ALTERNATIVE TECHNOLOGIES IN FUGITIVE GHG EMISSIONS QUANTIFICATION FOR LANDFILLS

Redefining possible.

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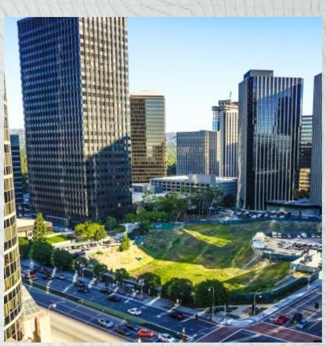
Air Quality Engineer

June 3rd, 2021

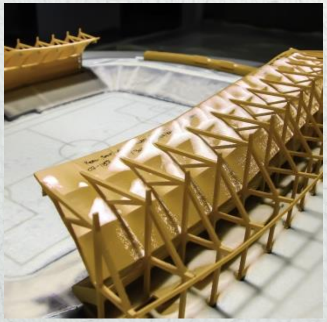
RWDI is committed to the fight against climate change

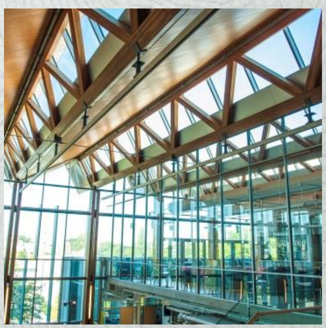
Climate Engineering

Building Performance



Environmental Engineering





Outline

- Common GHG emissions from landfills
- Regulatory obligations & opportunities
- First-order decay
- Direct measurements and modelling

Common GHG Emissions from Landfills

What is landfill gas made of ?

Landfill gas is generated from the decomposition of waste.

Landfill gas is comprised of

- 50-60% methane (v/v)

- 40–50% carbon dioxide (v/v)

- Trace amounts of other gases (less than 1%) such as:
  - non methane organic compounds (NMOC),
  - nitrous oxides (N_2O),
  - oxygen (O_2)

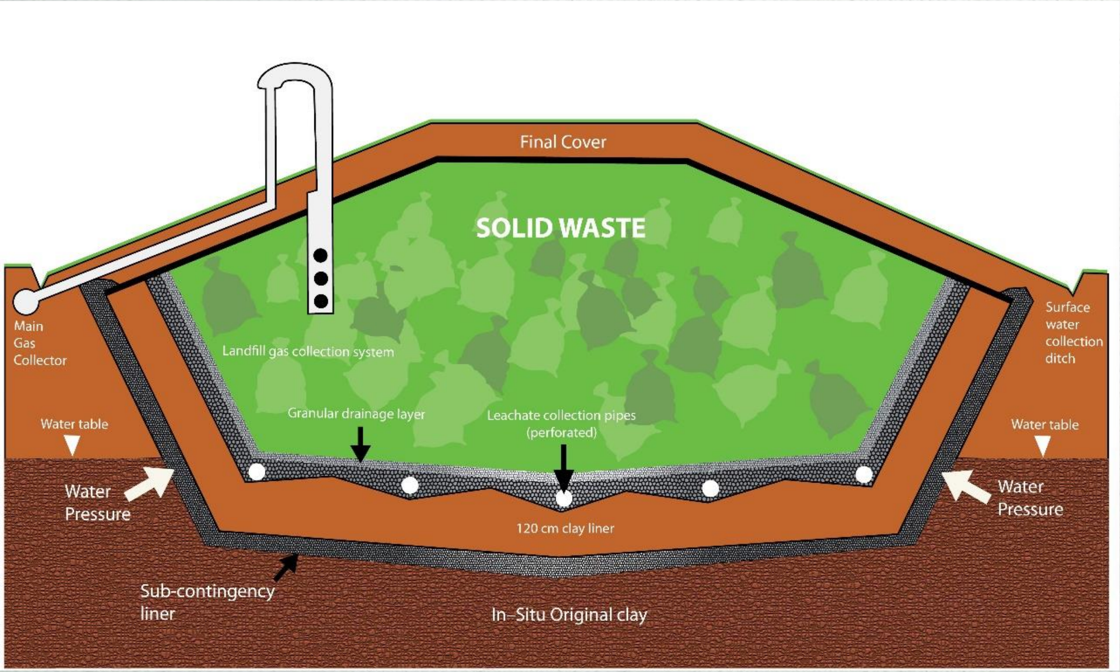
What affects landfill gas generation?

Almost 40% of municipal solid waste that goes to landfills is organic matter which contributes to methane production.

- Waste composition and quantity
- Moisture content
- pH
- Temperature
- Depth of landfill
- Particle size
- Waste density

Good landfill management can reduce emissions

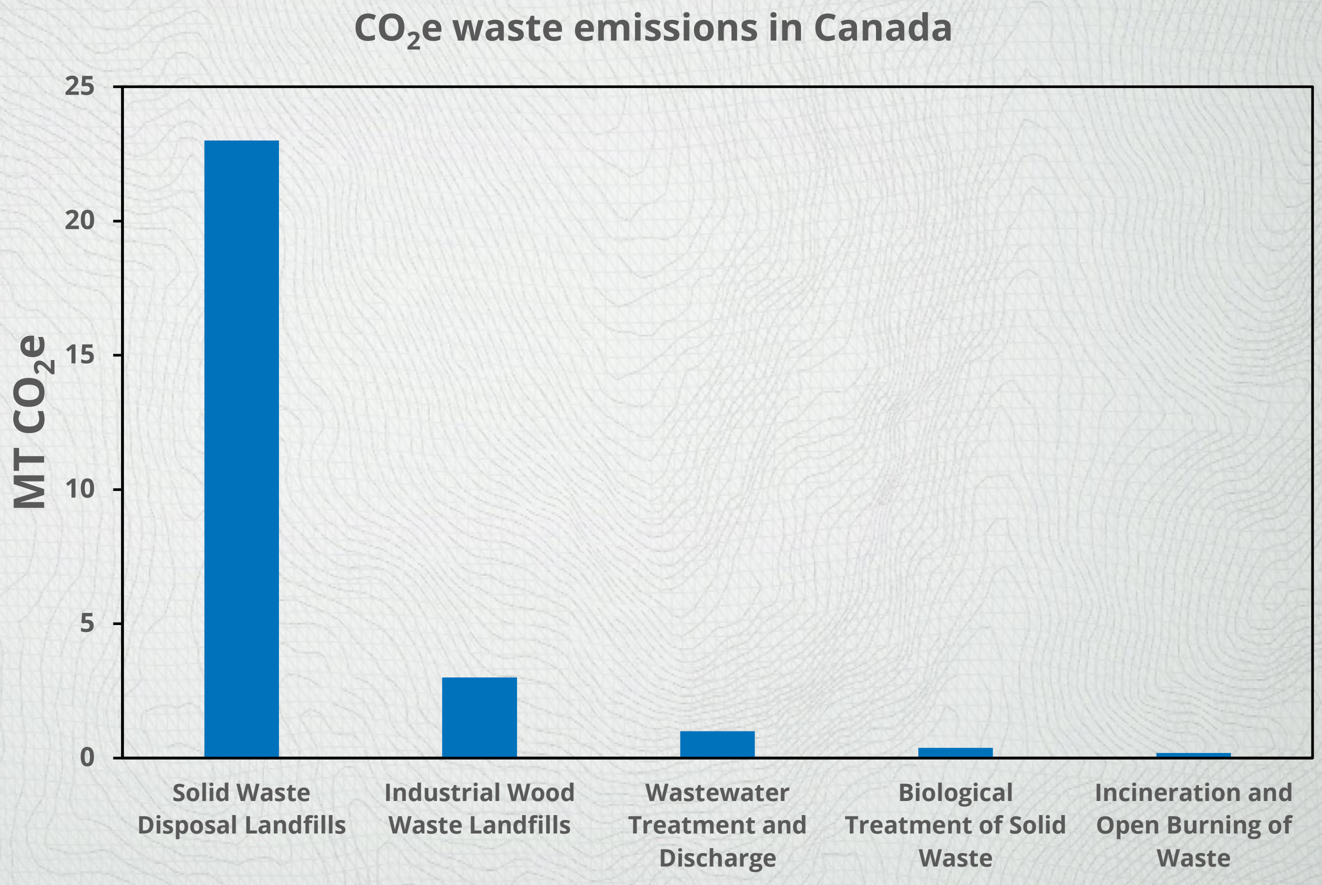
- Good cover practices for interim and final cover areas
- Active landfill cap reviews and maintenance for leaks
- Proper liners
- Well designed landfill gas collection system for optimal capture efficiency



Waste emission in Canada (2021 National Inventory Report)

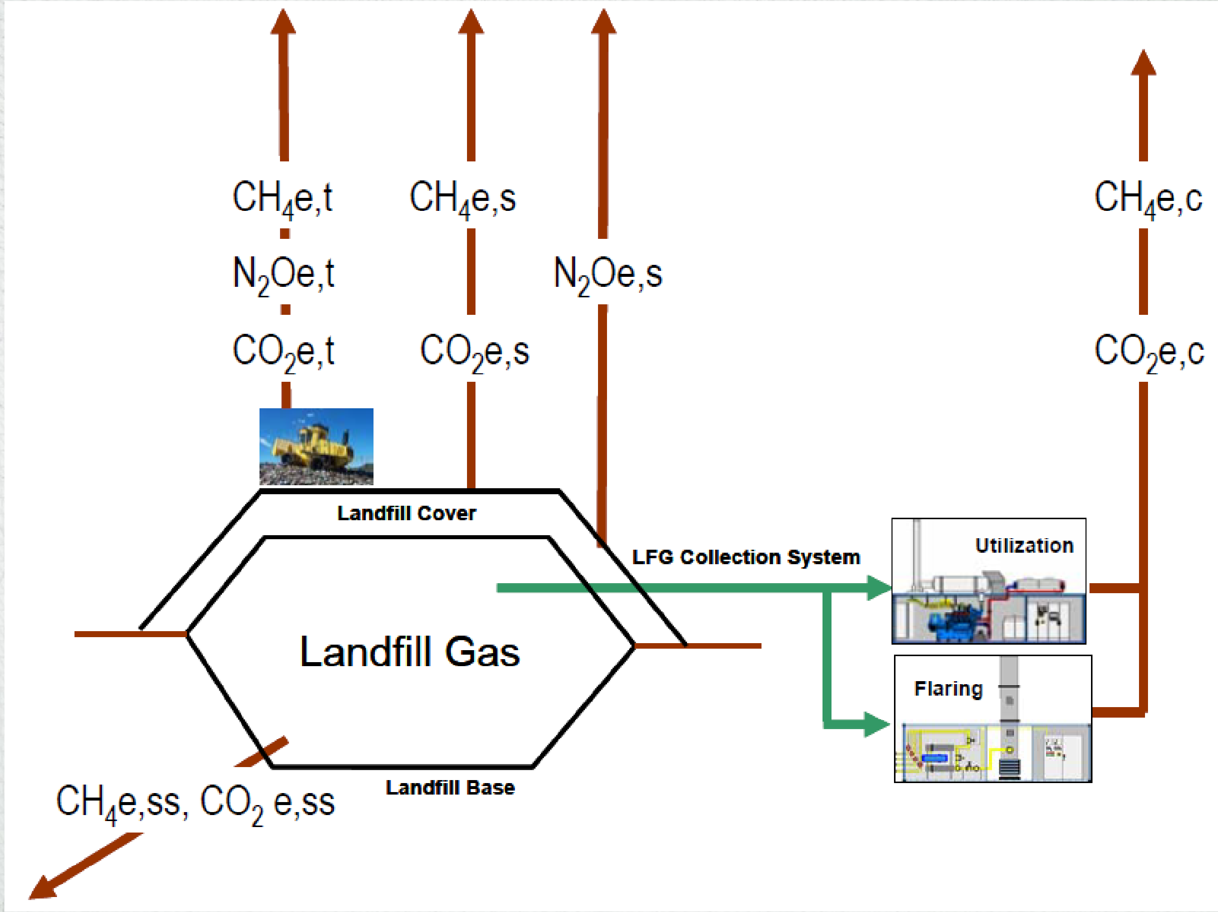
Emissions from Waste contributed 28 Mt CO_2e (3.8%) to Canada's total emissions in 2019.

In 2019, landfills (solid and industrial wood waste) accounted for 26 Mt CO_2e (94%) of Waste emissions.



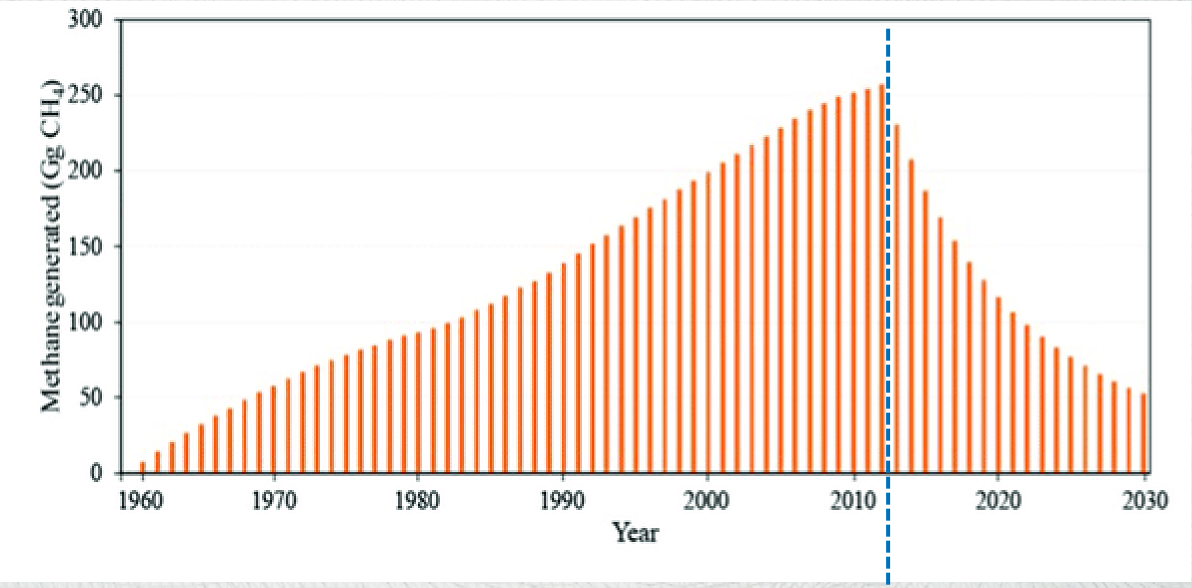
Overview of Direct Emission Pathways from Landfills

In addition to the decomposition of waste, other sources of GHG emissions exist at a landfill, such as emissions from equipment (dozers, compactors, etc.), N_2O from cover soils, and emissions from landfill gas combustion (flares, etc.)



Overview of Direct Emission Pathways from Landfills

Landfills continue to emit GHGs even after they stop receiving new waste.



No waste deposits after 2011

Regulatory Obligations & Opportunities

Federal Output-Based Pricing System (OBPS) SOR/2019-266

- If a facility is subject to OBPS regulation and has an on-site landfill, the landfill emissions should be quantified.

- OBPS Regulation came into effect in 2019 for areas that do not have a local GHG program.

- Federal OBPS is currently in effect in Ontario, Manitoba, New Brunswick, PEI, Yukon, Nunavut, and partially in Saskatchewan.

Alberta Technology Innovation and Emissions Reduction (TIER) Regulation

Large emitters (>100 ktCO_2e) are subject to TIER.

Other facilities may opt-in to TIER.

Conventional oil and gas facilities may form aggregates and apply to be regulated under TIER.

- Alberta's TIER regulation meets federal government's minimum stringency benchmark requirements.
- TIER replaced the Carbon Competitiveness Incentive Regulation (CCIR) on January 1st, 2020.
- TIER facilities are exempt from paying the federal fuel charge.
- Landfill emissions should be quantified if the facility is subject to TIER regulation.

Alberta Emission Offset System

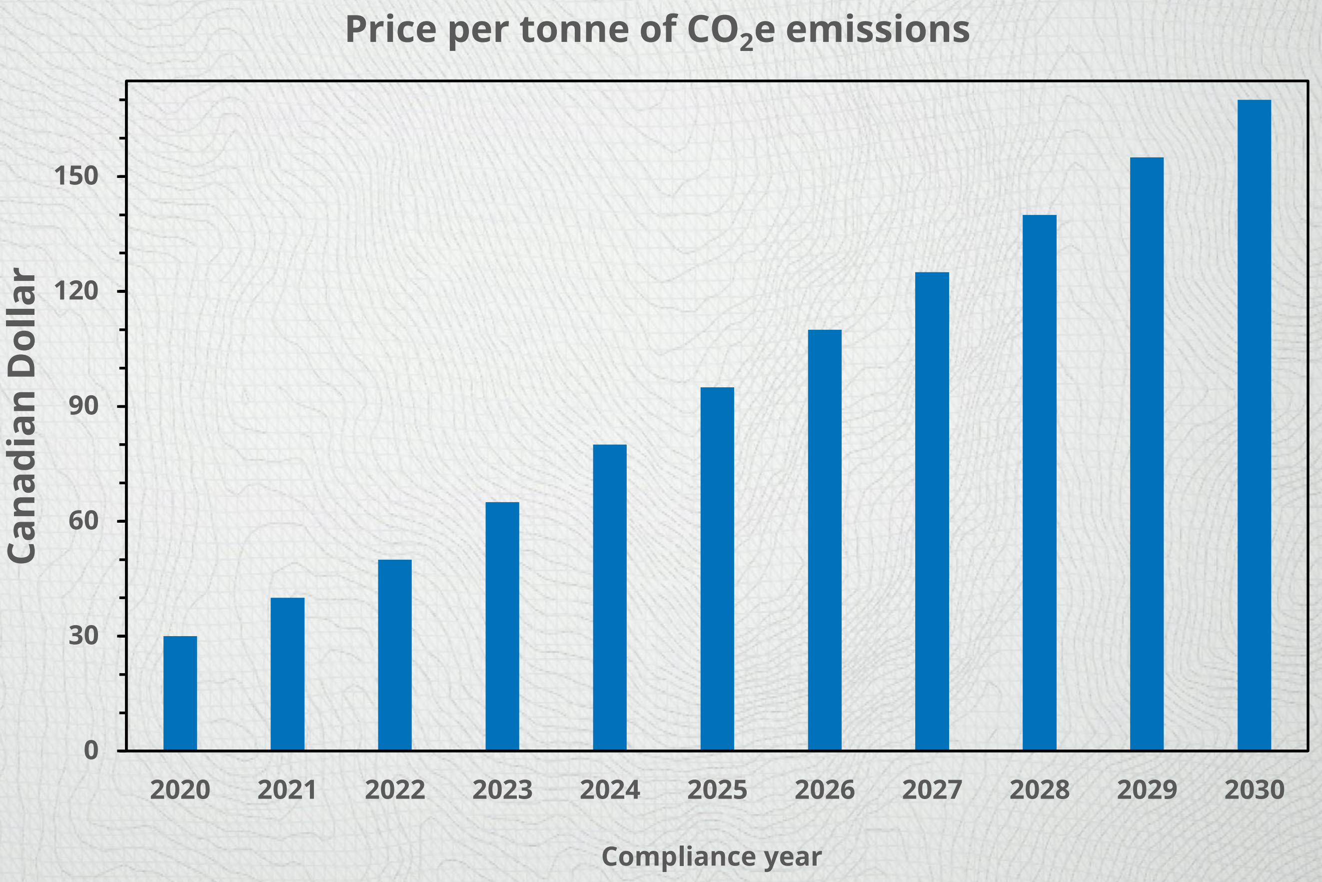
Facilities that are not subject to TIER as a large emitters or opted-in facilities can generate emission offsets.

Conventional Oil and Gas Aggregates that are regulated under TIER can generated emission offsets from non-stationary combustion sources.

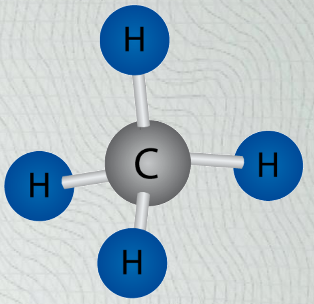
- Emission offsets are generated by projects that have voluntarily reduced their greenhouse gas emissions.
- Emission offsets may be traded in the carbon offset market.
- Emission offsets may be used to satisfy the facilities emission reduction obligations under TIER.
- Aerobic composting is one of the pathways that can be used to generate emission offsets

Carbon Emission Pricing

In December 2020, the Federal Government released an updated plan with a $15 per tonne per year increase in the carbon pricing from 2023, reaching $170 per tonne in 2030.

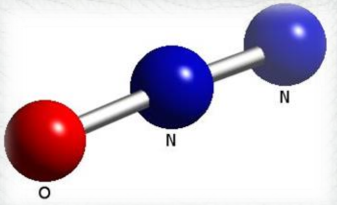


Landfill Gas Emission Quantification



CO_2 in landfill gas is not subject to pricing but under TIER it should be reported with quarterly sampling or measurement frequency for large emitters and opted-in facilities.

- Landfill gas emissions are considered Biomass Emissions
- Direct CO_2 in Landfill gas is not subject to emission pricing (but should be reported under TIER)
- CH_4 and N_2O emissions are subject to emission pricing.
- CH_4 emissions are multiplied by a Global Warming Potential (GWP) of **25** to obtain CO_2 equivalent (CO_2e) emissions.
- GWP for N_2O is **298**.



Luckily, there is usually less than 1% N_2O in landfill gas.

Landfill Gas Emission Quantification

Quantification methodology for Federal **OBPS**:

- ✓ IPCC 2006 guidelines including First Order Decay Model
- ✓ There is flexibility to use site-specific methodology

Quantification methodology for Alberta **TIER**:

- ✓ No prescribed methodology
- ✓ There is flexibility to use site-specific methodology

Quantification methodology for Alberta **Emission Offsets**:

- ✓ First Order Decay Model should be used.
- ✓ There is flexibility to use a site-specific key parameter (K-value)

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First-Order Decay

First-Order Decay (FOD) Method

The most common FOD method is the Scholl Canyon Model.

$$\mathbf{Q} = \sum_{x=1}^{40} \left[\mathbf{k} * \mathbf{W}_C * \mathbf{L}_o * e^{-k(x-1)} * (\mathbf{1} - \mathbf{R})\right] * (\mathbf{1} - \mathbf{OX})$$

Where:

Q = amount of methane emitted in the years x = 1 to 40 by the waste W_C (tonne CH_4/yr) under the assumed baseline waste disposal practice

k = methane generation rate (1/yr)

W_C = amount of eligible waste diverted from disposal in the current year C (wet weight, t)

L_o = methane generation potential (tonne CH_4/ tonne waste)

R = methane captured and destroyed (fraction)

OX = oxidation of methane in cover material (fraction)

First-Order Decay (FOD) Method

Depending on the landfill, the model may require some equations in addition to what is presented here.

$$L_o = MCF * DOC * DOC_f * F * 16/12$$

Where:

L_o = methane generation potential (tonne CH_4/ tonne waste)

MCF = methane correction factor (fraction) in the year of decomposition

DOC = fraction of degradable organic carbon in the waste (tonne Carbon/tonne waste, by wet weight) in the year of decomposition

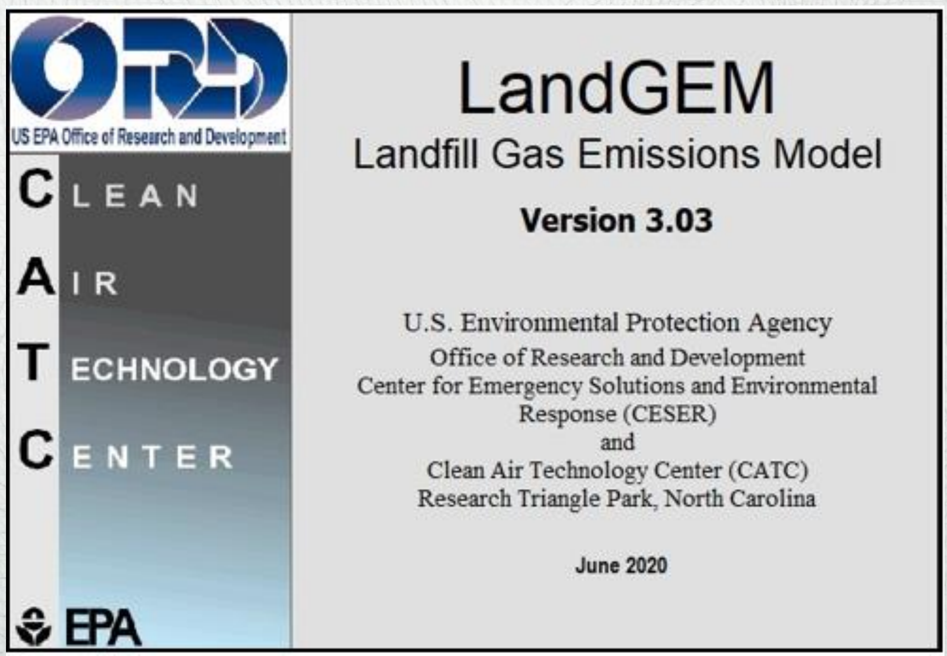
DOC_f = fraction of DOC that decomposes (weight fraction)

F= fraction by volume of methane in landfill gas

16/12 = stoichiometric factor to convert weight of carbon to weight of methane (molecular weight ratio CH_4/C)

U.S. EPA Landfill Gas Emissions Model (LandGEM)

- Excel Spreadsheet that calculates methane emission rates based on first order decay
- Factors developed based on data from landfills for various components


US EPA Office of Research and Development

CLEAN AIR TECHNOLOGY CENTER

EPA

LandGEM

Landfill Gas Emissions Model

Version 3.03

U.S. Environmental Protection Agency
Office of Research and Development
Center for Emergency Solutions and Environmental Response (CESER)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

June 2020

Comments on FOD

Can be enhanced by user input and adjustment of modelling inputs based on biodegradable portion of waste streams, accurate account of current and historical waste practices.

FOD can also be enhanced with a measurement - modelling approach where a series of ambient measurements are taken and the FOD model (or air dispersion model) is calibrated.

- Most parameters used in the model are chosen from a set of default values.
- Can be enhanced by user input and measurement/modelling approach as necessary
- Alberta offset emissions protocol requires the estimations for 40 years, and IPCC 2006 guideline recommends waste data for at least 50 years.

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Direct measurements and modelling

Flux Chambers

Number of samples required increases with the area of landfill.

- Well established but older method
- Provides direct measurement of emissions
- Fairly simple but can be labour intensive
- Small area and short time frame extrapolated to cover much larger area for entire year
- Can only measure where you can access.

Flame Ionization Detectors (FID) Surveys

- Used in landfill gas monitoring
- Can be used to determine the intensity of methane emissions
- Can help to identify possible locations of fugitive emissions
- Low maintenance requirements

Eddy Covariance

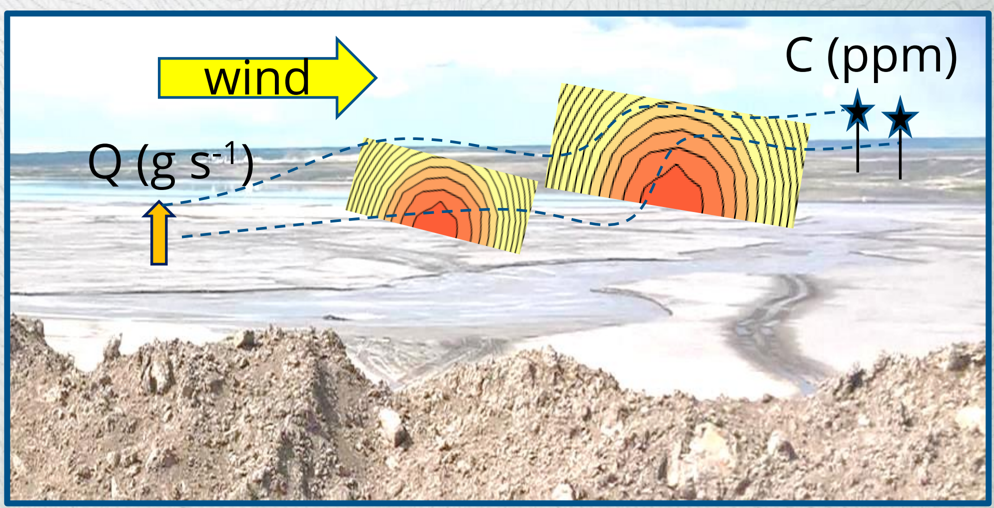
Eddy covariance technique is an atmospheric measurement technique to measure and calculate vertical turbulent fluxes within atmospheric boundary layers.

- Well established method
- Can be deployed over longer time frame
- Covers a larger area
- Does need input from meteorological measurements
- Deployment location is important

Inverse Dispersion Modelling (IDM)

Measures an ambient concentration to back calculate the emission rate that would have produced such measurement.

- Measurement points to capture both upwind and downwind conditions simultaneously
- Can account for more complicated terrain, heterogeneity of landfill
- Sampling is done over the edges of the area (safer, not interfering with operations).
- Meteorological conditions need to be collected concurrently
- Can get more complicated and sophisticated
  - 2D wind 3D wind
  - Terrain conditions
  - But it can handle it



To sum up …

1

Landfill gas contains

50-60% methane (v/v)

and

40–50% carbon dioxide (v/v)

2

A $15 per tonne per year increase in the carbon pricing from 2023,

reaching $170 per tonne in 2030

3

First-Order Decay (FOD) is commonly used such as in LandGEM

4

Direct measurement and alternative modelling methods are also available:

- Flux Chambers
- FID surveys
- Eddy Covariance
- IDM
- Etc.

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RWDI can assist facilities with both

FOD model

and

Direct measurement methods and IDM.

THANK YOU!

Redefining possible.

QUESTIONS?

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