



Understanding the Inventory of U.S. GHG Emissions and Sinks and the GHG Reporting Program for Landfills

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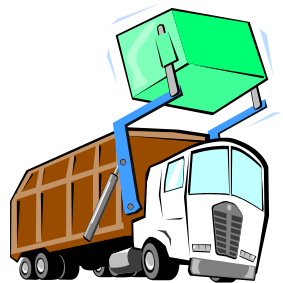
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Goals of this Presentation

- Methodological differences between the Inventory and the GHGRP for landfills
- How (and when) the GHGRP landfills data could potentially improve the Inventory



Landfill Gas Background



Landfill biogas:

~50% CO₂ + ~50% CH₄



CH₄ directly
emitted to
atmosphere



No

Is there a
GCS?

Yes



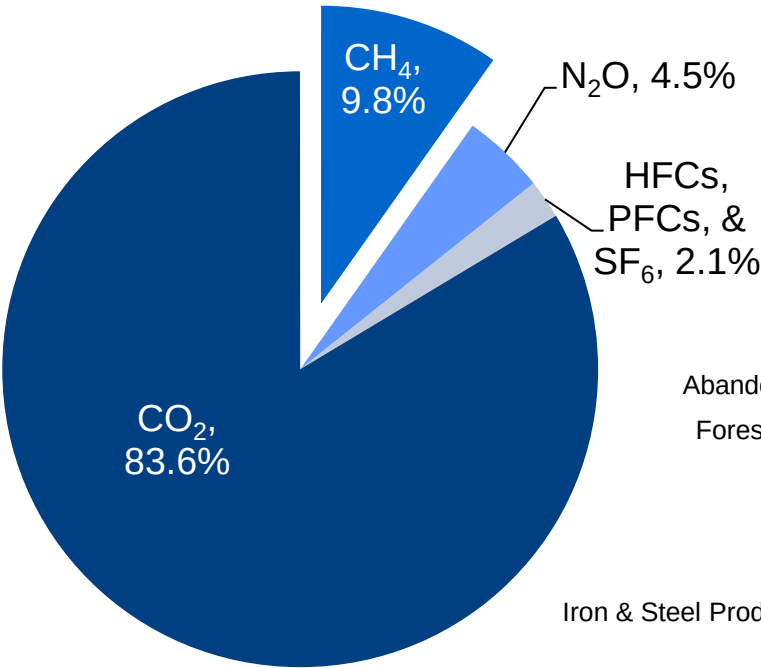
CH₄ recovered
and flared or
combusted

No O₂ +

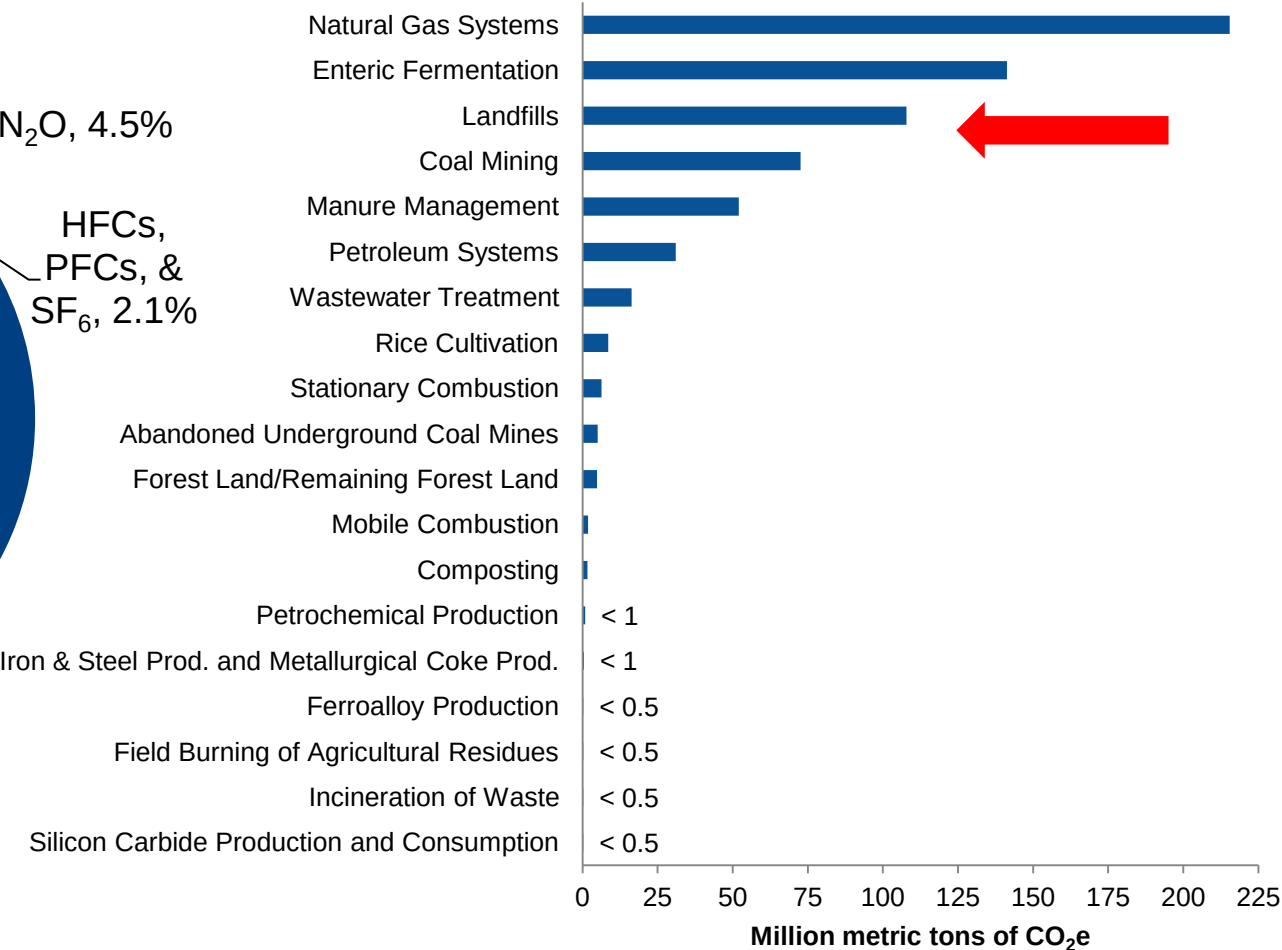


Why do we care about landfill gas?

2010 GHG Emissions by Gas across all Sectors
(USEPA, 2012)



2010 CH₄ Emissions by Source (USEPA, 2012)



How is the USEPA Tracking Landfill Emissions?

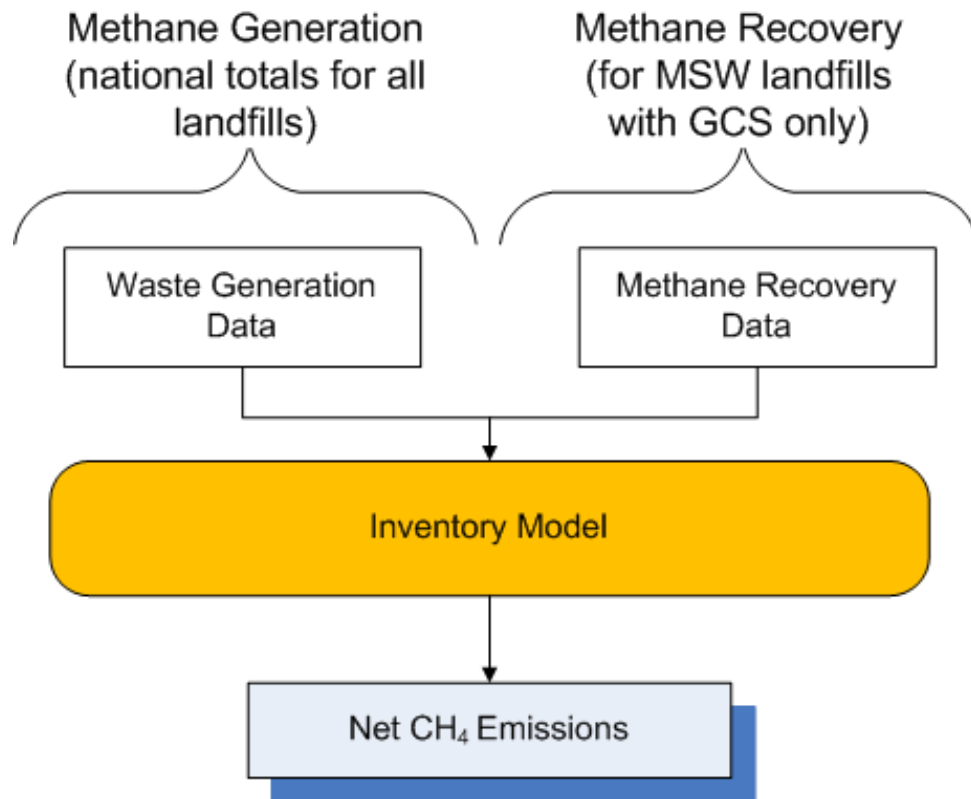
- Solid Waste Inventory (solid waste portion of the Inventory of U.S. GHG Emissions and Sinks)
- Subparts HH (Municipal Solid Waste Landfills) and TT (Industrial Waste Landfills) of the Greenhouse Gas Reporting Program (GHGRP)

Overview of the Inventory of U.S. GHG Emissions and Sinks

- Conducted annually since 1990 to meet UNFCCC requirements
- Impartial and policy-neutral
- Follows IPCC 2006 Guidelines
- Uses a combination of secondary datasets
- Current and archived U.S. GHG inventories available at:

<http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

How the Solid Waste Inventory Works



- CH₄ generation estimated from national waste totals (i.e., not landfill-specific)
- CH₄ recovery only for MSW landfills with GCS (i.e., is landfill-specific)
- No data on GCS at industrial waste landfills

Overview of the GHGRP for Landfills

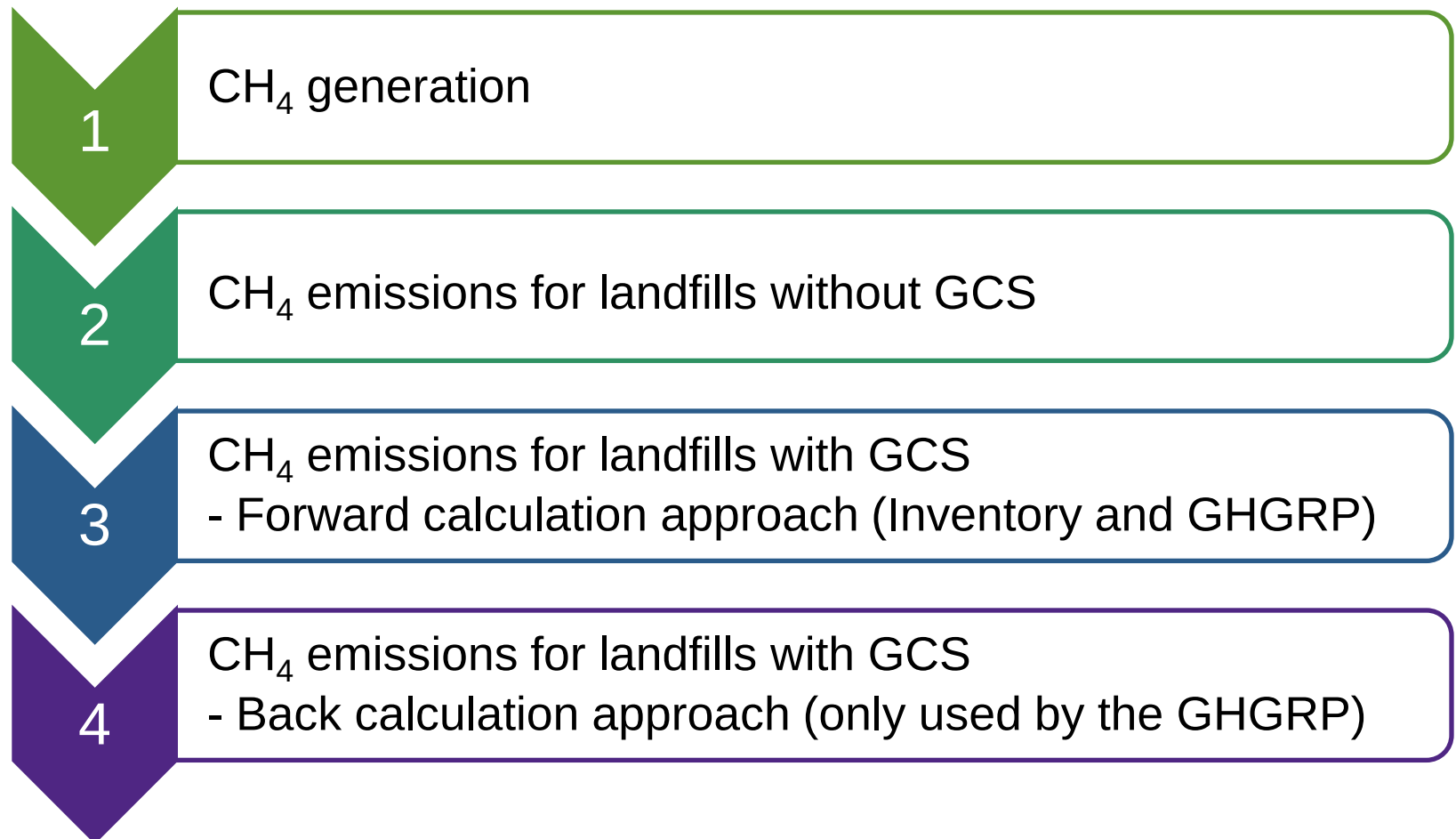
- Only landfills meeting the thresholds have to report
- HH (Municipal Solid Waste Landfills)
 - Accepted waste on or after 1/1/1980
 - CH₄ generation $\geq$ 25,000 MT or more of CO₂e
- TT (Industrial Waste Landfills)
 - Accepted waste on or after 1/1/1980
 - Located at a facility whose total landfill design capacity is $\geq$ 300,000 MT
 - Combined GHG emissions $\geq$ 25,000 MT

GHGRP Reporting Details

- Data reported through e-GGRT
- Extensive verification process
- Reporting schedule (annually)
 - HH first reported in 3/2011 for 2010
 - TT first reporting in 9/2012 for 2011
- Some data (emissions equation inputs) deferred from reporting until 3/2013 or 3/2015



Outline for Methodology Discussion



1

CH₄ Generation: IPCC FOD Model

- CH₄ generation is modeled using the IPCC first order decay (FOD) model
- Inventory and GHGRP use the same FOD equation, but different equation inputs

1

CH₄ Generation: IPCC FOD Model

$$G_{CH_4} = \left[\sum_{x=S}^{T-1} \left\{ W_x \times L_o \times \frac{16}{12} \times \left(e^{-k(T-x-1)} - e^{-k(T-x)} \right) \right\} \right]$$

where

G_{CH_4} = Total amount of CH₄ generated

T = Reporting year for which emissions are calculated

x = Year in which waste was disposed

S = Start year of calculation

W_x = Quantity of waste disposed of in the landfill in a given year

L_o = Methane generation potential

16/12 = conversion factor from CH₄ to C

k = Decay rate constant (yr⁻¹)

Inventory $\longrightarrow$ W_x = national waste generation; L_o = default inputs; CH₄ generation by climate (k = wet, moderate, arid)

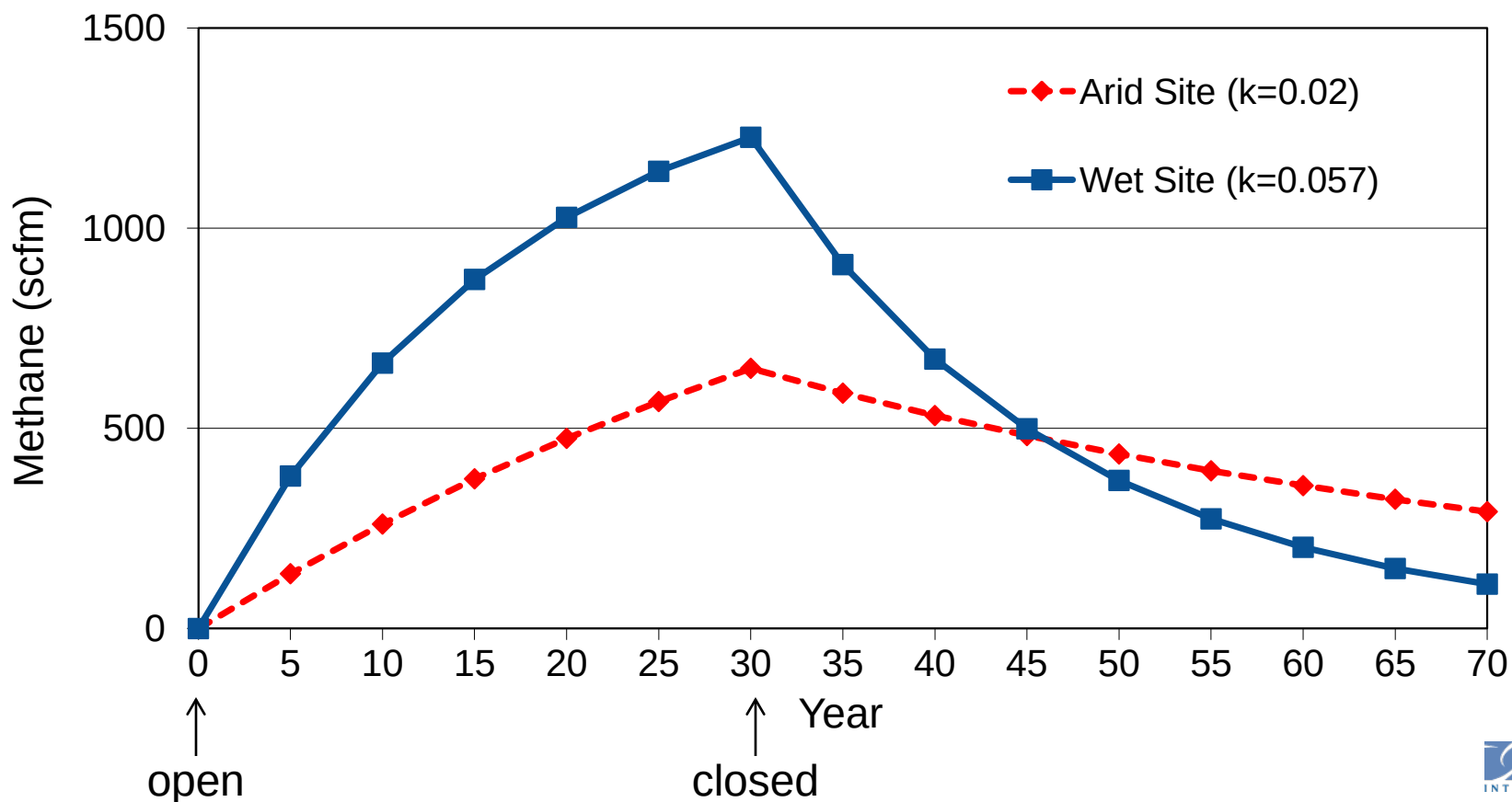
GHGRP $\longrightarrow$ Facility- and/or waste type-specific inputs (W_x , L_o , k)

1

CH₄ Generation: IPCC FOD Model

Example of Landfill Methane Generation

(disposed of 250,000 tons per year from Year 0 to 30)



2

CH₄ emissions for landfills without GCS

$$CH_4 \text{ emissions} = G_{CH_4} \times (1 - OX)$$

where

G_{CH_4} = the result from the FOD model

OX = a default oxidation factor of 10%

Both the Inventory and the GHGRP use this equation;
no differences

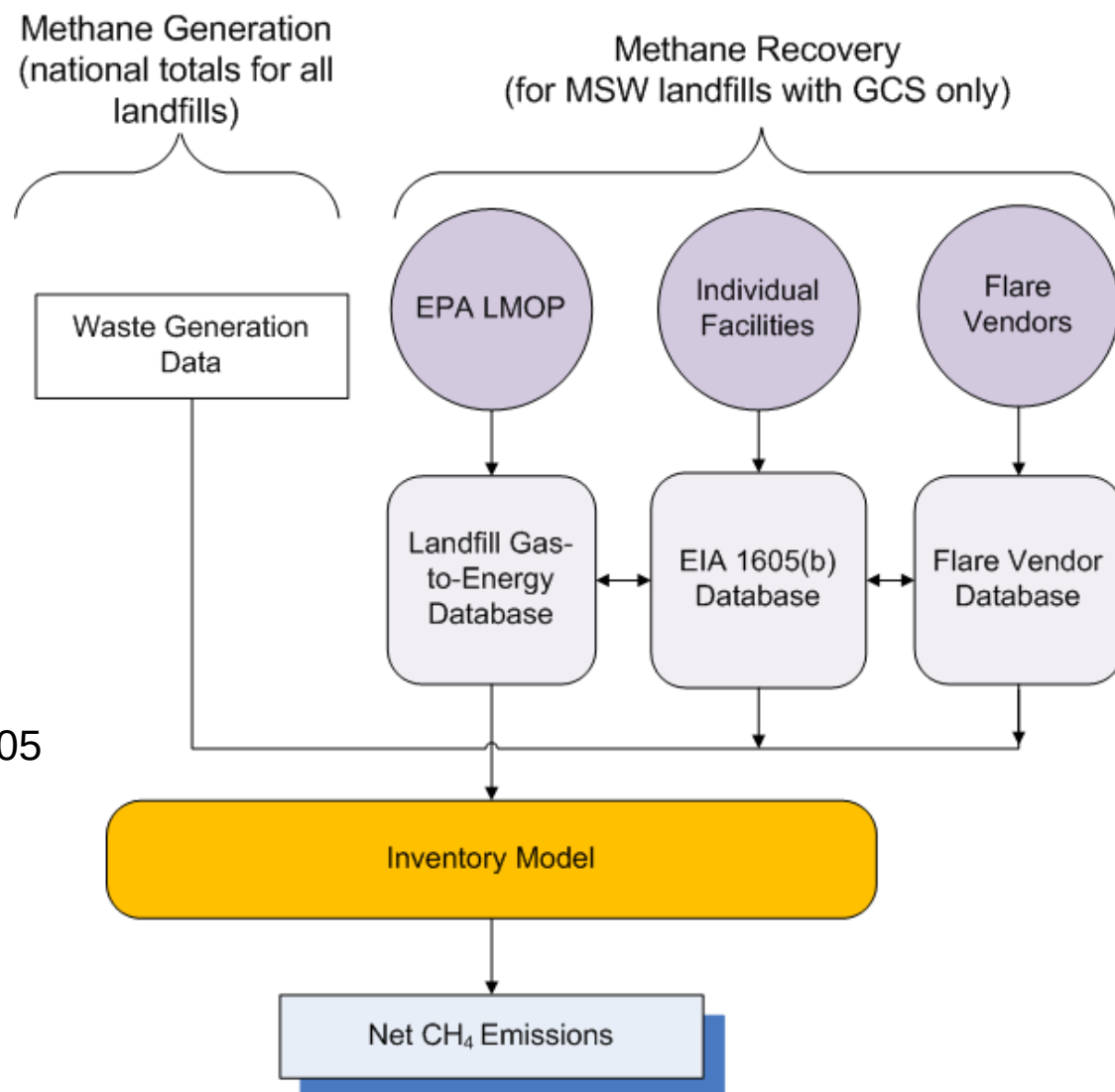
CH₄ Recovery from Landfills with GCS

There are significant differences!

1. Inventory uses 3 databases to determine CH₄ recovery (R)

- LMOP = Landfill Methane Outreach Program (annually)
- EIA 1605(b), last updated in 2005
- U.S. flare vendors (contacted annually)

= high uncertainty



CH₄ Recovery from Landfills with GCS (continued)

2. GHGRP requires direct measurements of flow rates and CH₄ concentration of the recovered landfill gas
= less uncertainty
3. GHGRP requires facilities to calculate CH₄ emissions 2 ways:
 - Forward calculation: Based on IPCC FOD Model (same as the Inventory)
 - Back calculation: Based on gas collection data

3

Forward calculation for landfills with GCS

- Forward calculation means based off of the FOD Model

$$\text{Net CH}_4 \text{ emissions} = (G_{\text{CH}_4} - R) \times (1 - \text{OX}) + R \times (1 - (\text{DE} \times f_{\text{Dest}}))$$

where

G_{CH_4} = CH_4 generated from the FOD model

R = amount of CH_4 recovered by the landfill GCS

OX = oxidation factor

DE = destruction efficiency

f_{Dest} = fraction of hours the destruction device was operating

- In the GHGRP, G_{CH_4} is either G_{CH_4} from the FOD model or the measured value of R , whichever is greater (to avoid negative net emissions)

4

Back calculation for landfills with GCS

- “Back calculation” means estimating G_{CH_4} from directly measured R , CE , and f_{REC}
- Only used by the GHGRP

$$Net\ CH_4\ emissions = \left[\left(\frac{R}{CE \times f_{REC}} - R \right) \times (1 - OX) + R \times (1 - (DE \times f_{Dest})) \right]$$

where

CE = collection efficiency estimated at the landfill, taking into account system coverage, operation, and cover system materials from Table HH-3 of the GHGRP

f_{REC} = fraction of hours the recovery system was operating

Back to the point of this presentation . . .

- What are the key methodological differences between the Solid Waste Inventory and the GHGRP for landfills?
- How (and when) can the GHGRP data potentially improve the Solid Waste Inventory?

Comparing the Methodologies

Data Element	U.S. GHG Emissions Inventory	GHGRP
Applicability	Entire U.S. economy (all GHG emissions)	Facilities meeting thresholds (85–95% of GHG emissions)
Waste generation data	Aggregated national data “top down”	Facility-specific data “bottom up”
CH ₄ generation	IPCC FOD model, default inputs, 3 climate types	IPCC FOD model, facility-specific inputs
CH ₄ emissions, no GCS	G _{CH4} - OX	G _{CH4} - OX
CH ₄ recovery	Estimated from 3 secondary databases = high uncertainty	Direct measurements = low uncertainty
CH ₄ emissions, GCS	Forward calculation approach	Forward and back calculation approaches

How and when can the GHGRP data improve the Inventory?

- When = the deferral expires in 3/2013, so 2014
- Potentially improve CH₄ generation estimates by:
 - Potentially revising the default FOD equation inputs (k, Lo)
 - Updating the standard MSW waste composition (affects Lo)
 - Incorporating industrial waste composition data
- Potentially improve CH₄ recovery estimates using:
 - Direct recovery measurements for MSW landfills and industrial waste landfills with GCS

Methane recovery will be the most meaningful improvement to the Inventory!

Thanks for your attention!

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