U.S. Greenhouse Gas Inventory: Update on Methodology Improvements for MSW Landfills

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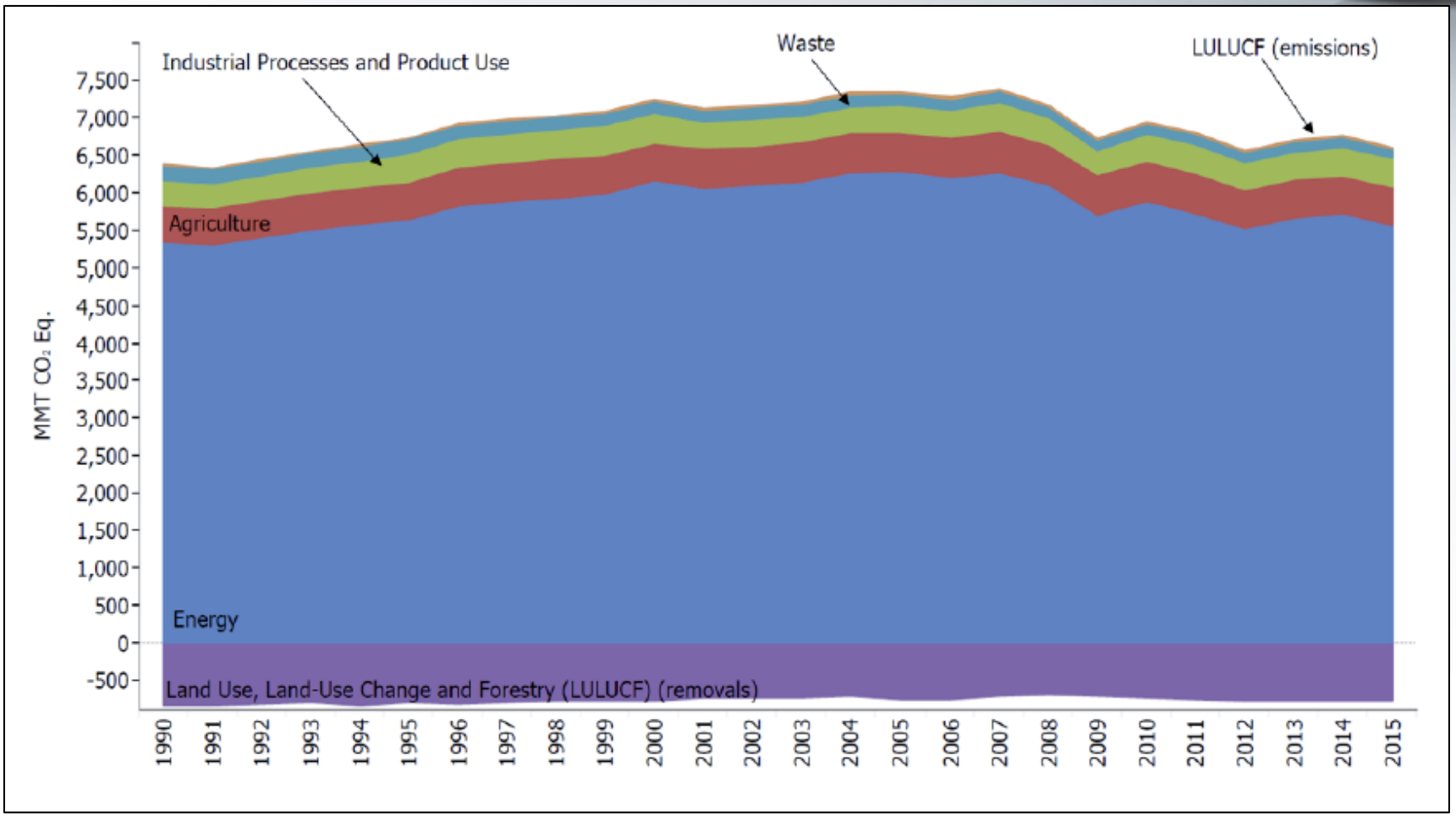
Agenda

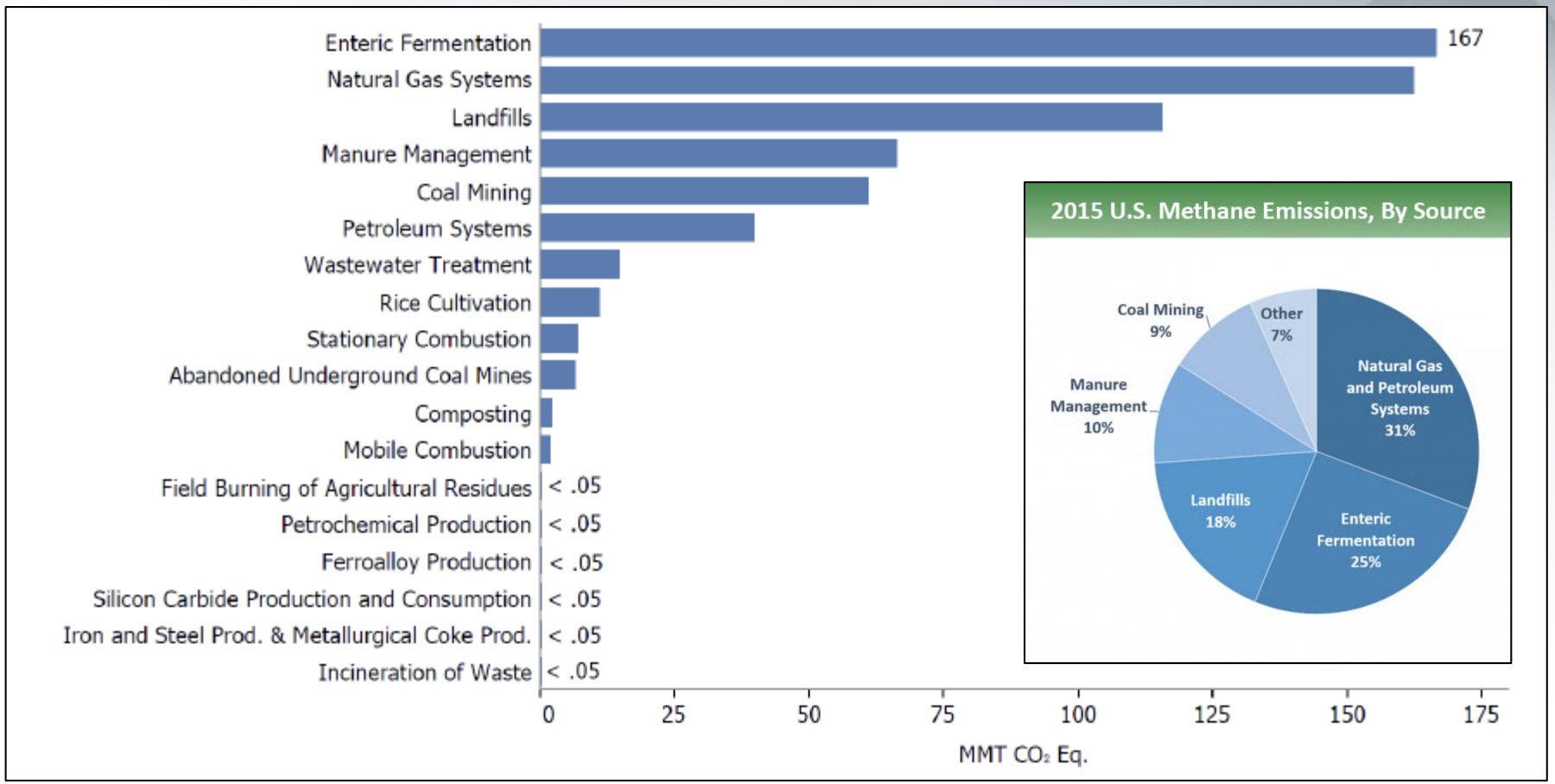
- Overview of waste sector emissions in the Inventory
- Methodological changes made to the 1990-2015 Inventory
- Update on methodological improvements for future Inventories
  - Revisions to the scale-up factor
  - Assessment of oxidation factor
  - Review of waste characterization studies for potential DOC revisions
- Q&A and discussion
- Schedule and next steps for the 1990-2016 Inventory

1990-2015 Inventory Emissions by IPCC Sector (MMT CO2eq)



Source: Figure ES-12 from the EPA Inventory of U.S. GHG Emissions and Sinks: 1990-2015. Available at https://www.epa.gov/sites/production/files/2017-02/documents/2017_executive_summary.pdf.

2015 Sources of Methane Emissions (MMT CO2eq)



Source: Figure ES-9 from the EPA Inventory of U.S. GHG Emissions and Sinks: 1990-2015. Available at https://www.epa.gov/sites/production/files/2017-02/documents/2017_executive_summary.pdf.

Summary of Methodological Changes to the 1990-2015 Inventory

1990-2015 Inventory Methods

Four major methodological recalculations:

1. Used net CH_4 emissions as directly reported to subpart HH of GHGRP for 2010 to 2015.
2. Applied a 12.5% scale-up factor to account for emissions from MSW landfills that are not required to report under subpart HH (for 2010-2015).
3. Back-casted net CH_4 emissions from subpart HH for 2005 to 2009.
   - Consistent with IPCC good practice when merging new data with previously used methods for time series consistency.
4. Used the first order decay model for 1990-2004 with revised MSW generation data.
   - MSW generation data adjusted to exclude C&D/inerts as reported in the State of Garbage Survey

1990-2015 Inventory

- For the first time, we used CH_4 emissions as directly reported to the GHGRP
  - Facility-specific CH_4 recovery (where applicable)
  - Variety of oxidation factors (0, 0.10, 0.25, 0.35)
  - Facility-reported annual waste disposal quantities 50 years prior to first acceptance
- Gap = emissions from facilities that do not report to the GHGRP
  - Accounted for by scale-up factor

Scale-Up Factor

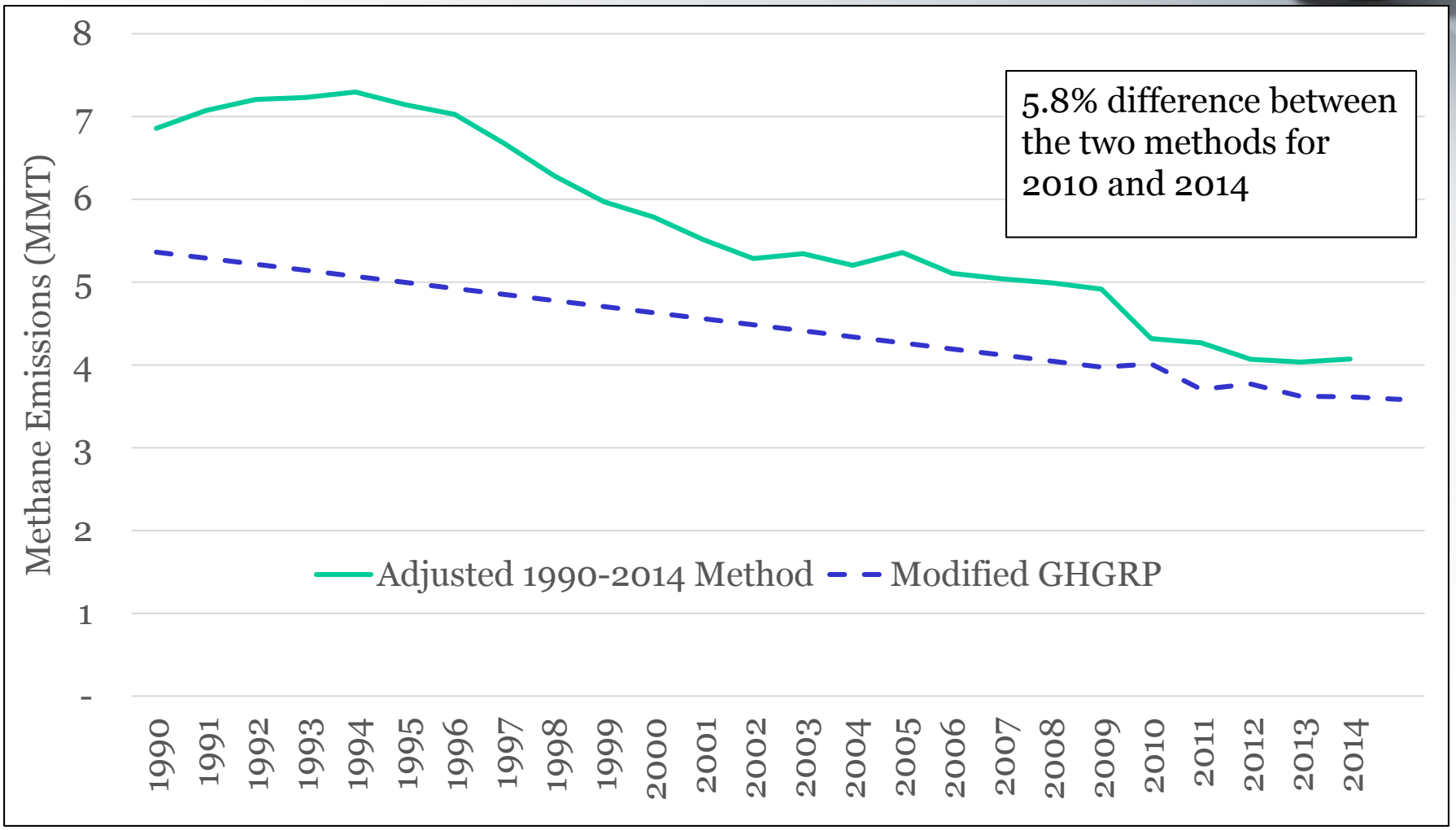
- The percentage of emissions from facilities that do not report to the GHGRP
- Used to supplement net reported emissions from the GHGRP
- Roughly estimated at 12.5%

Methods to Estimate the Scale-up Factor

- Details provided in the 1990-2015 Waste chapter

1. Back-casted GHGRP Emissions
   - Excel FORECAST function and reported GHGRP data for 2010-2015; back-casted for 1990 - 2009
2. Revised waste generation data
   - Impacted waste generation estimates for 2001 – 2009
   - Removed C&D/inerts based on State of Garbage Survey data for 2001-2008; revised 2009 data based on EREF 2010 estimates
3. Re-ran the Waste Model for the 1990-2014 Inventory
   - Generated "new" emissions estimates for the 1990-2014 time series

Difference Between Net Methane Emissions



Coverage of the GHGRP MSW Landfill Emissions

- In theory, the coverage of GHGRP emissions = GHGRP / Inventory emissions
- Previous estimates have varied
  - 82% (2009 Subpart HH Technical Support Document)
  - 85-95% (presentation at 2012 International Emission Inventory Conference)
- Large uncertainty in these estimates
- Inventory landfill uncertainty ranges from +/- 30 to 50%

GHGRP Landfill Emissions vs. Total Landfill Emissions

- Using this method, the coverage will fluctuate
- For example, for the year 2011:

Inventory Report Year	2011 Inventory MSW Landfill Emissions (million MT CO2e)[a]	2011 GHGRP MSW Landfill Emissions (million MT CO2e)	% of GHGRP Coverage
1990-2011	105.6	94[c]	89.1%
1990-2012	110.8		84.9%
1990-2013	104.3		90.2%
1990-2014	124.1[b]		75.8%
1990-2015	104.3		90.2%

[a] Data obtained from the Annex tables for each Inventory year: https://www.epa.gov/ghgemissions/us-greenhouse-gas-inventory-report-archive.

[b] As summarized in the Recalculations Discussion for this Inventory report, the recovery databases and flare correction factor were revised to remove duplicates, and the estimated GHGRP recovery estimates were adjusted. This resulted in a decrease in recovery by approximately 23 MMT CO2e.

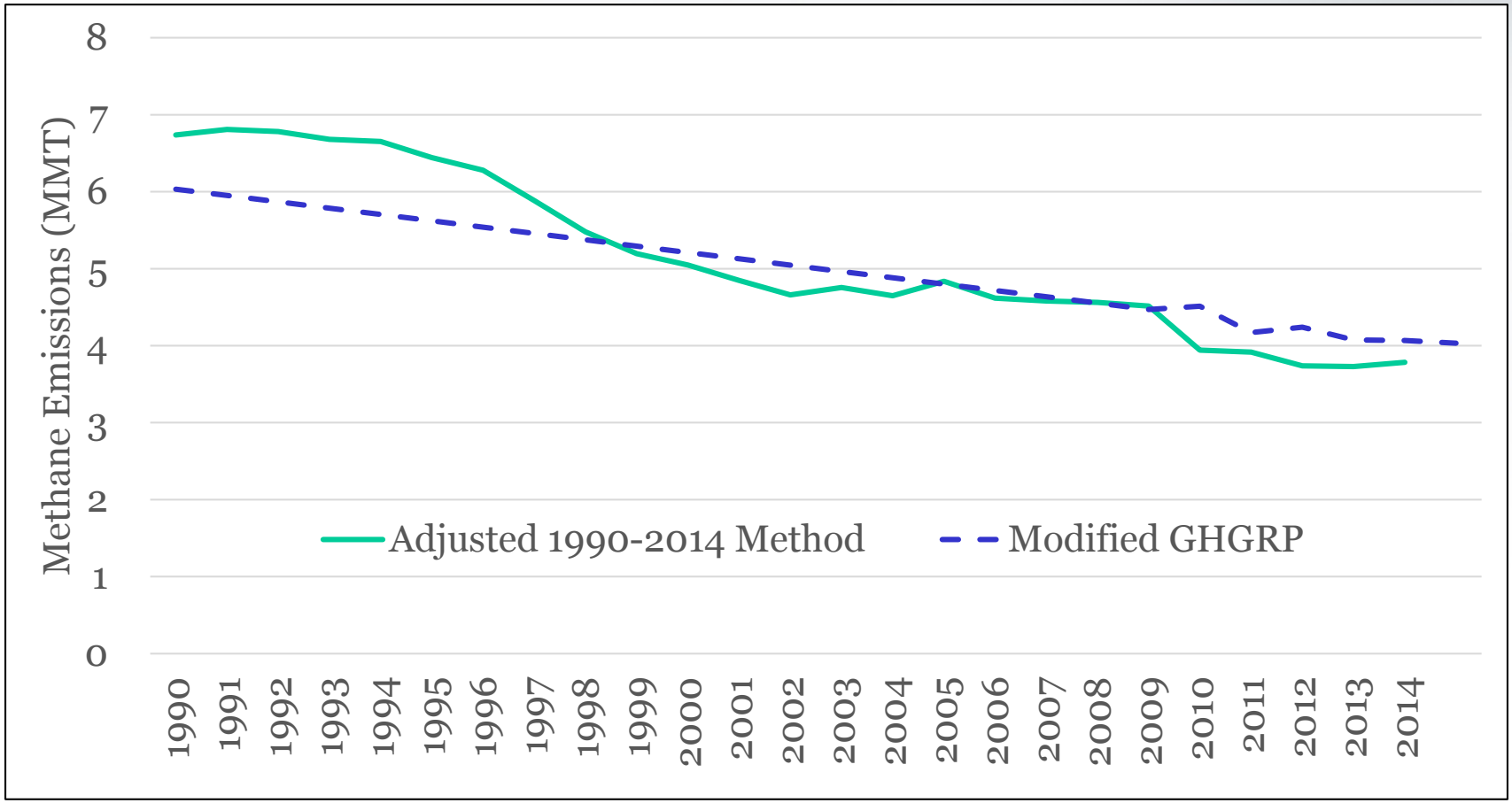
[c] GHGRP data were obtained from FLIGHT, August 2017.

Scale-up Factor used in the 1990-2015 Inventory

- Given time constraints, we made the following methodological changes:
  - Scale-up factor = 12.5% (average % difference between the GHGRP emissions and the Adjusted 1990-2014 emissions estimates for 2005-2014)
  - Back-casted GHGRP emissions = 2005 to 2009
    - Consistent with IPCC good practice guidance for time series consistency
    - Emissions for these years overlap with emissions estimated by the methodology used in previous years
  - Net reported GHGRP emissions = 2010 to 2015

Time Series Consistency

Using the IPCC's overlap technique, data for years 2005-2009 align very well.

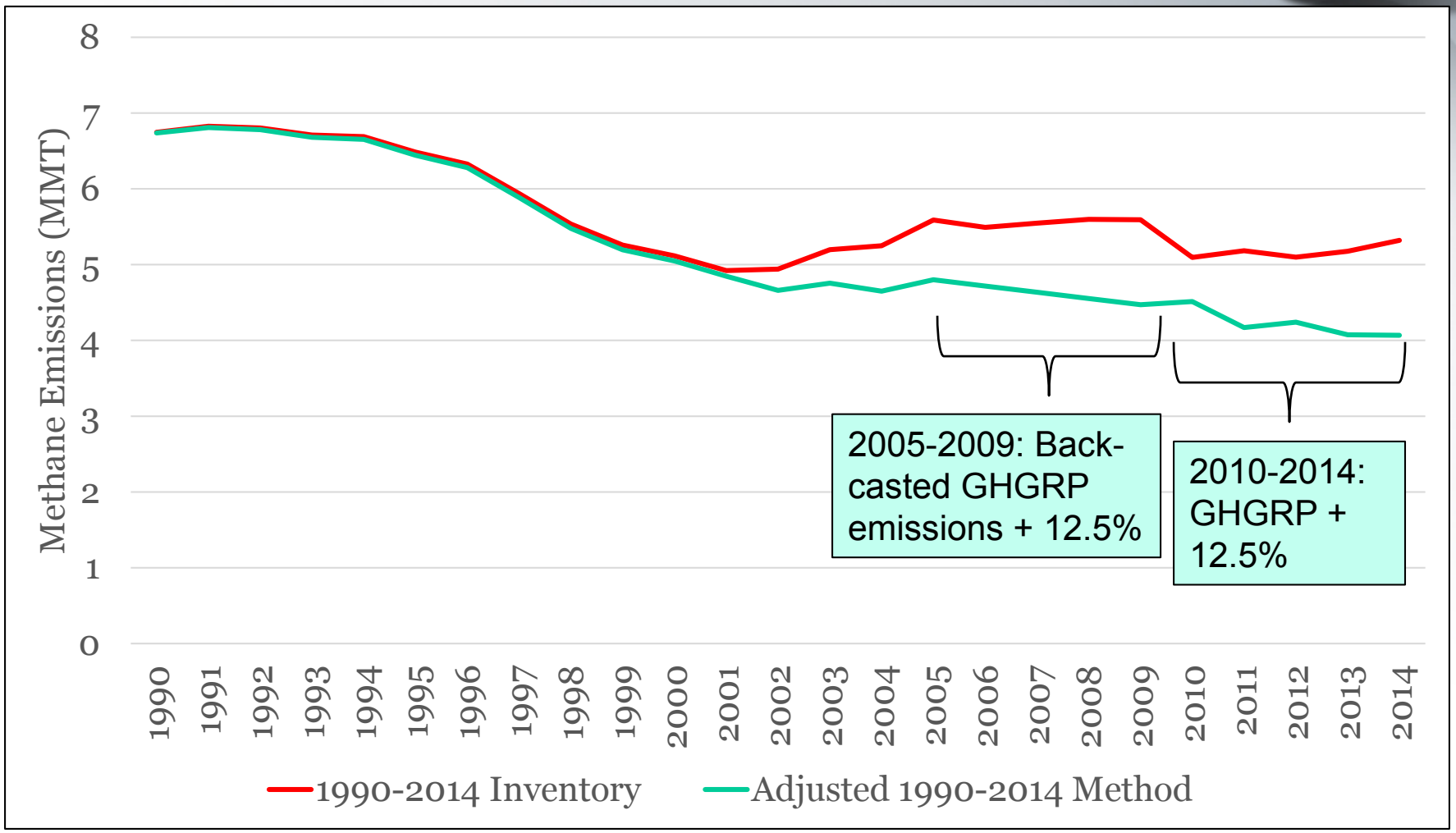


MSW Generation Data

- State of Garbage (SOG) survey data are larger than the EREF data
- In-between years are interpolated based on population growth
- Note the decrease between 2008 and 2010

Year	Solid Waste Generated (tons)	Source
2001	315,594,271	Interpolated
2002	387,010,387	SOG
2003	387,432,924	Interpolated
2004	387,855,460	SOG
2005	400,435,006	Interpolated
2006	413,014,552	SOG
2007	400,735,748	Interpolated
2008	388,456,943	SOG
2009	365,513,106	Interpolated
2010	342,569,269	EREF, 2016
2011	345,068,017	Interpolated
2012	347,605,362	interpolated
2013	346,958,499	EREF, 2016
2014	348,045,981	Extrapolated

Revised Inventory Methodology vs. the 1990-2014 Inventory



Methodological Improvements for the 1990-2016 and Future Inventories

Scale-up factor

Deeper Dive into the Scale-up Factor

- First step was to create a master list of landfills that have never reported to the GHGRP
- Detailed review of landfills and waste-in-place included in secondary data sources:
  - Waste Business Journal Directory 2016
  - LMOP Database 2017
  - EPA/OAQPS landfill dataset developed for the NSPS and EG for MSW landfills (40 CFR part 60, subpart WWW and 40 CFR part 60 subpart Cc, respectively)

Background on Datasets

Waste Business Journal Directory 2016	• Directory is comprised of data gathered from telephone surveys of owners and operators • Directory includes other waste processing and disposal operations – not limited to landfills
Landfill Methane Outreach Program (LMOP) database 2017	• Voluntary program • Dataset used in this analysis contains all landfills in the 2017 database, regardless of LMOP project status (i.e. Active, Planned, Shutdown, etc.)
EPA/OAQPS Landfill dataset	• Developed for the NSPS and EG for MSW landfills • Contains a combination of GHGRP and LMOP landfills, as well as NSPS/EG model landfills and newer, smaller landfills identified by OAQPS

Number of Facilities in each Dataset

Dataset	Number of Landfills	Comments
GHGRP	1,292	Landfills reporting to the GHGRP in any reporting year
LMOP 2017	2,405	Unique landfills within the primary LMOP database; focuses on landfills with gas collection
WBJ Directory 2016	1,578	Landfills only with primary waste acceptance types of MSW or blank
OAQPS (for NSPS/EG)	1,812	Omitting 5 EG model landfills; 22 separate facilities matched a WBJ facility not designated as a landfill and were omitted

Methods Used to Identify Non-Reporting Landfills

1. Created an initial list: GHGRP facilities (all program years), LMOP database (all facilities currently operational or closed), and WBJ database (only facilities with landfill designation, with non-MSW primary waste acceptance removed)

2. Compared landfills by name/state combinations:

a) In LMOP or WBJ that report to the GHGRP were removed

b) In both LMOP and WBJ were merged into 1 record

3. Compared landfills by coordinates:

Searched WBJ and LMOP databases for approximate latitude and longitude matches with GHGRP facilities; approximate matches by L&L and exact state match were removed.

4. QC Checks:

a) Compared the refined list to the GHGRP facilities (found 0)

b) Compared to OAQPS landfills dataset to find landfills not included in LMOP or WBJ (found 4)

Estimated Number of Non-Reporting Landfills

- 4 Steps yielded end result of 1,779 facilities

- Several limitations (and uncertainty):
  - Quality of the WBJ Directory
    - No granularity on type of landfill (MSW, C&D, industrial)
  - Landfills with slight name variations across the datasets
    - GHGRP definition of a "facility" may include several landfills in a contiguous area

Available Data to Estimate WIP Across Datasets

- To estimate WIP, we need: start year, closure year, and WIP or waste acceptance rate
- For facilities missing the start or closure year (the "1's") we "force filled" data gaps in order to estimate WIP
  - If closure year, but no start year: forced start year back 50 years
  - If start year, but no closure year: forced closure data of 2015 for WBJ facilities with daily tonnage acceptance

Missing Data Needed to Estimate WIP	Number of landfills	Percentage of 1,779 Landfills
0 (all data available)	1,072	60%
1 (1 missing data element, made assumptions to estimate WIP)	270	15%
2 (2 or more missing data elements, could not estimate WIP)	437	25%
Total	1,779	100%

Estimated WIP for 1,342 Non-reporting Landfills

	2015 WIP (MT)	Percentage of Total
GHGRP (2015)	12,936,398,280	89%
Non-reporting facilities (2015)*	1,604,238,495 (estimated)	11%
Total	14,540,636,775	

* WIP is not estimated for 25% of facilities, and is "forced" for 15% of facilities

Estimated Methane Emissions for Non-Reporting Landfills

- Summed annual waste disposal by year across all landfills
- Plugged data into the Waste Model using same assumptions in methane generation equation as used in the Inventory for years 1990-2004
  - DOC (0.2), k values by climate (0.02 [dry], 0.038 [moderate], 0.057 [wet]), oxidation (10%)
  - Adjusted for recovery for landfills included in Inventory recovery databases

Methane Emissions for 1,342 Non-Reporting Landfills

- Emissions are based on total WIP
- WIP not adjusted to remove inerts; this information is not included in the datasets

	2015 Net Methane Emissions (MMT)	Percentage
Non-reporting facilities (2015)	1.90	34%
GHGRP (2015)	3.64	66%
Total	5.54	

Estimated WIP for Non-reporting Landfills (adjusted)

- If we make the assumption that the same percentage of inerts (about 23%) reported to the GHGRP apply to the non-reporting landfills:

	2015 WIP (MT)	Percentage of Total
GHGRP (2015)	12,936,398,280	91%
Non-reporting facilities (2015)*	1,235,263,641 (estimated)	9%
Total	14,199,487,975	

* WIP is not estimated for 25% of facilities, and is "forced" for 15% of facilities

Methane Emissions for Non-Reporting Landfills (adjusted)

- Estimated emissions after subtracting out 23% of inerts/C&D from the annual waste disposal quantities:

	2015 Net Methane Emissions (MMT)	Percentage
Non-reporting facilities (2015)	1.27	26%
GHGRP (2015)	3.64	74%
Total	4.91	

Options for a Scale-up Factor

Potential Scale-up Factors	Basis
12.5%	Based on difference between back-casted GHGRP emissions and 1990-2014 Inventory emissions
11%	Based on total WIP
9%	Based on WIP adjusted for 23% C&D and inerts
34%	Based on estimated emissions from total WIP
26%	Based on estimated emissions from WIP adjusted for 23% C&D and inerts

- Currently weighing the strengths and limitations of each option
- One scale-up factor would be applied to both the back-casted GHGRP emissions for 2005-2009 and the GHGRP emissions reported for 2010 and later years

Methodological Improvements for the 1990-2016 and Future Inventories

Oxidation factor

Oxidation Factor (OX) Review

- IPCC 2006 Guidelines recommends a 10% OX
- The literature provides evidence for higher oxidation rates
- Inventory currently uses:
  - 10% for 1990-2004
  - About 19.5% for 2005-2015 (because we incorporated the GHGRP data)
    - Allowable GHGRP OX factors: 0, 0.10, 0.25, 0.35

Activities to Assess OX

Goal was to assess whether the OX applied for 1990-2004 for all landfills should be revised.

1. Reviewed the literature for data specifically for older, or smaller landfills

2. Reviewed the GHGRP data to determine the extent to which older, smaller GHGRP-reporting facilities use an OX based on their calculated methane flux

Findings from the Literature

- Literature tends to focus on landfills that would report to the GHGRP
  - Measurements of oxidation for location-specific facilities and/or gas management and cover systems
- Recent studies (e.g., Chanton and Abichou, 2011; Bogner et al., 2014; SWICS, 2012) provide evidence for higher OX rates at specific facilities
  - Results vary, but range up to 35% or more
  - Some support for 10% OX when accounting for a wide range of facilities, such as those that make up a nationwide Inventory

OX Reported in the 2015 GHGRP Data

- Distribution of OX across GHGRP equations for RY2015:

OX	RY2015					
	HH-5		HH-6		HH-8	
0	17	1%	9	1%	10	1%
0.1	763	66%	460	53%	439	51%
0.25	353	30%	286	33%	213	25%
0.35	27	2%	105	12%	198	23%
Total	1160	1	860	1	860	1

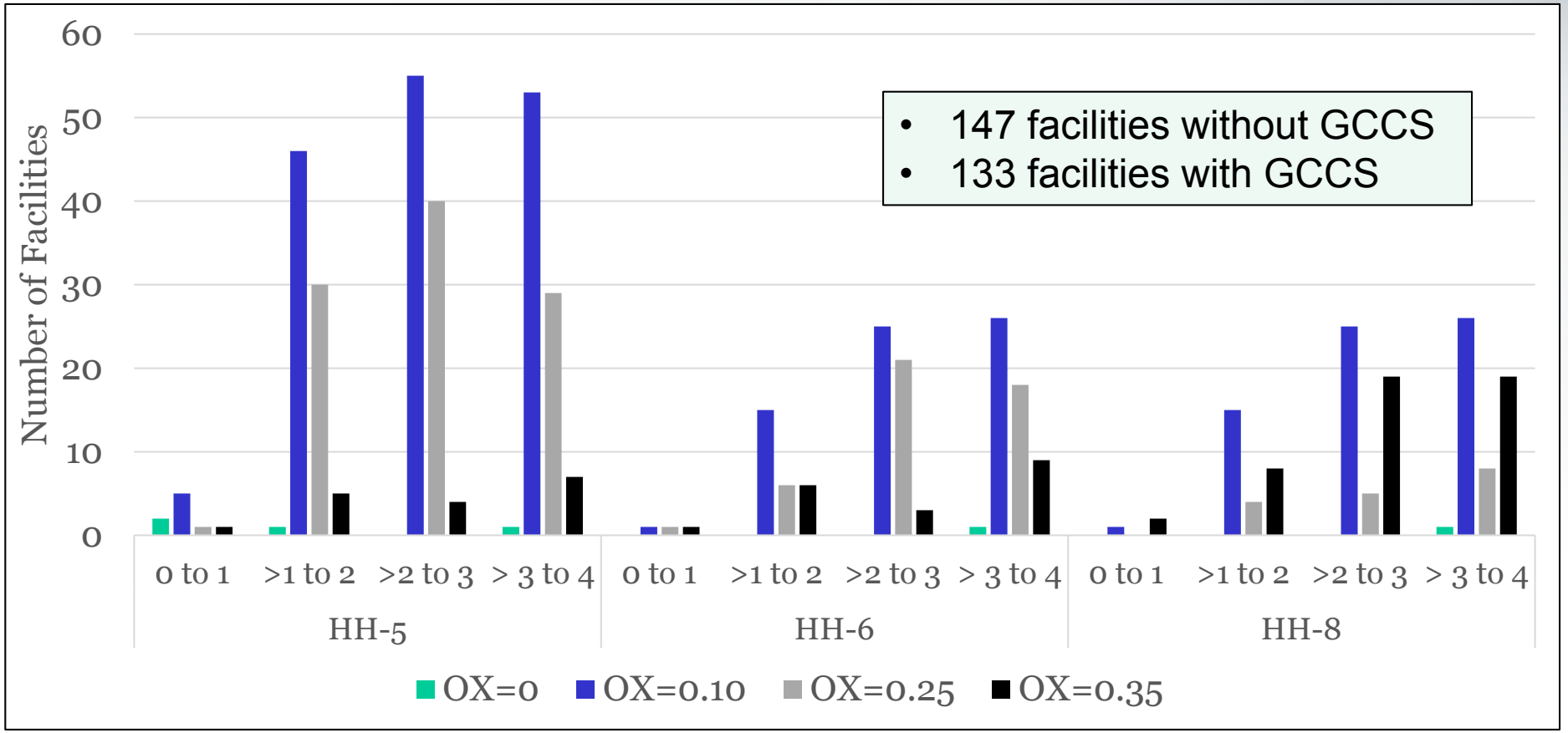
- Do not know the exact number of facilities that calculated their methane flux
  - Not a reporting requirement

Definition of Older and Smaller Landfills

- For the purposes of this analysis, we used these definitions:
  - Older = facilities with pre-1990 start dates (accepting waste for at least 27 years)
  - Smaller = facilities with < 4 million tons of WIP; which represent the lower 3rd of landfills reporting to the GHGRP

OX by WIP for "Older, Smaller" Landfills in 2015

- Older =<1990 start date, and smaller = <4 MMT WIP
- 1 facility used 0.10 in Eq. HH-5 and higher OX in HH-6/8



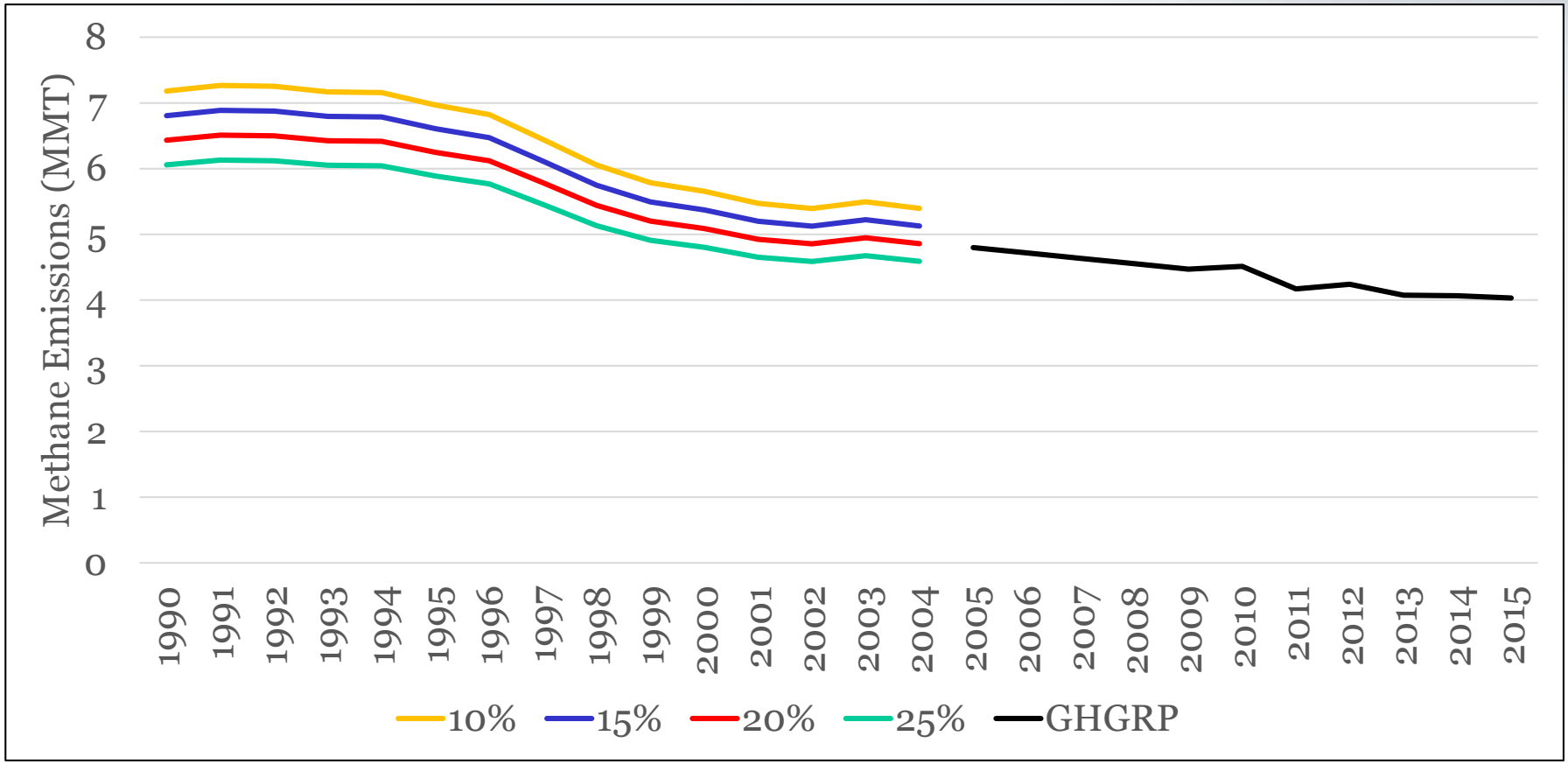
Additional Findings from the GHGRP

- OX averages:
  - 19.5% for all facilities (for equation used in facility total)
  - 18.2% for older, smaller facilities (across equations)
  - 15.3% for facilities with GCCS (Equation HH-5)
  - 20-25% for the 13 facilities that have off-ramped

- OX does not appear to significantly differ by:
  - Facility size (WIP)
  - US region (NE, SE, Midwest, Pacific NW, SW)

Impact on Inventory Time Series by OX Factor

- Net emissions decrease by 5% for each 5% increase in OX



Preliminary Conclusions

- Inventory is applying a higher OX for 2005-current year (averages to 19.5%) for all landfills
- GHGRP data and literature supports increasing the OX
- We are considering increasing the OX to 20% for all facilities from 1990-2004

Methodological Improvements for the 1990-2016 and Future Inventories

DOC value (through waste characterization studies)

Waste Characterization Review

- Goal is to
  - Determine if and how waste composition has changed since 1990, and by climate or region
  - Whether revisions to the Inventory DOC value of 0.20 for 1990-2004 are supported
- Created a database in 2014 of all publicly available waste characterization studies in the US:
  - State
  - Regional
  - City
  - County

Waste Characterization Review

- 149 studies in total, many within the same state
- Data are organized by waste types used in the IPCC Guidelines
  - Food waste, garden/park, paper/cardboard, rubber/leather, sewage sludge, textiles, wood, C&D, all other types
- Currently conducting QA/QC checks
- Near-term activities include calculating DOC values by study (geographical coverage and time frame) and by climate
- Initial conversation with EREF, look forward to further collaboration where possible

Q&A; Discussion

Schedule and Next Steps

- Another webinar to be held next month
- More information to come on review cycle for the 1990-2016 Inventory, but as a preview:
  - Prepare Waste Chapter for targeted expert review
    - Anticipated October/November 2017
  - Address comments and update for Public Review
    - Anticipated January/February 2018
  - Address comments and update for Final Inventory Report
    - Due to UNFCCC on April 15, 2018

For More Information and to Send Feedback

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