updated at minimum every 5 years.

Table 2. Electricity Grid Displacement and Grid Usage Factors

Factor	tCO_2e / MWh	Description
Electricity grid displacement with renewable generation	0.59	Applicable to projects displacing grid-electricity with renewable generation.
Increased on-site grid electricity use (includes line loss)	0.64	Applicable for use in projects that increase electricity usage in the project condition.
Reduction in grid electricity usage (includes line loss)	0.64	Applicable to energy efficiency projects resulting in decreased grid electricity usage.
Distributed renewable displacement at point of use (includes line loss)	0.64	Applicable to projects displacing grid electricity with distributed renewable electricity generation at point of use.

Table 3. Total Line Loss

Factor	MWh line loss / MWh consumed	Description
Total line loss for transmission and distribution	1.083	Weighted average line loss for transmission and distribution in Alberta is 7.7% (calculated as 1/(1-line loss)). Line loss is incorporated into the factors in Table 2 when reducing grid electricity usage or when renewable generation is at point of use.

2004. A Study on the Efficiency of Alberta's Electricity Supply System: Project# CASA-EEEC-02-04. Prepared for Clean Air Strategic Alliance. Jem Energy.

1.3 Fuel Extraction and Production Related Emissions

Below are emissions factors associated with the extraction and production of fuels. Values are sourced from a Canadian Association of Petroleum Producers (CAPP) report on upstream oil and gas emissions.

Table 4. Emission Intensity of Fuel Extraction and Production (Diesel, Natural Gas and Gasoline)

Source	Emission Factors		
	kg CO_2 / L	**kg CH_4 / L**	**kg N_2O / L**
Diesel Production	0.138	0.0109	0.000004
Gasoline Production	0.138	0.0109	0.000004
	kg CO_2 / m^3	**kg CH_4 / m^3**	**kg N_2O / m^3**
Natural Gas Extraction	0.043	0.0023	0.000004
Natural Gas Processing	0.090	0.0003	0.000003

September 2004. A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry, Volume 1. Clearstone Engineering Ltd. Prepared on behalf of Canadian Association of Petroleum Producers.

Emission factors must be used for fuel volumes corrected to 15°C and 101.325 kPa.

Table 5. Emission Factors for Gasoline and Diesel Production

	Approximate Proportionate Amount in Year of Emission Factor Generation ($10^3 m^3$ / yr)	Emission Factors (t / 10^3 m^3)		
		CO_2	**CH_4**	**N_2O**
Light / Medium Crude Oil Production	55,588	86.3	4.41	0.0038
Heavy Crude Oil Cold Production	30,924	75	25.1	0.0033
Heavy Crude Oil Thermal Production	10,589	594.2	3.75	0.009
Weighted Average		0.1381	0.0109	4.208E-6

September 2004. A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry, Volume 1. Clearstone Engineering Ltd. Prepared on behalf of Canadian Association of Petroleum Producers.

1.4 Fuel Combustion Related Emissions

Table 6. Emission Factors for Combustion of Natural Gas and Natural Gas Liquids

Source	Emission Factors		
	CO_2 (g/m^3)	CH_4(g/m^3)	N_2O(g/m^3)
Natural Gas			
Electric Utilities	1918	0.49	0.049
Industrial	1918	0.037	0.033
Producer Consumption (non-marketable product)	2380	6.4	0.06
Pipelines	1918	1.9	0.05
Cement	1918	0.037	0.034
Manufacturing Industries	1918	0.037	0.033
Residential, Construction, Commercial/Institutional, Agriculture	1918	0.037	0.035
Propane	**g/L**	**g/L**	**g/L**
Residential	1507	0.027	0.108
All Other Uses	1507	0.024	0.108
Ethane	976	0.024	0.108
Butane	1730	0.024	0.108

2014. National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada. The Canadian Government's Submission to the UN Framework Convention on Climate Change. Part 2.

Emission factors must be used for fuel volumes corrected to 15°C and 101.325 kPa.

Table 7. Emission Factors for Combustion of Refined Petroleum Products

Source	Emission Factors		
	CO_2 (g/L)	CH_4(g/L)	N_2O(g/L)
Light Fuel Oil			
Electric Utilities	2725	0.18	0.031
Industrial	2725	0.006	0.031
Producer Consumption	2643	0.006	0.031
Residential	2725	0.026	0.006
Forestry, Construction, Public Administration and Commercial/Institutional	2725	0.026	0.031
Heavy Fuel Oil			
Electric Utilities	3124	0.034	0.064
Industrial	3124	0.12	0.064
Producer Consumption	3158	0.12	0.064
Residential, Forestry, Construction, Public Administration, and Commercial/Institutional	3124	0.057	0.064
Kerosene			
Electric Utilities	2534	0.006	0.031
Industrial	2534	0.006	0.031
Producer Consumption	2534	0.006	0.031
Residential	2534	0.026	0.006
Forestry, Construction, Public Administration and Commercial/ Institutional	2534	0.026	0.031
Diesel	2663	0.133	0.4
Motor Gasoline	2289	N/A	0.02

2014. National Inventory Report 1990-2012: Greenhouse Gas Sources and Sinks in Canada. The Canadian Government's Submission to the UN Framework Convention on Climate Change. Part 2.

2.0 Common Quantification Methods

2.1 Quantification of Avoided Landfill and Stockpile Methane Emissions

The methodology for quantifying greenhouse gas emissions reductions from the diversion of organic materials from a Municipal Solid Waste (MSW) landfill, wood waste landfill or wood waste stockpile is provided below. Emissions reductions are achieved by reducing methane emissions associated with anaerobic decomposition. In Alberta, landfills are classified as outlined in the Waste Control Regulation. If a Class II landfill meets the definition of a MSW landfill or a wood waste landfill, waste diversion from it is eligible under this methodology. Waste diverted from Class III landfills is not eligible under this methodology because they are for the disposal of inert waste.

Table 8. Landfill Definitions Applicable to Avoided Landfill and Stockpile Methane Emissions Quantification in Alberta

Definitions	
Municipal Solid Waste (MSW) Landfill	A Municipal Solid Waste (MSW) landfill includes residential, institutional, commercial and industrial and construction and demolition wastes in various amounts.
Wood Waste Landfill	A wood waste landfill is an industrial on-site landfill for the disposal of wood waste.
Wood Waste Stockpiles (Permanent)	A wood waste stockpile is an above ground pile used for permanent disposal of wood waste.
Eligible Waste	Organic waste that is expected to decompose and generate methane in a landfill or stockpile under anaerobic conditions.
Class II Landfill	As defined in the Alberta Waste Control Regulation: a landfill for the disposal of waste not including hazardous waste.
Class III Landfill	As defined in the Alberta Waste Control Regulation: A landfill for the disposal of inert waste.
Inert Waste	Solid waste that, when disposed of in a landfill or re-used, is not reasonably expected to undergo physical, chemical or biological changes to such an extent as to produce substances that may cause an adverse effect, and includes, but is not limited to, demolition debris, concrete, asphalt, glass, ceramic materials, scrap metal and dry timber or wood that has not been chemically treated.
Projects related to landfills whose designation is unclear should contact ESRD for further guidance.	

Table 9. First Order Decay (FOD) Methane Quantification Model

First Order Decay (FOD) Methane Quantification Model	
Methane (CH_4) Quantification Model: Waste Diversion	The principle formula for the first order decay (FOD) Scholl-Canyon Model to be used for estimating avoided methane emissions as a result of waste diversion is: $\mathbf{Q} = \sum_{x=1}^{40} [\mathbf{k} * \mathbf{W}_C * \mathbf{L}_o * e^{-k(x-1)} * (\mathbf{1} - \mathbf{R})] * (\mathbf{1} - \mathbf{OX})$ Where: **Q = amount of methane emitted in the years x=1 to 40 by the waste W_C (t CH_4/yr) under the assumed baseline waste disposal practice** **k = methane generation constant (yr^{-1})** **W_C = amount of eligible waste diverted from disposal in the current year C (wet weight, t)** **L_o = methane generation potential (t CH_4/ t waste)** **R = methane captured and destroyed (fraction)** **OX = oxidation of methane in cover material (fraction)** x = iterative FOD emissions in year 1 to **40** from a given mass of waste **W_C** For the purpose of Alberta waste diversion protocols, the FOD model is used to calculate emissions forward over a period of 40 years (x=1 to 40), beginning in the year in which the waste is initially diverted. These emissions are applied to the total baseline emissions for the project in the year of waste diversion.
Methane Generation Potential (L_o)	$\mathbf{L_o} = \mathbf{MCF} * \mathbf{DOC} * \mathbf{DOC_f} * \mathbf{F} * \mathbf{16/12}$ Where: **L_o** = methane generation potential (t CH_4/ t waste) MCF = methane correction factor (fraction) DOC = fraction of degradable organic carbon in the waste (weight fraction) DOC_f = fraction of DOC that decomposes (weight fraction) F= fraction of methane in landfill gas 16/12 = stoichiometric factor (molecular weight ratio CH_4/C)

Table 10. Model Parameters for Quantification of Avoided Landfill and Stockpile Methane Emissions

Model Parameters[1]						
Parameter	**MSW Landfill**				**Wood Waste Landfill**	**Wood Waste Stockpiles Permanent**
Methane Correction Factor (MCF)	Managed (anaerobic)[a]	Unmanaged – Deep[c] (≥5 metres waste)	Unmanaged – Shallow[d] (<5 metres waste)	Uncategorized[e]		
	1.0 (0.5 semi-aerobic)[b]	0.8	0.4	0.6	0.8 (deep landfill >5m) 0.4 (shallow landfill <5m)	0.28[2]
	a -Anaerobic managed solid waste disposal sites (SWDS): These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste. b -Semi-aerobic managed SWDS: These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system. c - Unmanaged deep and/or high water table SWDS: All SWDS not meeting the criteria of managed SWDS and which have depths of greater or equal to 5 metres and/or high water table at or near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland by waste. d - Unmanaged shallow SWDS: All SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres. e - Uncategorized SWDS: Only if projects cannot categorize their SWDS into the above four categories can this category be used.					
Fraction of CH_4 in Landfill Gas (F)	0.5				0.5	0.5

<table>
<tr><th colspan="4">Model Parameters[1]</th></tr>
<tr><th>Parameter</th><th>MSW Landfill</th><th>Wood Waste Landfill</th><th>Wood Waste Stockpiles Permanent</th></tr>
<tr><td>Default Fraction of Degradable Organic Carbon (DOC)</td>
<td>If detailed information on the landfill waste composition is not available or applicable, default DOC should be used. If information on how the landfill is managed is not available to determine MCF, then use default Lo. Use DOC_f = 0.6 if comprehensive wood waste diversion program in place and DOC_f = 0.5 if no wood waste diversion program in place.
Default values for Alberta:
<table>
<tr><th>DOC content in % of wet weight</th><th>DOC</th><th>$L_o{}^f$ (DOC_f=0.5)</th><th>$L_o{}^f$ (DOC_f=0.6)</th></tr>
<tr><td>from 1990-present</td><td>0.17</td><td>56.67</td><td>67.95</td></tr>
</table>

f -L_o in kg CH_4/t waste. Must divide by 1000 kg CH_4 to convert to t CH_4/t waste.</td>
<td>$L_o{}^{f,g}$ | 80

g - for a shallow landfill L_o =40</td>
<td>$L_o{}^f$ | 40</td></tr>
<tr><td>Fraction of Degradable Organic Carbon (DOC)</td>
<td>If the landfill specific waste stream is well understood[h], individual DOC for the measured proportion of each waste stream in the landfill can be used to calculate a landfill-specific DOC using the formula provided below, or ideally based on measurement of the actual DOC content of each waste type in the landfill's waste stream. This landfill-specific mixed waste DOC value must be used in conjunction with the mixed waste landfill default DOC_f of 0.5 to 0.6.
DOC = (0.4*A) + (0.2*B) + (0.15*C) + (0.43*D)
DOC content in % of wet weight
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Waste Type</td><td>Paper</td><td>Garden and Yard</td><td>Food</td><td>Wood</td></tr>
<tr><td>DOC[3]</td><td>0.4</td><td>0.2</td><td>0.15</td><td>0.43</td></tr>
</table>
h -The sampling program for the waste composition monitoring should be based on industry accepted techniques. Sorting and documentation of the waste composition should be undertaken according to the Alberta Environment Provincial Waste Characterization Framework[4].</td>
<td>N/A</td><td>N/A</td></tr>
<tr><td>Default Fraction of Degradable Organic Carbon Dissimilated (DOC_f)</td>
<td>DOC_f = 0.6 if comprehensive wood waste diversion program in place

DOC_f = 0.5 otherwise</td>
<td>N/A</td><td>N/A</td></tr>
</table>

<table>
<tr><th colspan="4">Model Parameters[1]</th></tr>
<tr><th>Parameter</th><th>MSW Landfill</th><th>Wood Waste Landfill</th><th>Wood Waste Stockpiles Permanent</th></tr>
<tr><td>Waste Type-Specific DOC and DOC$_f$</td><td colspan="3">Currently not available.
The landfill/stockpile default L_o must be used when diverting a specific waste type (i.e. waste type-specific DOC cannot be used).</td></tr>
<tr><td>Oxidation Factor (OX)</td><td colspan="2">
<table>
<tr><th>Type of Site</th><th>CH_4 Oxidation Rates (OX, %)</th><th>Developed Area (m^2)</th></tr>
<tr><td>Default</td><td>10</td><td>-</td></tr>
<tr><td>Managed, unmanaged and uncategorized landfill (not covered with aerated material)</td><td>0</td><td>A</td></tr>
<tr><td>Managed covered with CH_4 oxidizing material e.g. topsoil/compost</td><td>10</td><td>B</td></tr>
</table>
For the case of different site types at different landfill areas, an average methane oxidation rate can be calculated by:
$$\mathbf{OX_{average}} = \frac{[(\mathbf{0\%} * \mathbf{A}) + (\mathbf{10\%} * \mathbf{B})]}{(\mathbf{A} + \mathbf{B})}$$
The use of an oxidation value other than 10 per cent should be clearly documented, referenced and supported by data relevant to the geographical context.</td><td>0.1</td></tr>
<tr><td>Methane Collection and Destruction (1-R)</td><td colspan="2">The fraction of methane collected and destroyed at the landfill (taking collection and destruction efficiencies into account). Projects diverting waste from landfills must provide clear documentation of landfill gas collection and destruction at all areas at the source landfills, i.e., the average LFG_{CE} at the source landfills (it cannot be assumed that R=0 because waste is being diverted from active cells).
R = LFG Collection Efficiency (LFG_{CE})*Methane Destruction Efficiency (LFG_{DE})
Default Values for LFG Collection Efficiencies (LFG_{CE})[5,6]:
<table>
<tr><th rowspan="2">Type of Cover System</th><th colspan="2">LFG Collection Efficiency</th><th>Developed Area</th></tr>
<tr><th>Range (%)</th><th>Default (%)</th><th>m^2</th></tr>
<tr><td>Operating Cell</td><td>-</td><td>35.0</td><td>A</td></tr>
<tr><td>Temporary Covered Cell</td><td>65-68</td><td>66.5</td><td>B</td></tr>
<tr><td>Final Clay Covered Cell</td><td>85-92</td><td>88.5</td><td>C</td></tr>
<tr><td>Composite Liner System</td><td>90-97</td><td>93.5</td><td>D</td></tr>
<tr><td>LFG Mitigation Control System</td><td>Site Specific</td><td>Site Specific</td><td>E</td></tr>
</table></td><td>N/A</td></tr>
</table>

<table>
<tr><th colspan="4">Model Parameters[1]</th></tr>
<tr><th>Parameter</th><th>MSW Landfill</th><th>Wood Waste Landfill</th><th>Wood Waste Stockpiles Permanent</th></tr>
<tr><td></td><td colspan="2">
For the case of various cover systems applied to different landfill areas, an average LFG_{CE} can be calculated by:

$$\mathbf{LFG_{CEaverage}} = \frac{[(\mathbf{35\%} * \mathbf{A}) + (\mathbf{66.5\%} * \mathbf{B}) + (\mathbf{88.5\%} * \mathbf{C}) + (\mathbf{93.5\%} * \mathbf{D})}{(\mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D})}$$

Default Values for Methane Destruction Efficiency (LFG_{DE})[7]:

<table>
<tr><th>Type of LFG Device</th><th colspan="2">Methane Destruction Efficiency</th></tr>
<tr><th></th><th>Range (%)</th><th>Average (%)</th></tr>
<tr><td>Boiler/Steam Turbines</td><td>67-99+</td><td>99.8</td></tr>
<tr><td>Gas Turbines</td><td>97-99+</td><td>98.2</td></tr>
<tr><td>Flares</td><td>38-99+</td><td>99.7</td></tr>
<tr><td>IC Engines</td><td>25-99+</td><td>86.1</td></tr>
<tr><td>Passive Venting</td><td>n/a</td><td>0</td></tr>
</table>

Alternative methane controls at landfills must be appropriately taken into account (i.e., bioreactor technology, enhanced oxidation practices).
</td><td></td></tr>
<tr><td>Default k-value</td><td>
The recommended equation as per Alberta's Technical Guidance for Quantification of Specified Gas Emissions from Landfills[8] is to be used to calculate k-values until on-going research permits further assessment of these values.

k=0.00003*PCPN + 0.01

Where:

PCPN = Annual average precipitation at the nearest weather station for the most recently available Environment Canada 30-year climate normal period (mm/yr).

In the case where additional liquids are introduced into the landfill (e.g. at a bioreactor landfill), the amount of additional liquids should be converted and added to the amount of precipitation at the site. For these cases the formula for k would be:

k=0.00003*(PCPN+AL) + 0.01

Where:

AL = Amount of additional liquid into the landfill cell (mm/yr.)
</td><td>0.02</td><td>0.02</td></tr>
</table>

Model Parameters[1]			
Parameter	**MSW Landfill**	**Wood Waste Landfill**	**Wood Waste Stockpiles Permanent**
Landfill-Specific k-value	Landfill-specific k-value calculation for those landfills in a position to do should follow the MSW Landfill k-value Calculation[9].		

[1] 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

[2] 2009. Methodological Tool. Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site. EB 41 Annex 10 Version 04. United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM).

[3] 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5 Waste. Intergovernmental Panel on Climate Change (IPCC).

[4] 2005. Provincial waste characterization framework: A Joint Project of Alberta Environment, Government of Canada, Action Plan 2000 on Climate Change (Enhanced Recycling Program) and the Recycling Council of Alberta, Final Report. Alberta Environment.

[5] 2003. French Calculation Guidelines for Estimating Atmospheric Emissions of CH4, CO2, SOX and NOX released by Non-Hazardous Waste Landfills (English Version). French Environmental Agency. ADEME.

[6] 2007. Current MSW Industry Position and State-of-the-Practice on LFG Collection, Methane Oxidation, and Carbon Sequestration in Landfills. Prepared for Solid Waste Industry for Climate Solutions (SWICS). Prepared by SCS Engineers.

[7] 1998. USEPA AP-42 Compilation of Emission Factors, November 1998, Attachment A. U.S. Environmental Protection Agency.

[8] 2008. Technical Guidance for the Quantification of Specified Gas Emissions from Landfills (Version 1.2). Alberta Environment

[9] October 2014. MSW Landfill k-value Calculation Best Management Practice. Alberta Environment.