Use of Steam Flow Method for Estimating GHG Emissions from Heterogeneous Solid Fuels

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AB 32 Mandatory Reporting

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AB 32 requires:

Operators of electricity generating facilities located in California, with a nameplate generating capacity of greater than or equal to 1 MW, which annually emit more than 2,500 metric tonnes CO_2 to annually report and have GHG emissions verified.

Deadline for reporting: April 1, annually (with the exception of 2009)

Annual verification – Generating Capacity ≥ 10MW (and combusts fossil fuels)

Triennial verification – Generating Capacity ≤ 10 MW or combusts only biofuels

AB 32 Mandatory Reporting Methodology Selection

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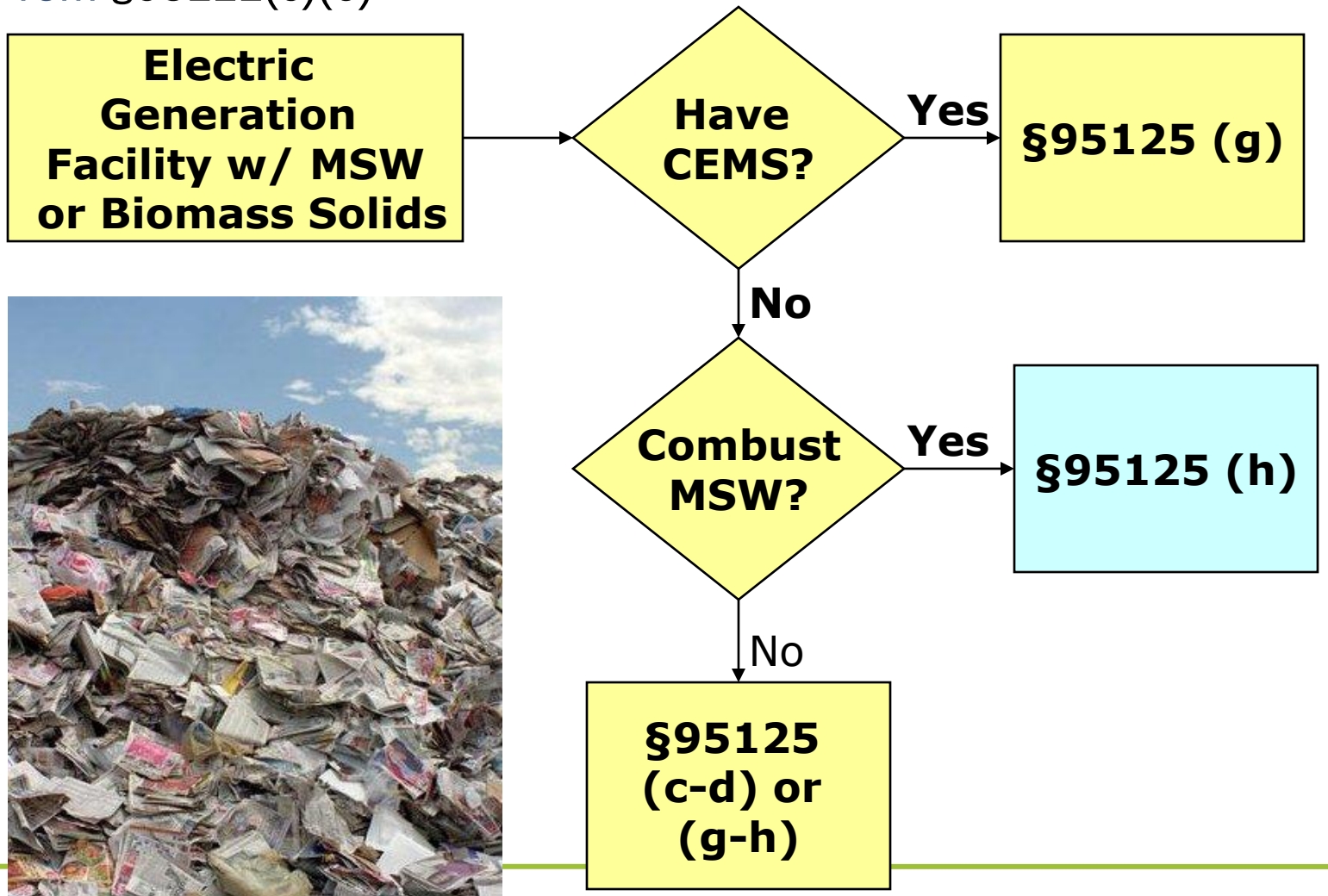
From §95111(c)(6)



Accepted Approaches to Determine CO_2

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1. CEMS Method (§95111(g))

   Disadvantages:

   - *Costly*
   - *Difficult to install and maintain*
   - *Abatement systems can interfere with operation*
   - *No biogenic/anthropogenic differentiation*

2. Annual Source Testing (§95111(h)(3))

   Disadvantages:

   - *Can be costly, only provides a "snapshot" of operations*

3. Steam Method (§95111(h)(1))

   Disadvantages:

   - *Indirect measurement of CO2*

Steam Method to Determine CO_2 from Biomass, MSW, and Refuse-Derived Fuels

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$$CO_2 = Heat\ Input \times CCEF \times 3.664 \times 0.001$$

CO_2	=	Annual emissions, metric tonnes per year
Heat	=	Calculated heat input, MMBtu per year
CCEF	=	Default carbon content emission factor, kg carbon per MMBtu
3.664	=	CO_2 to carbon molar ratio
0.001	=	Conversion factor, metric tonnes/kg

Issue is determining heat input for a fuel of heterogeneous composition

Biomass fuels have variable moisture content (normalize in terms of BDT)

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Solution: Use steam design input to actual ratio to determine actual heat input

Determining Actual Heat Input by Steam Method

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$$Heat\ Input_{actual} = Steam_{actual} \times \frac{Heat\ Input_{design}}{Steam_{design}}$$

Advantages:

- Steam must be monitored for facilities under NSPS for MWC (40CFR60 Subpart Cb or Cc)
- Steam commonly used metric to determine performance
- No CEMS required!

Apply Appropriate F Factor to Determine CO_2 from Heat Input

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- F Factors represent volumes of combustion products per unit heat input (scf/MMBtu)
- Specific to type of fuel combusted
- Found in 40 CFR 60 Appendix A-7 (Method 19)
- Multiply by calculated CO_2 percent (derived from O_2), molecular weight of CO_2, and divide by molar volume to obtain CO_2

Determination of Biogenic and Anthropogenic Fractions

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- Use ASTM Method D6866-06a
  - Uses Liquid Scintillation Counting (LSC) techniques to measure C^{14} to other carbon ratios
  - Quantifies young carbon (biogenic)
  - Anthropogenic fraction = 1 – biogenic fraction
- Disadvantage:
  - Snapshot only
- Advantages over performing a Waste Characterization Study:
  - Less time-intensive
  - Accuracy improved over “garbology” studies

MSW Facility Example

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Goal: Compute biogenic and anthropogenic CO_2 emissions

Actual data[1]

$Steam_{actual}$ = 90.8 klb/hr

$Steam_{design}$ = 100.5 klb/hr

$Heat\ Input_{design}$ = 173.3 MMBtu/hr

$$Heat\ input_{actual} = Heat\ input_{design} \times (Steam_{actual}/Steam_{design})$$

$$= 173.3\ MMBtu/hr \times (90.8\ klb/hr / 100.5\ klb/hr)$$

$$Heat\ input_{actual} = 156.6\ MMBtu/hr$$

Note 1: Data from hour 0, January 1, 2007

CO_2 Emissions Computation

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$$CO_2 = MW\ CO_2 / V_m \times F_c \times H_a$$

Reference Data

MW CO2	= 44.01 lb/lb-mol
Vm	= 385.3 scf/mol (at 20°C)
Fc	= 1820 scf/MMBtu (40 CFR 60 Appen. A-7)
Heat Input actual	= 156.6 MMBtu/hr

= 44.01 lb/lb-mol / 385.3 scf/mol x 1820 scf/MMBtu x 156.6 MMBtu/hr

CO_2 = 32,555 lb/hr = 14.77 tonnes/hr

Biogenic Fraction (ASTM D6866-06a) = 65.7%

Biogenic CO_2 = 0.657 x 14.77 tonnes/hr = 9.70 tonnes/hr

Anthropogenic CO_2 = (1 – Biogenic %) x CO_2 = (1 - 0.657) x 14.77 tonnes/hr = 5.07 tonnes/hr =

References

Balentine, H.; Goff, N.; and Hahn, J.; “Use of Steam Flow Method for Estimating GHG Emissions from Heterogeneous Solid Fuels.”, Air and Waste Management Association Greenhouse Gas Measurement Symposium, March 22 – 25, 2009, San Francisco, California.

For additional information, or if you have any questions:

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