MEMORANDUM

DATE: August 2013

TO: Docket EPA-HQ-OAR-2010-0929

FROM: Lisa Grogan-McCulloch, U.S. EPA

SUBJECT: **Evaluation of Alternative Calculation Methods**

1.0 Introduction and Purpose of Analysis

In the August 25, 2011 final rule deferring reporting to March 31, 2015 of certain inputs to emission equations under 40 CFR part 98 (76 FR 53057), the EPA expressed its intent to further evaluate the inputs to emission equations. The EPA outlined a four-step process for this evaluation in the final rule, and in a supporting memorandum entitled "Process for Evaluating and Potentially Amending Part 98 Inputs to Emission Equations" (docket EPA-HQ-OAR-2010-0929).

The purpose of this memorandum is to describe the review undertaken for the third step of the evaluation process: the EPA's evaluation of alternative calculation methods. The evaluation of alternative calculation methods is divided into two reviews: (1) review of alternative greenhouse gas (GHG) emission equations, and (2) review of application of direct measurement using continuous emissions monitoring systems (CEMS). The alternative calculation evaluation was undertaken for 25 of the 28 subparts of the greenhouse gas reporting program (GHGRP), for which reporting of inputs to emission equations has been deferred to March 31, 2015 (hereafter referred to as "inputs to equations" data elements). The review was not undertaken for subparts W and II because the EPA's evaluation of these inputs under Step 2 did not identify the need to proceed to Step 3.[a] Please see memorandum "Evaluation of Competitive Harm from Disclosure of "Inputs to Equations" Data Elements Deferred to March 31, 2015" for the results of Step 2 of the evaluation.

Section 2.0 of this memorandum presents the procedures used to collect and review alternative calculation equations, and the results of the review. Section 3.0 presents the procedures used to collect information on and evaluate application of direct measurement of emissions using CEMS, and summarizes the results of the evaluation. Section 4 provides a summary of the evaluation. Appendix A presents detailed evaluations of all the alternative calculation equations reviewed for each subpart. Appendix B presents a detailed characterization of facilities and processes using CEMS for each of the subparts. Appendix C provides detailed cost estimates of requiring CO_2 CEMS.

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[a] The review was not conducted for "inputs to equations" in subpart I because reporting of the "inputs to equations" data elements for that subpart was addressed in a separate proposed action [see 77 FR 63538]. Additionally, the evaluation of the subpart C "inputs to equations" in this memorandum encompasses the one subpart A "input to equation" data element. As a result, the one subpart A "input to equation" data element is not listed explicitly in this memorandum.

2.0 Alternative Calculation Equations

Section 2.0 of this memorandum evaluates alternative equations to calculate GHG emissions. Section 2.1 discusses the procedures used to identify alternative calculation equations, section 2.2 discusses the data sources reviewed to obtain the alternative calculation equations, and section 2.3 summarizes the results of the review.

2.1 Procedures for Identifying and Reviewing Alternative Calculation Equations

Alternative calculation equations were identified based on three sources of information: (1) previous calculation equations that were evaluated during the development of the GHGRP, (2) calculations used in non-EPA GHG reporting programs since the GHGRP was developed, and (3) methods suggested by public commenters in response to the Call for Information notice [75 FR 81338]. Each alternative calculation was evaluated to determine if it was the same as the method chosen in the GHGRP. For calculations different than what is required in the GHGRP, the alternative calculation equations were evaluated to determine whether equation inputs are the same as the "inputs to equations" data elements, and therefore, would not resolve the disclosure concerns identified in Step 2 of the evaluation. Additionally, the equations that are different were also evaluated as to whether they would decrease accuracy or increase uncertainty in the calculated emissions based on information provided in the sources reviewed. For those calculation equations that were identified as using inputs different than the "inputs to equations" data elements, and also had similar or lower uncertainty and similar or higher accuracy in emissions estimation than the current method, costs were estimated if sufficient cost information was available. The cost of the alternative was then compared to the current method.

2.2 Data Sources Reviewed

As discussed in section 2.1, three sources of information were evaluated. Calculation equations that the EPA had previously considered but not included in the final rule were identified in the technical support documents (TSDs)[1-25] for each of the subparts and the preambles to the proposed and final GHGRP. The original sources of the calculation methods were then reviewed to determine if the calculation methods had been updated since the development of the GHGRP and to obtain more detailed information. The original sources consisted of the following:[26-42]

- Annual Inventory of U.S. GHG Emissions and Sinks (U.S. Inv)
- Climate Leaders protocols (CL)
- U.S. Department of Energy (DOE) 1605(b) reporting program
- The Climate Registry (TCR)
- State programs (California Climate Action Registry (CCAR), California Air Resources Board (CARB) cap and trade program, New Mexico)
- Regional Programs (Regional Greenhouse Gas Initiative [RGGI])
- Western Climate Initiative (WCI)
- 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines
- European Union Emissions Trading System (EU ETS)

- Country-specific GHG reporting programs (Australia National Greenhouse Gas Reporting Program (ANGGRP), Canada)
- World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) protocols
- American Petroleum Institute (API) protocols
- American Iron and Steel Institute
- European Bank For Reconstruction and Development

Methods used in newer non-EPA GHG programs since the GHGRP was developed were evaluated. These include:[43-44]

- U.N. Framework on Climate Change - Clean Development Mechanism (CDM)
- Australian Emissions Trading Scheme

Lastly, the EPA's Call for Information notice solicited input from commenters on alternative calculation methods. Commenters suggested alternative calculation methods for 5 subparts: K, P, Q, R, and X.[45-48]

2.3 Results of Evaluation

Table 2-1 summarizes the results of evaluating alternative calculation equations. The table indicates that for all of the subparts except subparts X and Y, the alternative calculation equations either used many of the same inputs to the calculation equations as the "inputs to equations" data elements, used new inputs that are the same type of reporting elements that the EPA determined have disclosure concerns[49], mandated process configurations (which is not the intent of the GHGRP), or increased uncertainty or decreased accuracy in emission estimates. Because of this result, no further evaluation of costs was undertaken for these alternative calculations. For alternatives that were identified as viable in Subparts X and Y, further analysis indicated they resulted in a high cost to implement. Appendix A contains detailed evaluations for each subpart and for each alternative calculation method identified.

Table 2-1. Summary of Evaluation of Alternative Calculation Equations

Subpart of Part 98	Viable Alternative Identified (Y/N)	Evaluation of Alternative Calculation Equations[a]				
		Uses Same "Inputs to Equations" Data Elements [b]	Uses Same Type of Inputs that do not Alleviate Disclosure Concerns[c]	Mandates Process Design[d]	Increased Uncertainty/ Decreased Accuracy	High Cost to Implement[e]
C	N	√				NA
E	N	√			√	NA
F	N	√			√	NA
G	N	√	√		√	NA
H	N	√	√		√	NA
K	N	√			√	NA

L	N	√			√	NA
N	N	√			√	NA
O	N	√			√	NA
P	N	√			√	NA
Q	N	√			√	NA
R	N	√			√	NA
S	N	√	√		√	NA
U	N	√			√	NA
V	N	√			√	NA
X	N	√		√	√	√
Y	N	√	√		√	√
Z	N	√			√	NA
AA	N	√			√	NA
BB	N	√	√			NA
CC	N	√				NA
EE	N	√	√		√	NA
GG	N	√	√		√	NA
TT	N	√			√	NA

NA = Not analyzed because other criteria disqualified alternative.
[a]The table generally summarizes reasons why the alternative calculation methods were considered to not be viable options. Appendix A contains detailed evaluations for each alternative calculation method reviewed for each subpart.
[b]The alternative calculations used many of the same inputs to the calculation equations as the "inputs to equations" data elements (and therefore, provided no benefit in comparison to the current method).
[c] The alternative calculations used new data elements that are the same type of reporting elements that the EPA determined to have disclosure concerns (see the memorandum "Evaluation of Harm from Disclosure of 'Inputs to Equations' Data Elements Deferred to March 31m 2015").
[d]The alternative calculations mandated process configurations (which is not the intent of the GHGRP).
[e]Costs were only analyzed for equations that did not have data elements for which disclosure concerns were identified, had low uncertainty, and high accuracy.

3.0 Direct Emissions Monitoring Using Continuous Emissions Monitoring Systems

Section 3.0 of this memorandum evaluates the use of CEMS for each subpart instead of calculation equations for GHG reporting. For the evaluation of CEMs, we initially applied the same criteria that were used for the Alternative Calculation Equations. Because CEMS are directly measuring emissions, no equation inputs are used. As a result, the use of CEMS would alleviate the disclosure concerns identified in Step 2 of the evaluation. In addition, use of the CEMS does not result in increased uncertainty or decreased accuracy. However, CEMS are generally higher cost than the other methodologies in the GHGRP, and the majority of reporters that reported to the GHGRP in 2011 did not use CEMS. In addition, they cannot be used for fugitive emission sources that are not routed through a stack. This review characterizes the facilities (or process units in a facility) that currently use CO_2 CEMS (or N_2O or methane CEMS if applicable), the facilities that use another form of CEMS that may be upgraded for use in the GHGRP, and the cost impacts of applying the upgrades. Section 3.1 describes the evaluation performed, and section 3.2 summarizes the results of the review.

3.1 Description of Evaluation Performed

The GHGRP requires the use of a CO_2 CEMS only if a facility already has CEMS for another regulation and meets certain additional criteria [i.e., the six conditions specified in subpart C 98.33(b)(4)(ii)]. Such facilities would not need to build a structure or install a sampling system in order to measure CO_2 emissions using a CEMS. Most of the subparts with "inputs to equations" data elements allow CEMS as an option to determine CO_2 emissions (some also allow N_2O with approval).

Characterization of Facilities and Process Units

The first step in the evaluation of applying GHG CEMS for each subpart was to develop an up-to-date characterization of the facilities and process units subject to each subpart and the number that use CEMS. The data reported to the EPA through annual report submissions in the GHGRP[50] provides the most up-to-date information on facility counts, as well as actual usage of GHG CEMS. Many facilities also use non-GHG CEMS (that can be converted to GHG CEMS), which are not accounted for in the GHGRP. Therefore, for this evaluation, we also used information in the GHGRP regulatory impacts analysis (RIA)[51], the GHGRP background technical support documents (TSD), and information in other EPA databases (particularly databases used in the development of air rules and regulations, such as new source performance standards (NSPS) or national emission standards for hazardous air pollutants (NESHAP)), to obtain information on facilities and process units with non-GHG CEMS.

Estimating Current and Potential CEMS usage

Where information was available in the GHGRP indicating reporters using CEMS for CO_2, CH_4, and N_2O in facilities, those data were used to identify the actual number of facilities or process units that currently use CO_2 CEMS (or N_2O or methane, if applicable).

NSPS and NESHAP rule requirements that apply to GHGRP reporters may also require CEMS usage not related to GHGs. These regulations do not generally require CO_2 CEMS because they regulate criteria pollutants and air toxics. However, the CEMS installed to meet the rules may be modified to be used for GHG reporting, which would lower the overall cost of installing the CEMS. Table 3-1 summarizes the NSPS and NESHAP applicable to sources subject to each subpart with "inputs to equations" data elements, and identifies the NSPS and NESHAP that have CEMS as an option or requirement. The CEMS standards in the NESHAPs and NSPS were used to develop a count of potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP. Appendix B contains detailed summaries of applicability of the air rules for sources or processes in each subpart.

Table 3-1. NSPS and NESHAP Applicable to GHGRP Reporters with "Inputs to Equations" Data Elements

Subpart of Part 98	NESHAP/NSPS Subparts Reviewed[a]	Are CEMS an option or requirement under the NSPS and/or NESHAP and, if so, can they be used for GHGRP?
C	NSPS: Subpart Db	Yes
	NESHAP: Subpart DDDDD	Yes
	NESHAP: Subparts CCC and DDD	Yes
E	NSPS: Subpart NNN	Yes; however CEMS is not required; it is one of several compliance options
	NSPS: Subpart RRR	
F	NSPS: Subpart S	No
	NESHAP: Subpart LL	No
G	None	Not applicable
H	NSPS: Subpart LL	Yes
	NSPS: Subpart F	Yes
	NESHAP: Subpart EEE	Yes
K	NSPS: Subpart Z	No
	NESHAP: Subpart XXX	No
	NESHAP: Subpart YYYYYY	No
L	NESHAP: Subpart FFFF	Yes
N	NSPS: Subpart CC	No
	NSPS: Subpart PPP	No
	NSPS: Subpart NNN	No
	NESHAP: Subpart HHHH	No
	NESHAP: Subpart SSSSSS	No
	NESHAP: Subpart N (Part 61)	No
O	NESHAP: Subpart FFFF	Yes; however CEMS is not required; it is one of several compliance options
P	NESHAP: Subpart CC	No
Q	NESHAP: Subpart RRRRR	No
	NESHAP: Subpart FFFFF	No
	NESHAP: Subpart L	No
	NESHAP: Subpart CCCCC	No
	NSPS: Subpart AA and AAa	No
	NESHAP: Subpart YYYYY	No
R	NSPS: Subpart L	No
	NSPS: Subpart R	Yes; however CEMS is not required for new sources only
	NESHAP: Subpart X	No
S	NSPS: Subpart HH	No
	NESHAP: Subpart AAAAA	No
U	None	Not applicable
V	NSPS: Subpart G	Yes

Subpart of Part 98	NESHAP/NSPS Subparts Reviewed[a]	Are CEMS an option or requirement under the NSPS and/or NESHAP and, if so, can they be used for GHGRP?
X	NSPS: Subpart III	Yes; however CEMS is not required; it is one of several compliance options
	NSPS: Subpart NNN	
	NSPS: Subpart RRR	
	NESHAP: Subpart F	
	NESHAP: Subpart G	
	NESHAP: Subpart YY	No
Y	NSPS: Subpart J	Yes
	NESHAP: Subpart CC	No
	NESHAP: Subpart UUU	Yes
Z	NSPS: Subpart T	No
	NESHAP: Subpart AA	No
AA	NSPS: Subpart BB	Yes for Kraft and Semichemical mills; No for others.
	NESHAP: Subpart S	No
	NESHAP: Subpart MM	No
BB	None	Not applicable
CC	NSPS: Subpart OOO	No
	NSPS: Subpart UUU	No
EE	NSPS: Subpart LL	No
GG	NSPS: Subpart Q	No
	NSPS: Subpart LL	No
	NESHAP: Subpart GGGGGG	No
	NESHAP: Subpart TTTTTT	No
TT	None	Not applicable

[a]NSPS subparts are in 40 CFR part 60; NESHAP subparts are in 40 CFR part 63.

Estimating Cost Impacts

Depending on the type of monitoring requirements in the NSPS or NESHAP regulations, the modifications needed to install a CO2 CEMS for the purpose of monitoring for the GHGRP may be minimal, such as adding a CO_2 analyzer only, or more costly, such as adding a CO_2 analyzer, flow meter, and infrastructure. In order to accurately assess the cost impacts of requiring CEMS for the GHGRP, the potential number of facilities that, due to the requirements in NSPS and NESHAP, would be able to install a CO_2 CEMS at a reduced cost was evaluated. Based on the requirements in the rules, the GHGRP subparts, and the process/facility count and CEMS information (discussed earlier), the following CEMS usages were identified:

- Source has CO_2 CEMS
- Source has non-CO_2 GHG CEMS (such as N_2O CEMS) or has non-GHG CEMS (such as NO_X or CO monitors)
- Source has no CEMS

After the CEMS characterization was completed, the cost impacts of requiring CO_2 CEMS were estimated for each subpart based on the number of facilities (or sources) or units (or processes) that would need to upgrade existing monitoring equipment to meet the requirements of the GHGRP. Cost information in the RIA was reviewed and separated into the components necessary for CO_2 CEMS.[51] Based on the type of CEMS used, five CEMS usage scenarios were developed. The costs associated with adding equipment to meet the GHGRP monitoring requirements for sources/units in each of the five CEMS usage scenarios were developed from the CEMS component costs. Table 3-2 summarizes the costs and equipment necessary for each scenario. For Scenarios 2 and 3, costs were assigned considering specific rule requirements that are presented in Appendix B and information in the RIA.

Table 3-2. Summary of Costs for CO_2 CEMS Modifications

Scenario #	Scenario	Total annual cost/application
1	Source has no CEMS -- Add CO_2 analyzer, flow meter, and infrastructure	$ 70,265
2	Source has CEMS for other pollutants -- Add CO_2 analyzer and flow meter	$ 56,040
3	Source has CEMS for other pollutants -- Add CO_2 analyzer only	$ 20,593
4	Source has CEMS for other pollutants -- Add flow monitor only	$ 24,511
5	Source has CO_2 CEMS	No Cost

3.2 Results of Evaluation

Table 3-3 summarizes the results of the characterization analysis. The table shows for each subpart whether information was collected on a facility, unit or process basis. The table summarizes the actual number of facilities subject to the subpart that use CO_2 CEMs, non-CO_2 GHG CEMS, or non-GHG CEMS. The table also shows the potential number of sources that may have the same monitoring equipment based on a review of requirements in NSPS or NESHAP, and assumptions regarding which facilities would use CEMS. The potential number includes both the actual number and additional units/facilities that result from reviewing the NSPS or NESHAP. In some cases, a potential estimate could not be made based on the evaluation of the air rules, but an actual number was identified based on data sources reviewed. Appendix B contains detailed summaries of the CEMS characterization analysis for each subpart.

Table 3-3. Summary of CEMS Characterization for Each Subpart with "Inputs to Equations" Data Elements

Subpart	Basis	Number Subject to Subpart[a]	Reporting CO_2 CEMS in GHGRP	Reporting non-CO_2 GHG CEMS in GHGRP I	Reporting non-GHG CEMS in NSPS/NESHAP	
					Actual	Potential
C	Facilities	1,985	177	0[b]	NA	NA
	Units	14,197	311	0[b]	1056	1151
E	Facilities	3	0[l]	0[b]	NA	NA
F	Facilities	10	0[l]	0[b]	NA	NA
G	Facilities	22	0[l]	0[b]	NA	NA
H	Facilities	96	82	0[b]	14[c]	14[c]
	Units	140	112	0[b]	0[d]	28[e]
K	Facilities	10	0[l]	0[b]	NA	NA
L	Facilities	16	0[l]	1	NA	NA
N	Facilities	110	3	0[b]	NA	NA
	Units	NA	3	0[b]	NA	NA
O	Facilities	5	0[l]	0[b]	NA	NA
P	Facilities	103	3	0[b]	NA	NA
	Units	NA	3	0[b]	NA	NA
Q	Facilities	128	11	0[b]	NA	NA
	Units	165	14	0[b]	NA	NA
R	Facilities	13	0[l]	0[b]	NA	NA
S	Facilities	73	1	0[b]	NA	NA
U	Facilities	18	0[l]	0[b]	NA	NA
V	Facilities	36	0[l]	0[b]	20[g]	NA
	Units	65	0[l]	0[b]	36[g]	NA
X	Facilities	64	2	0[b]	NA	NA
	Units	NA	2	0[b]	NA	NA
Y- Catalytic Cracking and Sulfur Recovery	Facilities	145	21	0[b]	NA	104[h]
	Process Units	317	26	0[b]	NA	317[i]
Y - Other Process Units[j]	Facilities	145	0[l]	0[b]	0	0
	Process Units	1,580	0[l]	0[b]	0	0
Z	Facilities	13	0[l]	0[b]	7[k]	7[k]
AA	Facilities	110	0[l]	0[b]	89[m]	NA
	Units	330[m]	0[l]	0[b]	266[m]	NA
BB	Facilities	1	0[l]	0[b]	NA	NA
CC	Facilities	4	1	0[b]	NA	NA
	Units	NA	1	0[b]	NA	NA
EE	Facilities	7	0[l]	0[b]	NA	NA

GG	Facilities	6	0[l]	0[b]	NA	NA
TT	Facilities	173	0[l]	0[b]	NA	NA

NA = No estimate available

[a] Number of facilities that reported to the GHGRP in 2011.

[b] No units or facilities are known to be using non-CO_2 GHG CEMS (e.g., for CH_4 or N_2O).

[c] Used 96 as the actual and high estimate of the number of operating plants, minus the 82 that reported to GHGRP in 2011 that they are using CO_2 CEMS.

[d] The count of units with non-GHG CEMS (102) in Table 4-3 of the RIA for the GHGRP is lower than the number that reported to GHGRP in 2011 that they are using CO_2 CEMS (112). Therefore, we cannot assume that any additional facilities have non-GHG CEMS installed.

[e] Based on the assumption that all kilns will have a non-GHG CEMS to comply with the NESHAP; used the estimated number of units (140) in the "Summary of Environmental and Cost Impacts for Final Portland Cement NESHAP and NSPS" (August 6, 2010), minus the 112 that reported to GHGRP in 2011 that they are using CO_2 CEMS.

[g] Based on data reported as a part of the *1990-2006 Inventory of U.S. Greenhouse Gas Emissions and Sinks*, which are shown in the TSD to subpart V. A high estimate was not generated since the inventory data were reported by the facility and presumed to be the actual count of units with NO_X CEMS.

[h] Count of facilities which have catalytic cracking and/or sulfur recovery processes. Some facilities have both.

[i] Unit count assumes all catalytic cracking processes have catalyst regenerators (130+187), and all will use CEMS to comply with the NESHAP/NSPS.

[j] Includes fluid coking, coke calcining, catalytic reforming, flares, loading operations, and other process vents. Stationary combustion units are covered under subpart C.

[k]Counts are based on data reported in the NESHAP ICR responses.

[l] No facilities reported to GHGRP in 2011 that they were using a CEMS to report GHG emissions.

[m] The National Council for Air and Stream Improvement (NCASI) survey provided process unit data and the 2009 RIA estimated that units were subject to Tier 4 requirements. However, these count data and the count for facilities that reported to GHGRP in 2011 (110) could not be directly related. Therefore, based on the data, unit and facility counts were estimated.

Table 3-4 summarizes the estimate of capital and annual cost impacts for each subpart if CO_2 CEMS are required for sources or process units subject to the GHGRP. The table does not show the cost of applying N_2O or CH_4 CEMS. The table presents the cost to upgrade monitoring equipment (existing equipment for actual sources and likely equipment for potential sources based on the air rules) and the cost to add full CO_2 CEMS for facilities that are subject to the GHGRP, but do not have CEMS. Table 3-4 summarizes costs based on actual counts of units/facilities with CEMS, and potential counts of units/facilities with CEMS based on NSPS and NESHAP rule requirements. Potential costs incorporate information from actual number of units/facilities where information is known as well as the additional potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. See Appendix B for detailed information for each subpart. Appendix C contains detailed cost estimates for each subpart and each CEMS scenario. Appendix C also contains cost estimates for all three types of GHG CEMS (CO_2, N_2O, and CH_4).

Table 3-4. Summary of Cost Impacts From Requiring CEMS for GHGRP Subparts

Subpart of Part 98	Capital Cost Estimate For Using CEMS ($)		Total Annual Cost Estimate for Using CEMS ($/yr)	
	Actual[a]	Potential[b]	Actual[a]	Potential[b]
C	$1,680,248,013	$1,689,440,545	$960,678,190	$966,001,990
E	$ -	$ -	$ -	$ -
F	$1,229,981	$1,229,981	$702,650	$702,650
G	$2,705,958	$2,705,958	$1,545,830	$1,545,830

H	$4,004,048	$560,101	$2,544,024	$576,604
K	$1,229,981	$1,229,981	$702,650	$702,650
L	$ -	$ -	$ -	$ -
N	$13,160,798	$13,160,798	$7,518,355	$7,518,355
O	$ -	$ -	$ -	$ -
P	$12,299,811	$12,299,811	$7,026,500	$7,026,500
Q	$18,572,715	$18,572,715	$10,610,015	$10,610,015
R	$1,598,975	$1,598,975	$913,445	$913,445
S	$8,855,864	$ -	$5,059,080	$ -
U	$ 2,213,966	$ 2,213,966	$ 1,264,770	$ 1,264,770
V	$ -	$ -	$ -	$ -
X	$7,625,883	$7,871,879	$4,356,430	$4,496,960
Y	$191,139,063	$175,521,765	$109,191,810	$101,365,847
Z	$878,014	$878,014	$565,741	$565,741
AA	$33,613,009	$33,613,009	$19,404,705	$19,404,705
BB	$122,998	$122,998	$70,265	$70,265
CC	$368,994	$368,994	$210,795	$210,795
EE	$860,987	$860,987	$491,855	$491,855
GG	$737,989	$737,989	$421,590	$421,590
TT	$ -	$ -	$ -	$ -
Total	**$1,981,467,047**	**$1,962,044,020**	**$1,133,278,700**	**$1,123,378,467**

[a]Costs are based on the actual number of units/facilities for which information was available indicating current use of CEMS under the GHGRP. See Appendix B for detailed information for each subpart.
[b]Costs are based on potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. Costs include actual number of units/facilities based on reporting to the GHGRP as well as the additional potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. See Appendix B for detailed information for each subpart.

4.0 Summary

Based on the results of this evaluation, the EPA proceeded to Step 4 of the evaluation for all of the 25 subparts evaluated in this memorandum.

5.0 References

1. U.S. EPA. "Technical Support Document for Stationary Fuel Combustion Emissions: Proposed Rule for Mandatory Reporting of Greenhouse Gases." Office of Air and Radiation. January 30, 2009. Available: http://www.epa.gov/ghgreporting/documents/pdf/archived/tsd/TSD%20Stationary%20Combustion%202-02-09.pdf.

2. U.S. EPA. "Technical Support Document for the Adipic Acid Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases." Office of Air and Radiation. January 22, 2009. Available: http://www.epa.gov/ghgreporting/documents/pdf/archived/tsd/TSD%20Adipic_EPA%202-12-09.pdf.

3. U.S. EPA. "Technical Support Document for Process Emissions from Primary Production of Aluminum: Proposed Rule for Mandatory Reporting of Greenhouse Gases." Office of Air and Radiation. February 4, 2009. Available: http://www.epa.gov/ghgreporting/documents/pdf/archived/tsd/TSD%20Aluminum_20090204.pdf.

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5. U.S. EPA. "Technical Support Document for Process Emissions from Cement: Proposed Rule for Mandatory Reporting of Greenhouse Gases." Office of Air and Radiation. January 28, 2009. Available: http://www.epa.gov/ghgreporting/documents/pdf/archived/tsd/TSD%20Cement%20_EPA%201-28-09.pdf.

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Appendix A1
Summary Evaluation of Alternative Calculation Equations

Table A1-1. Summary of the Evaluation of Alternative Calculation Equations For Each Subpart

Subpart	Description	Summary of Evaluation of Alternative Calculations
C	Combustion	No calculation methodologies were identified that would be an appropriate alternative. In general, calculation methods reviewed are the same as the current methods required, which are based on the IPCC methods. The alternative methods would still require fuel information (e.g., fuel input, fuel purchases, heat content, etc.) for the calculations; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
E	Adipic Acid	No calculation methodologies were identified that would be an appropriate alternative. Methodologies are similar to 2 IPCC methods. The IPCC Tier 1 methodology calculates emissions using facility-level data rather than unit-level data and results in lower accuracy in estimating emissions. IPCC Tier 2 methodology is similar to the Tier 1 methodology, except default factors are used instead of facility-specific information resulting in lower accuracy than Tier 1. Both methods still require facility production information as an input; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
F	Aluminum	No calculation methodologies were identified that would be an appropriate alternative. 3 methods were identified. Two (IPCC Tier 1 for CF_4 and C_2F_6 and IPCC Tier 1 for CO_2 emitted during electrolysis) use default emission factors which result in greater uncertainty than the current method. The third for calculating CF_4 and $C2F_6$ from smelter specific anode effects is the IPCC Tier 2 method, which also has high uncertainty compared to estimating emissions with the current method for CF_4 and C_2F_6, ±50 percent. The alternatives still use production data; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
G	Ammonia	No calculation methodologies were identified that would be an appropriate alternative. Several alternative calculation methods were identified, but all are based on 3 IPCC methodologies: IPCC Tier 1, 2, and 3. The IPCC Tier 1 and 2 methods are not considered viable alternative calculation methods because they would result in higher uncertainty than the current method and would still require reporting of ammonia production and feedstock information, which, according to Step 2 of the evaluation, disclosure concerns were identified.[a] The Tier 3 method is not considered a viable alternative because it would also require reporting of current "inputs to equations" data elements which, according to Step 2 of the evaluation, disclosure concerns were identified.[a]
H	Cement Kilns	No calculation methodologies were identified that would be an appropriate alternative. Calculation methodologies used in various GHG reporting programs and protocols can be grouped into 3 categories: (1) calculation of emissions based on clinker production, (2) calculation of emissions based on cement production, (3) calculation of emissions based on carbonate input to the kiln. The clinker calculation methods reviewed are variations on the current method using more general emission factors (national or default factors) and/or not calculating emissions from some emission sources (e.g., raw materials). The alternatives eliminate the need for some of the current "inputs to equations" data elements. However, they still require clinker production; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] The alternative methods are all less accurate, with higher uncertainty levels depending on how general the emission factors used are to calculate GHG emissions. Calculation method (2) is no longer considered appropriate because it has a much higher uncertainty in emissions. Calculation method (3) would require more detailed inputs to be reported for raw materials for the kiln (unless defaults are used); raw material information was identified as having disclosure concerns in Step 2 of the evaluation.[a] Use of calculation method (3) would result in more significant revisions to the reporting rule. The EPA previously determined this option could potentially be more costly and would not reduce the uncertainty in emissions calculations.

Subpart	Description	Summary of Evaluation of Alternative Calculations
K	Ferroalloy	No calculation methodologies were identified that would be an appropriate alternative. For CO_2, other methods reviewed included using production or process input data with an emission factor; mass balance with less site-specific data; and mass balance with more generic carbon content data. All alternative methods reviewed still use production data and/or process input data; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] No other methods were identified for CH_4.
L	Fluorinated Gas Production	No calculation methodologies were identified that would be an appropriate alternative. Two methods from IPCC were reviewed. However, the methods either use default factors and result in a high uncertainty in emission estimates or still require some of the same "inputs to equations" data elements which, according to Step 2 of the evaluation, disclosure concerns were identified.[a]
N	Glass	No calculation methodologies were identified that would be an appropriate alternative. Alternative calculation methodologies for this subpart are categorized as either input-based (using raw material information) or output based (using production information). The output-based methods have a higher uncertainty and use default values. Annual glass production for each furnace and total for the facility are reported under 98.146(b)(3) but and were determined to be CBI in 76 FR 30782 (May 26, 2011). Therefore, the output-based methods would not avoid the disclosure concerns. All input-based methodologies are based on IPCC Tier 3 calculations. Differences between different programs are due to different defaults. Estimates using Tier 3 will be higher than the current method. The input equations still use "inputs to equations" data elements, which, according to Step 2 of the evaluation, disclosure concerns were identified.[a]
O	CFC	No calculation methodologies were identified that would be an appropriate alternative. Alternative methods include calculating emissions using HCFC-22 production data with a default or site-specific emission factor, and parameter monitoring data (using process operating rate as a proxy for HFC-23 emissions). The alternative methods reviewed still use production data and/or process input data which, according to Step 2 of the evaluation, disclosure concerns were identified.[a] The alternative methods result in increased uncertainty.
P	Hydrogen	No calculation methodologies were identified that would be an appropriate alternative. Commenters on the call for information suggested calculating emissions using aggregated fuel and feedstock consumption data to obscure specific information. This method would still require monthly analyses of carbon content for each fuel and feedstock; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] Commenters also suggested calculating emissions on a carbon feed basis and not require disaggregation of fuel/feedstock by type. There is insufficient information or analysis provided by the commenters to assess the accuracy of this methodology. The method would not reveal any of the "inputs to equations" data elements for which disclosure concerns were identified, but would require new calculation algorithms. One newer method from CDM is limited in use and would not apply to all reporters in this subpart. Alternative calculation methodologies reviewed previously for the GHGRP primarily use emission factors (default or site-specific). These methodologies are less accurate than the current method. Other methods use hydrogen production information, which, according to Step 2 of the evaluation, disclosure concerns were identified.[a]
Q	Iron and Steel	No calculation methodologies were identified that would be an appropriate alternative. Alternative calculation methodologies used in various GHG reporting programs and protocols can be grouped into 5 categories: (1) calculation of emissions using production based emission factors, (2) calculation of emissions using input based emission factors, (3) calculation of emissions using default carbon weight fractions, (4) process unit mass balance calculation that excludes small contributors, and (5) plant-wide CO_2 mass balance for integrated mills only. The alternative methods (1) through (4) eliminate the need for some of the current data elements. However, they still require other data elements to be reported, such as production information or

Subpart	Description	Summary of Evaluation of Alternative Calculations
		ingredient information, which, according to Step 2 of the evaluation, disclosure concerns were identified.[a] Method (5) was previously determined by the EPA to not be appropriate because verification is needed on a process basis rather than a facility basis. Facility-wide estimates also have a higher uncertainty than process based calculations.
R	Lead	No calculation methodologies were identified that would be an appropriate alternative. Other methods reviewed included using production or process input data with an emission factor or default carbon content data. The alternative methods reviewed still use production data and/or process input data which, according to Step 2 of the evaluation, disclosure concerns were identified.[a] The alternative methods result in increased uncertainty in emission estimates.
S	Lime	No calculation methodologies were identified that would be an appropriate alternative. The EPA previously considered allowing a process input based methodology (based on feedstock) at proposal, but decided not to proceed with that alternative in the final GHGRP. The process input based methodology requires feedstock based information (e.g., mass of lime, mass of carbonate consumed); according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] Several of the alternatives use a process output based methodology using production information; according to Step 2 of the evaluation, disclosure concerns were identified for this information. A third methodology reviewed uses the mass balance of carbonates in the inputs and outputs; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
U	Carbonate	No calculation methodologies were identified that would be an appropriate alternative. Two alternative calculation methods were identified: IPCC Tier 1 and Tier 2. The IPCC Tier 1 method uses emission factors based on the total mass of carbonate consumed in limestone and dolomite. Default values are used for the fraction of the carbonate comprised of limestone and dolomite. The calculation method results in a high uncertainty in emissions compared to the current method and still requires using overall carbonate consumed as an input; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] The IPCC Tier 2 methodology is the same as Tier 1, except the fraction of carbonate in the limestone versus dolomite consumed is not a default value. This methodology is more accurate than Tier 1, but still less accurate than current method. It also requires using the mass of carbonates consumed by carbonate type; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
V	Nitric Acid	No calculation methodologies were identified that would be an appropriate alternative. Several alternative calculation methods were identified, all of which are similar to IPCC Tier 1 and Tier 2 methodologies. Both IPCC methodologies calculate emissions using plant level emission factors. Tier 2 is more refined in that emissions are also calculated by different control technologies used. Both methodologies still require using production information; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] Both have a higher level of uncertainty than the current method.
X	Petrochemical	No calculation methodologies were identified that would be an appropriate alternative. Three alternative calculation methodologies were identified. One is the IPCC Tier 1 methodology, which calculates emissions using default emission factors for CO_2 and CH_4 (published by IPCC) multiplied by the production of each product. The method still uses plant specific production rates; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] . Additionally, the level of uncertainty is high compared to current method (10-60% higher for CO_2; 30-80% higher for CH_4). The second alternative requires routing of process vent emissions to stacks for direct and continuous measurements of CO_2 emissions from each process stack (except flares) and each combustion source stack. While more accurate and introducing less uncertainty than the current method, it requires mandating process configurations that are not the intent of the GHGRP. However, the use of CEMS is evaluated in section 3.0 as part of the CEMS analysis. A third methodology was

Subpart	Description	Summary of Evaluation of Alternative Calculations
		suggested by a commenter to the Call for Information notice. The commenter suggested allowing the use of subpart PP methodologies, which require direct measurements using gas analyzers on a quarterly basis. The alternative has a high level of accuracy because it is based on source specific data. It may likely be more costly due to quarterly measurements. Additional analyses of the methodology would need to be undertaken to fully evaluate it, including assessing availability of equipment, applicability of analyzers for sources in this subpart, and cost.
Y	Refineries	No calculation methodologies were identified that would be an appropriate alternative. IPCC's Tier 1 and Tier 2 approaches use default emission factors to calculate GHG emissions from non-combustion sources at refineries and would provide less reliable emissions data for the entire refinery and no data on emissions from individual units. The following is a summary of the alternative calculation methods that were evaluated for individual emission points covered by subpart Y. Flares: Two alternative approaches were identified for calculating CO_2 emissions. The first alternative approach uses default emission factors multiplied by the amount of flare gas burned. The second method uses test data (either from facility or vendor testing). However, both of these methods would be unlikely to yield accurate results since waste gas composition is highly variable especially during unit startup, shutdown, and malfunctions. Catalytic Cracking Units and Fluid Coking Units: part 98 currently includes all three possible calculation methods. Asphalt Blowing: One alternative method is based on default emission factors for calculating the emissions of CO_2 and CH_4 from asphalt blowing operations. Part 98 calculation methods for both controlled and uncontrolled asphalt blowing operations rely on site-specific emission factors from facility-specific test data (though default emission factors are also provided for facilities that do not have the necessary test data). Allowing all users to use default emission factors instead of site-specific emission factors result in less accurate GHG emission estimates and would not avoid the use of "inputs to equations" data elements data; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] Equipment Leaks: Two alternative methods were identified for estimating emissions from equipment leaks. The first alternative method uses the crude feedstock throughput and a default emission factor to estimate fugitive emissions. This approach will yield less accurate results than the methods currently included in part 98. Furthermore, according to Step 2 of the evaluation[a], disclosure concerns were identified with crude feedstock throughput data. The second alternative method would require refineries to measure the flow rates of each leaking component (i.e., flanges, connectors, pumps, compressors, valves, pressure relief valves, etc) using Hi-Flow Samplers™, calibrated bag, or other measurement methods. The measured flow rate for each leaking component is multiplied by the time period during which the component is known to have been leaking, and the result adjusted for the uncertainty in the measurement of the flow rate. The total emissions for the refinery are the sum emissions for all leaking components. Due to the large number of components that would have to be regularly monitored and the difficulty of conducting such measurements for some inaccessible components, this approach is likely to be difficult and costly to implement. Storage Tanks: For storage tanks used to store unstabilized fuel oil, 3 alternatives were identified. The first uses default emission factors multiplied by the quantity of crude oil to calculate the CH_4 emissions from flashing losses and are based on data from upstream oil and gas production facilities rather than on data from refinery storage tanks. The second approach uses computer simulation programs to estimate emissions from flashing losses. The third approach is to use a correlation equation, such as the Vasquez-Beggs Equation, standing correlation, or EUB rule of thumb. However, all of these methods would require one or more of the same inputs used in the existing part 98 methods (e.g., tank-specific methane composition data, quantity of unstabilized crude oil received, etc.); according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]

Subpart	Description	Summary of Evaluation of Alternative Calculations
		Other Emission Sources: There were no new alternative calculation methods identified for the flares, catalytic reforming units, sulfur recovery units, coke calcining, process vents, blowdowns, working and breathing losses from storage tanks not used to store unstabilized crude oil, and loading operations. All of the previously identified calculation methods considered by the EPA were incorporated into part 98.
Z	Phosphoric Acid	No calculation methodologies were identified that would be an appropriate alternative. Only 1 alternative calculation methodology was identified. The methodology requires using default factors based on regional chemical composition of phosphate rock to calculate emissions. The methodology was considered and not used in the GHGRP because it was much less accurate than the method selected. Additionally, the alternative methodology would still require monthly phosphate rock consumption; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
AA	Pulp and Paper	No calculation methodologies were identified that would be an appropriate alternative. The major source of GHG emissions from facilities in this subpart are combustion sources - lime kilns, recovery boilers, and power boilers. Emissions from power boilers are covered under the subpart C analysis. Two alternative calculation methodologies for the biogenic component in recovery furnaces were identified. Both are based on using default factors. One is based on using default values for HHV instead of site-specific values and the method is only applicable to kraft or soda mills. The second is based on multiplying the total energy of spent liquor combusted and emission factors relating energy to emissions. Neither is very accurate and both have high uncertainty in emissions. The first method also uses some of the same "inputs to equations" data elements which, according to Step 2 of the evaluation, disclosure concerns were identified.[a] The second method does not allow emissions to be verified on an equipment basis, and applies only to the facility as a whole.
BB	Silicon Carbide	No calculation methodologies were identified that would be an appropriate alternative. Two alternative calculation methods were identified, based on using the IPCC Tier 1 calculation methodology. One option is to use an input-based (using raw material information) approach using default emission factors from IPCC, and the petroleum coke input. The option would still use many of the same data elements as inputs that the current method uses; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a] The second option is to use an output-based (using production information) approach using default emission factors from IPCC, and the silicon carbide production. However, silicon carbide production information, which is reported under 98.286(a)(2) and (b)(2), was determined to be entitled to confidential treatment in 76 FR 30782 (May 26, 2011).
CC	Soda Ash	No calculation methodologies were identified that would be an appropriate alternative. Two alternative calculation methodologies were identified that were previously considered but not adopted in the GHGRP. Both are based on the IPCC Tier 2 methodology. One would use default factors applied to the facility. The other would use site-specific factors. Both have a slight decrease in emissions accuracy estimates. However, both still require quantity of trona used or soda ash produced as inputs; according to Step 2 of the evaluation, disclosure concerns were identified for this information.[a]
EE	Titanium Dioxide	No calculation methodologies were identified that would be an appropriate alternative. Two alternative calculation methods were identified. One option is to use the IPCC Tier 1 approach, which calculates emissions using a default emission factor and production information. However, production information, which is reported under 98.316(a)(3) and (b)(4), was determined to be CBI in 76 FR 30782 (May 26, 2011). This option also increases uncertainty. The second option is to estimate emissions based on the carbon reducing agent. Emissions would be estimated by multiplying the tonnage of carbon reducing agent and 2 default factors. The uncertainty of this option has not been determined, but is likely much higher than the current method because 2 default factors are used rather than site-specific information.
GG	Zinc	No calculation methodologies were identified that would be an appropriate alternative.

Subpart	Description	Summary of Evaluation of Alternative Calculations
		Five alternative calculation methods were identified. Several of the options (IPCC Tier 1 and Tier 2, U.S. inventory) use default emission factors which would introduce higher uncertainty in emissions and are more appropriate for aggregated process information on a sector-wide or nationwide basis. One of the methods would also require production information which, according to Step 2 of the evaluation, disclosure concerns were identified.[a] . One other method is similar in that default emission factors are used, but the calculation of emissions is based on the quantity of carbon used in the production of metal. This method has a lower uncertainty, but it is still is not as accurate as the current method.
TT	Industrial Landfills	No calculation methodologies were identified that would be an appropriate alternative. One alternative calculation method was identified. Reporters would use the existing part 98 CH_4 calculation methodology with default factors. This would result in a higher uncertainty in emissions than the current method due to the default factor. In addition , it requires reporting of some "inputs to equations" data elements which, according to Step 2 of the evaluation, disclosure concerns were identified.[a]

a For additional details on the alternative calculation equations evaluated, please see Appendix A2. For the Step 2 evaluation, please see "Evaluation of Competitive Harm from Disclosure of 'Inputs to Equations' Data Elements Deferred to March 31, 2015" memorandum.

Appendix A2
Detailed Evaluation of Alternative Calculation Equations

Appendix A2. Subpart C – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	CARB	1	Same as 40 CFR part 75: CEMS.
		2	Calculate emissions similar to IPCC methods using fuel consumption and carbon or heat content. Still requires fuel input information for calculations, which was identified as having disclosure concerns in Step 2 of the evaluation.
	CCAR	1	Similar to IPCC methods. Still requires information on fuel burned in calculations, which was identified as having disclosure concerns in Step 2 of the evaluation.
		2	Same as 40 CFR part 75: CEMS.
	TCR	1	Calculate emissions similar to IPCC methods. Still require fuel input data in calculations, which was identified as having disclosure concerns in Step 2 of the evaluation.
		2	Same as 40 CFR part 75: CEMS.
	CCX	1	CEMS
		2	Calculate emissions using WRI/WBCSD protocols. Still requires fuel input data in calculations, which was identified as having disclosure concerns in Step 2 of the evaluation
	RGGI		Same as 40 CFR part 75: CEMS, with additional net energy output monitoring.
	DOE	1	Same as 40 CFR part 75: CEMS.
		2	Mass balance using fuel burned based on measured purchases or consumption and default or facility specific factors. Similar to IPCC methods. Still requires fuel input information which was identified as having disclosure concerns in Step 2 of the evaluation.
	40 CFR part 75		CO_2 CEMS combined with stack flow monitor or calculate mass emissions using fuel sampling for percent carbon content and fuel flow monitoring.
	CL	1	Same as 40 CFR part 75: CEMS.
		2	Similar to IPCC calculation methods.
	EU ETS		Emissions calculated using mass balance approach similar to Tier 3. Still requires fuel and heat content information as inputs which were identified as having disclosure concerns in Step 2 of the evaluation.
	ANGERS	Tier 1	CEMS.
		Tier 2	Similar to IPCC Tier 2, but uses EF based on direct sampling and analysis. Still requires fuel feed information as inputs and requires fuel specific inputs to calculate EF which were identified as having disclosure concerns in Step 2 of the evaluation. .
		Tier 3	Similar to IPCC Tier 2, but uses EF based on representative sampling. Still requires fuel feed information which was identified as having disclosure concerns in Step 2 of the evaluation.
		Tier 4	Similar to IPCC Tier 1. Still requires fuel feed information.
	CA GHG	1	References IPCC Tier 3 approaches.
		2	CEMS when a CO_2 diluent monitor is installed for measurements of other pollutants.
	EU ETS	1	Emissions calculated using mass balance approach similar to Tier 3. Still requires fuel and heat content information as inputs, which were identified as having disclosure concerns in Step 2 of the evaluation.
		2	CO_2 CEMS allowed if combined with a stack flow monitor and requires supplementary calculations.
Protocols and programs created after GHGRP	None identified.		

[1] CARB = California Air Resources Board Mandatory Reporting Rule; CCAR = California Climate Action Registry; TCR = The Climate Registry; CCX = Chicago Climate Exchange; RGGI = Regional Greenhouse Gas Initiative; DOE = U.S. DOE 1605 (b) program; CL = U.S EPA Climate Leaders; EU ETS = European Union Emissions Trading Scheme; ANGERS = Australian National GHG and Energy Reporting System; CA GHG = Canadian GHG National Reporting Program.

Appendix A2. Subpart E – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	IPCC	Tier 1	Multiplies facility-level production times the highest default emissions factor in IPCC Tier 1, which assumes no abatement of N_2O emissions. Much lower accuracy than current method, still requires production data which was identified as having disclosure concerns in Step 2 of the evaluation.
		Tier 2	Similar to Tier 1. Uses technology-specific default factors to account for abatement. Lower accuracy than current method and still requires production information which was identified as having disclosure concerns in Step 2 of the evaluation. .
	WRI/WBCSD	2	Same as IPCC Tier 2.
		3	Same as IPCC Tier 1.
	U.S. Inv		Same as IPCC Tier 2.
	TCR	Tier B	Same as IPCC Tier 2.
	DOE	B	Similar to IPCC Tier 2, but uses actual destruction factors and not defaults. More accurate than IPCC Tier 2 but still uses many of current “inputs to equations” data elements and is not as accurate as current method which were identified as having disclosure concerns in Step 2 of the evaluation.
		C	Similar to IPCC Tier 2.
Protocols and programs created after GHGRP	None identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; DOE = Department of Energy’s 1605 (b) Voluntary Reporting Program; TCR = The Climate Registry.

Appendix A2. Subpart F – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="3">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="3">None identified.</td></tr>
<tr><td rowspan="4">Methods previously considered but not adopted in final GHGRP</td><td>Source[1]</td><td>ID</td><td>Description</td></tr>
<tr><td rowspan="3">IPCC</td><td>Tier 1 - General</td><td>Uses default emission factors for CF_4 and C_2F_6 and production information. Significant uncertainty and still uses production data which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>Tier 2 – Smelter specific anode effects</td><td>Uses factors for CF_4 and C_2F_6. High uncertainty compared to estimating emissions with the current method for CF_4 and C_2F_6, about ±50 percent. Could develop new emission factors for CF_4 and C_2F_6 to reduce the uncertainty of the methodology, but the method still uses quantity of aluminum produced which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>Tier 1 - Electrolysis</td><td>Uses default emission factors for CO_2 and production information. Higher uncertainty compared to current method (5 – 10%) and still uses production data which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="3">None identified.</td></tr>
</table>

[1] IPCC = Intergovernmental Panel on Climate Change, 2006.

Appendix A2. Subpart G – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	IPCC	Tier 1	Uses default factor per unit of output multiplied by facility-level ammonia production. Introduces one additional input (ammonia production) which was identified as having disclosure concerns in Step 2 of the evaluation. Higher uncertainty in emissions than the current method due to defaults used.
		Tier 2	Same as IPCC Tier 1 except that it estimates emissions per fuel type, using ammonia production disaggregated by fuel input and process type. Introduces one additional input (ammonia production) which was identified as having disclosure concerns in Step 2 of the evaluation. Still requires feedstock information which was identified as having disclosure concerns in Step 2 of the evaluation. Results in higher uncertainty in emissions than the current method due to defaults used.
		Tier 3	Same as IPCC Tier 2 method, except uses actual total fuel requirement rather than default. Allows both default and measured carbon content and carbon oxidation factors. Introduces two additional inputs (total fuel requirement per plant and carbon oxidation factor) that are the same type of information identified as having disclosure concerns in Step 2 of the evaluation. Still requires feedstock information, which was identified as having disclosure concerns in Step 2 of the evaluation. Very accurate method only if actual carbon content and carbon oxidation factors are used.
	WRI/WBCSD	2	Same as IPCC Tier 2 if no facility-specific fuel requirement is available and default factors are used.
		3	Same as IPCC Tier 3 if facility-specific fuel requirement is available to calculate emissions.
	U.S. Inv		Same as IPCC Tier 2.
	DOE	B Rated	Similar to IPCC Tier 2. It allows actual or default carbon content value and calculates annual, facility-wide emissions. If actual (not default) factors are used, then the method introduces little uncertainty; however, calculates only facility-level estimate.
	TCR-GRP	Tier A2	Same as IPCC Tier 2.
Protocols and programs created after GHGRP	None identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; WRI/WBCSD = The World Resource Institute and World Business Council for Sustainable Development's Greenhouse Gas Protocol; TCR-GRP = The Climate Registry General Reporting Protocol For the Voluntary Reporting Program, May 2008; DOE = Department of Energy 1605(b) Voluntary Reporting Program – Ammonia; U.S. Inv = U.S. National Inventory Report, 2008 Method.

Appendix A2. Subpart H – Evaluation of Alternative Calculation Equations

Alternative	Analysis			
Methods in the Call for Information	No calculation methods identified.			
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Method Type[2]**	**Description**
	IPCC	Tier 1	Cement	Default factors; Clinker production inferred from cement production. Not recommended; high uncertainty.
	IPCC	Tier 2	Clinker	National factor; higher uncertainty than current method.
	IPCC	Tier 3	Carbonate	Default EF for carbonates. Potentially more costly; larger # of new inputs.
	U.S Inv		Clinker	IPCC Tier 2 w/default factors.
	WRI/WBCSD	1A	Clinker	Similar to IPCC Tier 2 w/CKD EF.
	WRI/WBCSD	1B	Clinker	Similar to WRI/WBCSD, 1A but w/default factors.
	WRI/WBCSD	2A	Cement	Site/corporate clinker/cement ratio. Not recommended; high uncertainty.
	WRI/WBCSD	2B	Cement	Same as WRI/WBCSD, 2A but w/default factors.
	CA AB32		Clinker	Same as WRI/WBCSD, 1A.
	CCAR	A	Clinker	Same as WRI/WBCSD, 1A.
	CCAR	B	Clinker	Same as WRI/WBCSD, 1B.
	CCAR	A	Cement	Same as WRI/WBCSD, 2A.
	CCAR	B	Cement	Same as WRI/WBCSD, 2A, but w/more default factors.
	DOE	A	Clinker	Uses clinker production w/site specific ratios of clinker content.
	DOE	B	Clinker	Same as DOE, A but with default factors.
	DOE	A	Cement	Same as WRI/WBCSD, 2A.
	DOE	B	Cement	Same as WRI/WBCSD, 2A but w/default factors.
	DOE	C	Cement	Not recommended; high uncertainty. Default factor x cement production.
	CL	1A	Clinker	Same as WRI/WBCSD, 1A but doesn't report raw material emissions.
	CL	1B	Clinker	Same as WRI/WBCSD, 1B.
	CL	2A	Cement	Same as WRI/WBCSD, 2A.
	CL	2B	Cement	Same as WRI/WBCSD, 2A but w/default factors.
	CL	3	Carbonate	Same as IPCC Tier 3.
	EU ETS	A	Carbonate	Same as IPCC Tier 3, but w/more default factors.
	EU ETS	B1	Clinker	Same as WRI/WBCSD, 1A.
	EU ETS	B2	Clinker	Same as WRI/WBCSD, 1B.
	NM		Clinker	Same as WRI/WBCSD, 1A.
	TCR		Clinker	Same as WRI/WBCSD, 1A but doesn't report raw material emissions.
	TCR		Clinker	Same as WRI/WBCSD, 1B.
	TCR		Carbonate	Same as IPCC Tier 3.
Protocols and programs created after GHGRP	No new calculation methods identified.			

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; CA AB32 = CA Mandatory Reporting Program; CCAR = California Climate Action Registry; DOE = Department of Energy's 1605 (b) Voluntary Reporting Program; CL = EPA Climate Leaders; EU ETS = European Union Emission Trading System; NM = New Mexico Mandatory GHG Reporting Program; TCR = The Climate Registry.

[2] Cement method relies on information about the composition and quantity of raw materials consumed, the quantity of clinker incorporated into the cement, and the quantity of cement produced. It calculates CO_2 emissions based on the amount of raw materials and their carbonate content. This approach directs companies to

collect data on cement production, the raw material ratio to produce clinker and the $CaCO_3$ equivalent content of the raw materials, thus allowing companies to monitor changes in emissions due to modifying the cement manufacturing process.

Clinker Production-Based method is a mass balance approach based on the quantity of clinker produced. It calculates CO_2 emissions based on the volume and composition of clinker produced as well as the amount of cement kiln dust (CKD) not recycled to the kiln. This approach has become an industry standard due to all companies knowing clinker production and the CaO/MgO content data.

Carbonate Input Approach method is based on the collection of disaggregated data on the types (compositions) and quantities of carbonate(s) consumed to produce clinker, as well as the respective emission factor(s) of the carbonate(s) consumed. It includes an adjustment to subtract any uncalcined carbonate within CKD not returned to the kiln.

Appendix A2. Subpart K – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	**Source[1]**	**ID**	**Description**
	Dow Corning	1	Same as current method for CO_2, except excludes from the mass balance inputs contributing less than 5% of plant wide emissions. This exclusion is allowed in Subpart K if <1% of total mass of carbon in or out. Method still requires using "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation. Small reduction in burden and negligible reduction in accuracy.
	Dow Corning	2	Same as current method for CO_2, except with more flexibility in how carbon content is reported (e.g., supplier, independent laboratory, IPCC). Still uses mass of each process input and process outputs which were identified as having disclosure concerns in Step 2 of the evaluation. Unknown reduction in accuracy.
Methods previously considered but not adopted in final GHGRP	IPCC	CO_2 Tier 1	Uses mass of process outputs (product and nonproduct) and production-based emission factors. Still uses production data which was identified as having disclosure concerns in Step 2 of the evaluation. Method decreases accuracy of estimates 25-50%.
	IPCC	CO_2 Tier 2	Similar to current method but uses default emission factors instead of facility specific carbon content. Still uses mass of each process input which was identified as having disclosure concerns in Step 2 of the evaluation. Methods use of defaults decreases accuracy of estimates by 15-40%.
	ANGGRP		Uses quantity of carbon material, energy content of carbon material, and emission factor based on energy content. Use of default factors would decrease accuracy of estimates by 15-40%. Use of facility specific factors would be similar to current method. Still requires knowing carbon content of materials and amount of materials which was identified as having disclosure concerns in Step 2 of the evaluation.
	U.S. Inv		Same as IPCC CO_2 Tier 1.
	IPCC	CH_4 Tier 1	Use mass of product and generic production-based emission factors. Still uses production data which was identified as having disclosure concerns in Step 2 of the evaluation. Method decreases accuracy of estimates by 40%.
Protocols and programs created after GHGRP	No programs were identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; Dow Corning – Comments submitted under Call for Information (DCN: EPA-HQ-OAR-2008-0508-0562); ANGGRP = Australian National Government Greenhouse and Energy Reporting Program; U.S. Inv = U.S. EPA Inventory for Greenhouse Gas Emissions and Sinks.

Appendix A2. Subpart L – Evaluation of Alternative Calculation Equations

Alternative	Analysis			
Methods in the Call for Information	No calculation methods identified.			
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Method Type**	**Description**
	IPCC	Tier 1	Default emission factor and production data	Uses default F-gas generation factor and mass of F-gas produced. High uncertainty due to emission variability (0.8 to 2% of production).
	IPCC	Tier 3A	Direct process measurement	Uses frequent or continuous measurement of the concentration and flow-rate (i.e., CEMS) from the vents at an individual plant to obtain instantaneous F-gas emission rate. Total quantity of F-gas released is the annual sum of measured instantaneous releases**.**
	IPCC	Tier 3B	Parameter monitoring	Uses process operating rate (e.g., feedstock flow rate, F-gas production rate) as proxy for F-gas emission rate. Still uses process data (e.g., feedstock flow rate, production rate) which were identified as having disclosure concerns in Step 2 of the evaluation
Protocols and programs created after GHGRP	No new calculation methods identified.			

[1] IPCC = Intergovernmental Panel on Climate Change, 2006.

Appendix A2. Subpart N – Evaluation of Alternative Calculation Equations

The current calculation methodology is a modified version of IPCC Tier 3. Process CO_2 emissions are calculated using a carbon mass balance for each continuous glass melting furnace. The equation is based on: mass fraction of carbonate mineral in each raw material, mass of carbonate raw material charged, default emission factor for carbonate-based raw material (shown in Table N-1 of the rule), and fraction of calcination achieved for each raw material.

Alternative	Analysis			
Methods in the Call for Information	No calculation methods identified.			
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Method Type**	**Description**
	IPCC	Tier 1	Output	Uses a default emission factor based on typical raw material mixtures and total glass production data. Significant decrease in accuracy of emission estimates (60% from current method).
	IPCC	Tier 2	Output	Uses default emission factors and cullet ratios, and production information for specific types of glass produced. Accuracy of emission estimates decreases by 10% from current method.
	IPCC	Tier 3	Input	Similar to current method. Does not limit calculation to mass fraction of carbonate-based mineral in carbonate-based raw material. Resulting estimates will be higher than current method. Still uses "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation.
	U.S Inv		Output	Similar to IPC C Tier 1 and 2. Uses default carbon weight fractions for each raw material charged which were identified as having disclosure concerns in Step 2 of the evaluation. .
	DOE		Input	Same as IPCC Tier 3. Still uses "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation.
	ANMGGRP	D	Input	Similar to IPCC Tier 3. Uses different calcination fraction. Still uses "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation.
	ANMGGRP	H	Input	Same as IPCC Tier 3. Still uses "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation.
	EU ETS	A	Input	Same as IPCC Tier 3. Still uses "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation.
	EU ETS	B	Input	Similar to IPCC Tier 3. Uses default fraction of calcination for carbonate-based raw material. Still uses "inputs to equations" data elements which were identified as having disclosure concerns in Step 2 of the evaluation.
	EB		Input	Same as IPCC Tier 3. Still uses "inputs to equations" data elements.
Protocols and programs created after GHGRP	No new calculation methods identified.			

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; DOE = Department of Energy's 1605 (b) Voluntary Reporting Program; EU ETS = European Union Emission Trading System; ANMGGRP = Australian National Mandatory Greenhouse Gas Reporting Program; EB = European Bank for Reconstruction and Development.

Appendix A2. Subpart O – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	No calculation methods identified.		
Methods previously considered but not adopted in final GHGRP	**Source** [1]	**ID**	**Description**
	IPCC	Tier 1	Uses default HFC-23 generation factor and mass of HCFC-22 produced. For control devices, uses estimated destruction efficiency. Still requires production data which was identified as having disclosure concerns in Step 2 of the evaluation. Higher uncertainty in emissions than the current method due to default factor (using a default emission factor of 4 percent yields 50 percent uncertainty).
	IPCC	Tier 2	Uses site-specific HFC-23 generation factor (based on records of carbon and fluorine efficiencies), mass of HCFC-22 produced, and data on fraction of year process vent stream was released untreated which were identified as having disclosure concerns in Step 2 of the evaluation. Uncertainty varies according to sampling frequency (daily sampling yields 1 – 2 percent uncertainty).
	IPCC	Tier 3A	Simplified version of current method (uses concentration of HFC-23 in the gas vented from process, mass flow of process stream, mass flow of HFC-23/other product stream, and fraction HFC-23 in HCFC-22/other stream.) Methods allow continuous and less frequent monitoring. Still requires 2015 input data which were identified as having disclosure concerns in Step 2 of the evaluation. Uncertainty due to measurement frequency (current method requires weekly) and exclusion of HFC-23 destroyed offsite, sold, and stored.
	IPCC	Tier 3B	Uses process operating rate as proxy for HFC-23 emitted. Still uses two current "inputs to equations" data elements (i.e., fraction HFC-23 in HCFC-22/other stream and mass flow of HFC-23/other product stream) which were identified as having disclosure concerns in Step 2 of the evaluation
	U.S. Inv		Same as IPCC Tier 3B.
	WRI/WBCSD	2	Similar to IPCC Tier 3A. Accounts for onsite HFC-23 destruction (fraction abated and control utilization data)
	WRI/WBCSD	3	Similar to IPCC Tier 3A. WRI method uses default factors for the loss in production efficiency of HCFC-22, carbon and fluorine content factors, and carbon and fluorine balance efficiencies.
	WRI/WBCSD	4	Same as IPCC Tier 1.
	DOE		Similar to IPCC Tier 3A. Accounts for onsite HFC-23 destruction (fraction abated and control utilization data)
	TCR	Tier B	Similar to IPCC Tier 2.
	TCR	Tier C	Similar to IPCC Tier 1. TCR method accounts for HFC-23 destroyed by collecting fraction abated and control device utilization data.
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] IPCC = 2006 Guidelines for National Greenhouse Gas Inventories; U.S. Inv = U.S. National Inventory Report 2008 Method (U.S. Inventory of Greenhouse Gas Emissions and Sinks 1990-2006); WRI/WBCSD = World Resources Institute & World Business Council for Sustainable Development. Greenhouse Gas Protocol: HCFC-22 Emissions from Production of HCFC-22, Version 2.0. December 2007; DOE = Department of Energy's 1605(b) Voluntary Reporting Program; TCR = The Climate Registry.

Appendix A2. Subpart P – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	**Commenter[1]**		**Description**
	ACC		Calculate emissions using aggregated fuel and feedstock consumption data to obscure specific information. Method would still require monthly analyses of carbon content for each fuel and feedstock which were identified as having disclosure concerns in Step 2 of the evaluation. Method is less accurate than current method.
	ACC		Calculate emissions on a carbon feed basis and not require disaggregation of fuel/feedstock by type. Insufficient information or analysis provided to assess the accuracy of the methodology. Method would not reveal any of the “inputs to equations” data elements that were identified as having disclosure concerns in Step 2 of the evaluation, but would require new calculation algorithms.
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	EU ETS	Tier 1	Uses default emission factor. Less accurate than current method.
	EU ETS	Tier 2	Uses a facility specific emission factor calculated from carbon content of feed gas. Still requires composition information which was identified as having disclosure concerns in Step 2 of the evaluation. More accurate than Tier 1 but less accurate than current method.
	DOE	A	Based on fuel burned and the ratio of CO_2 to fuel determined from fuel analysis. Still requires fuel input and composition information which were identified as having disclosure concerns in Step 2 of the evaluation.
	DOE	B	Uses default emission factors based on fuel. Less accurate than the current method and still requires fuel consumption information which were identified as having disclosure concerns in Step 2 of the evaluation.
	API	1	Uses production rate and simplified stoichiometric ratios. Method requires reporting of data element determined to be in 76 FR 30782 (May 26, 2011).
	API	2	Uses a default emission factor and feedstock volume. Less accurate than current method and still requires feedstock information which was identified as having disclosure concerns in Step 2 of the evaluation.
	CARB	1	Similar to current method, but only accounts for carbon in feedstock. Less comprehensive and accurate than the current method.
	IPCC	Tier 1	Based on hydrogen production and facility specific proportionality factor. Less accurate than current method and still requires production information which was identified as having disclosure concerns in Step 2 of the evaluation.
Protocols and programs created after GHGRP	CDM provides a different calculation methodology based on using biogas to displace LPG as a feedstock and fuel in a hydrogen production unit. Method is limited in use. Method has high accuracy and low uncertainty as the calculated emissions are related to a monetary value under CDM.		

[1] ACC = American Chemistry Council; IPCC = Intergovernmental Panel on Climate Change, 2006; DOE = Department of Energy; EU ETS = European Union Emission Trading System; API = American Petroleum Institute; CARB = California Air Resources Board; CDM = Clean Development Mechanism.

Appendix A2. Subpart Q – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="3">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="3">Two methods identified by Sierra Club are similar to methods previously considered but not adopted in the final GHGRP: (1) a simple mass balance assuming all the carbon input to the process converts to CO_2; and (2) exclude small contributors from the mass balance for EAFs only. These are addressed in the following summary.</td></tr>
<tr><td rowspan="16">Methods previously considered but not adopted in final GHGRP</td><th>Source[1]</th><th>ID</th><th>Description</th></tr>
<tr><td>CL</td><td>Section 2.2</td><td rowspan="2">Exclude small contributors from mass balance (e.g., CL: slag out of an EAF furnace, DOE: APCD residue from a decarburization vessel).
• Allowed under GHGRP if <1% of total mass of carbon in or out; concept also recommended by AISI.
• Small reduction in burden and negligible reduction in accuracy.
• Retains 2015 data elements which were identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>DOE</td><td>Section 1.E.4.1.6.3</td></tr>
<tr><td>IPCC</td><td>Tier 1</td><td>Use production based emission factors instead of site-specific information and information on inputs.
• Not comprehensive, i.e., IPCC listed only 5 of the 7 processes in GHGRP
• Hides recipes/ingredients, but not production rate which was identified as having disclosure concerns in Step 2 of the evaluation.
• Decreases accuracy of estimates by 20%.</td></tr>
<tr><td>AISI</td><td>Fenceline principle</td><td>Use input based emission factors instead of site-specific information and information on production.
• Not comprehensive, e.g., excludes scrap to BOF or EAF and materials produced on-site like sinter.
• Hides production rates, but not recipes/ingredients, which was identified as having disclosure concerns in Step 2 of the evaluation.
• Decreases accuracy of estimates by 25%.</td></tr>
<tr><td>IPCC</td><td>Tier 2</td><td rowspan="3">Use default carbon weight fraction instead of carbon content of inputs and products.
• Hides site specific carbon content, but still requires production rate and recipes/ingredients which were identified as having disclosure concerns in Step 2 of the evaluation.
• Preamble indicates analysis of carbon content is not burdensome.
• IPCC claims accuracy decreases by 5%, but preamble indicates that use of defaults is more appropriate for a sector wide or national total.</td></tr>
<tr><td>WRI/WBSCD</td><td>Tier 1</td></tr>
<tr><td>CL</td><td>All</td></tr>
<tr><td>EU ETS</td><td>ANNEX VI</td><td rowspan="4">If mill is integrated; conduct a plant-wide CO_2 mass balance (ignore movement of energy sources within plant boundaries) instead of by process.
• Preamble indicates process level info is needed for verification and to identify reduction opportunities; so verification issues with option.
• Composite totals are used.</td></tr>
<tr><td>AISI</td><td>Fenceline principle</td></tr>
<tr><td>CL</td><td>Section 2.1</td></tr>
<tr><td>DOE</td><td>Section 1.E.4.1.6.5</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="3">4 programs were identified. However, the methods used to calculate emissions are the same as the methods previously considered but not adopted in the final GHGRP or are identical to methods in the GHGRP. Therefore, no further analyses of these are presented in this table. The 4 programs are:
• Australian Government – NGER technical guidelines, section 4.67 (similar to CL, section 2.2)
• Australian Government – NGER technical guidelines, section 4.66 (similar to IPCC Tier 2)
• UN, Framework on Climate Change – Clean Development Mechanisms; AMS-III.V.: Decrease of coke (similar to IPCC Tier 1)
• CARB (same as GHGRP)</td></tr>
</table>

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; DOE = Department of Energy; CL = EPA Climate Leaders; EU ETS = European Union Emission Trading System; AISI = American Iron and Steel Institute.

Appendix A2. Subpart R – Evaluation of Alternative Calculation Equations

Alternative	Source	ID	Description
Methods in the Call for Information	The Association of Battery Recyclers suggested using default carbon content, rather than measured carbon content, for secondary lead smelters, as the feed material is predominantly used in lead-acid batteries. Using a default carbon content value would result in ±10% uncertainty compared to the current method. However, the annual mass of each carbon-containing material is the same type of information identified as having disclosure concerns in Step 2 of the evaluation.		
Methods previously considered but not adopted in final GHGRP	**Source**	**ID**	**Description**
	IPCC	Tier 1	Uses default emission factor by production type (imperial smelting furnace, direct smelting furnace). Uses production data, which was identified as having disclosure concerns in Step 2 of the evaluation, and results in a ±45% increase in uncertainty.
	IPCC	Tier 2	Similar to IPCC Tier 1 except emission factors are based on country-specific information on the use of reducing agents, furnace types, and other process materials, and default carbon contents. Method is more accurate than IPCC Tier 1, but is less accurate than current method and also requires production information, which was identified as having disclosure concerns in Step 2 of the evaluation.
	Stack test		Uses emissions data from a stack test to develop site-specific emission factors that is applied to the quantity of feed or product material. Appropriate for facilities where process inputs and operating parameters are consistent. This option was not adopted because of the potential for significant variation at smelters in the feed to the furnace and process operating parameters.
	U.S. Inv		Same as IPCC Tier 1.
	ANMGGRP		Similar to current method, but is based on energy content. Still requires information on quantity and carbon content of feed to smelter, which was identified as having disclosure concerns in Step 2 of the evaluation.
	Env Canada		Use current method for metal ore and reducing agents charged to the furnace only. For any other non-fuel process input materials, use emission factors. This method would still require reporting of raw material and carbon content data for metal ore which were identified as having disclosure concerns in Step 2 of the evaluation. It would underestimate emissions, and has an unknown uncertainty compared to the current method. Would need to develop emission factors.
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; ANMGGRP = Australian National Mandatory Greenhouse Gas Reporting Program; Env Canada = Environment Canada; U.S. Inv = U.S .Inventory of Greenhouse Gases.

Appendix A2. Subpart S – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="4">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="4">None identified</td></tr>
<tr><td rowspan="13">Methods previously considered but not adopted in final GHGRP</td><td>Source[1]</td><td>ID</td><td>Method Type[2]</td><td>Description</td></tr>
<tr><td>IPCC</td><td>Tier 1</td><td>Output</td><td>Uses default emission factors for each of the 3 types of lime produced. Still requires production information which was identified as having disclosure concerns in Step 2 of the evaluation and has a high uncertainty.</td></tr>
<tr><td>IPCC</td><td>Tier 2</td><td>Output</td><td>Uses default emission factors based on lime type correcting for the amount of calcined byproduct/waste produced. Still requires production information which was identified as having disclosure concerns in Step 2 of the evaluation and has a high uncertainty.</td></tr>
<tr><td>IPCC</td><td>Tier 3</td><td>Input</td><td>Uses measured quantities of carbonate inputs to the kiln and emission factors and calcinations fractions to the carbonates consumed. Low uncertainty in emissions but requires feedstock information which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>U.S. Inv</td><td></td><td>Output</td><td>Same as IPCC Tier 2.</td></tr>
<tr><td>WRI/ WBCSD</td><td>1</td><td>Output</td><td>Similar to IPCC Tier 2, but encourages more plant-specific data.</td></tr>
<tr><td>WRI/ WBCSD</td><td>2</td><td>Input</td><td>Same as IPCC Tier 3.</td></tr>
<tr><td>EU ETS</td><td>1A</td><td>Mass balance</td><td>Based on a carbonate mass balance and emission factor. Still requires composition and product information which were identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>EU ETS</td><td>1B</td><td>Output</td><td>Based on identifying MgO and CaO in the lime produced. Still requires composition and product information which were identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>EU ETS</td><td>2A</td><td>Input</td><td>Based on carbonate input to kilns only. Has a higher uncertainty than IPCC Tier 3 and requires feedstock information which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>EU ETS</td><td>2B</td><td>Output</td><td>Same as EU ETS 1B.</td></tr>
<tr><td>TCR</td><td>1, 3</td><td>Input</td><td>Same as IPCC Tier 3, allows plant-specific data.</td></tr>
<tr><td>TCR</td><td>2, 4</td><td>Output</td><td>Same as IPCC Tier 3, allows plant-specific data.</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="4">This alternative is for a new methodology for producing lime. It is not widely used (or used at all) and not appropriate for consideration. The CDM provides a methodology for hydraulic lime production uses fossil fuel usage and electricity usage to estimate emissions. This method is for a new method of producing hydraulic lime for construction purposes by blending conventional hydraulic lime with alternative material additives.</td></tr>
</table>

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; EU ETS = European Union Emission Trading System; TCR = The Climate Registry; CDM = Clean Development Mechanism

[2] Emissions calculated based on inputs to kiln, outputs from kiln, or mass balance of inputs and outputs.

Appendix A2. Subpart U – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="3">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="3">None identified.</td></tr>
<tr><td rowspan="4">Methods previously considered but not adopted in final GHGRP</td><td>Source[1]</td><td>ID</td><td>Description</td></tr>
<tr><td>IPCC</td><td>Tier 1</td><td>Uses emission factors based on the mass of carbonate consumed. Considers only limestone and dolomite are used and assigns default fraction partitioning the use of them. High uncertainty in emissions. Still requires knowing overall carbonate consumed which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>IPCC</td><td>Tier 2</td><td>Same as Tier 1, except the fraction of limestone versus dolomite consumed is not a default value. More accurate than Tier 1, but still less accurate than current method and also requires using mass carbonates consumed by carbonate type, which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>ANMGGRP</td><td></td><td>Same as current method.</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="3">None identified.</td></tr>
</table>

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; ANMGGRP = Australian National Mandatory Greenhouse Gas Reporting Program.

Appendix A2. Subpart V – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	IPCC	Tier 1	Uses default emission factors and assumes no abatement. Facility level based rather than unit based. Still requires production information which was identified as having disclosure concerns in Step 2 of the evaluation and has a high uncertainty in estimates.
	IPCC	Tier 2	Similar to current method. Uses plant-level production data disaggregated by technology and default emission factors and destruction factors on a site-specific basis. Still requires using production information which was identified as having disclosure concerns in Step 2 of the evaluation.
	WRI/WBCSD	2	Similar to IPCC Tier 2.
	WRI/WBCSD	3	Similar to IPCC Tier 1.
	U.S. INV		Uses default factor for calculating N_2O emissions. No inputs are used that had disclosure concerns identified in Step 2of the evaluation, but accuracy is severely reduced and is more appropriate for national estimates. Facility level data are not collected.
	TCR	Tier B	Similar to IPCC Tier 2.
	DOE	B	Similar to IPCC Tier 2.
	DOE	C	Similar to IPCC Tier 2, except uses other published emission factors rather than IPCC for uncontrolled and non-selective catalytic reduction control technologies.
Protocols and programs created after GHGRP	None identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; DOE = Department of Energy; TCR = The Climate Registry.

Appendix A2. Subpart X – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
	Source	**Method**	**Description**
Methods in the Call for Information	American Chemistry Council	Gas composition meter	Commenter suggested allowing the use of subpart PP methodologies, which require direct measurements using gas analyzers. • Quarterly monitoring is required • High accuracy due to source specific information
Methods previously considered but not adopted in final GHGRP	IPCC Tier 1	Emission factor	Use default emission factors for CO_2 and CH_4 published by IPCC multiplied by the production of each product. • Still uses plant specific production rates, which were identified as having disclosure concerns in Step 2 of the evaluation. • Low cost to implement • Level of uncertainty is high compared to current method (10-60% for CO_2; 30-80% for CH_4) • Default factors cannot reflect site-specific differences in characteristics such as the type of feedstock, operating conditions, etc. • More appropriate for sector wide estimates
	IPCC Tier 3, modified	Direct measurements	Requires routing of process vent emissions to stacks for direct and continuous measurements of CO_2 emissions from each process stack (except flares) and each combustion source stack. • More costly • Mandates process configuration changes, which is not the intent of the GHGRP • Flare emissions based on emission factor • CH_4 and N_2O emissions from combustion sources would be calculated using subpart C procedures. • More accurate and less uncertainty than current option • Similar to IPCC Tier 3 approach, except IPCC indicates that process vent emissions may be either estimated or measured, and IPCC CH_4 estimation methods for flares is more rigorous
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006.

Appendix A2. Subpart Y – Evaluation of Alternative Calculation Equations
Flares

Alternative	Analysis		
	Source	**Method**	**Description**
Methods in the Call for Information	No new calculation methods identified.		
Methods previously considered but not adopted in final GHGRP	API, CARB, DOE, EU, and IPCC	Default emission factors	Use quantity of waste gas burned and default emission factors. Still uses plant specific production rates; according to Step 2 of the evaluation, disclosure concerns were identified with this information. • Low cost to implement. • Level of uncertainty is higher compared to using measured carbon content or HHV data because the composition of waste gas sent to flares is known to vary considerably due to process upsets, maintenance activities, etc. However, the default emission factor approach is thought to be reasonably accurate during normal operation. • More appropriate for sector wide estimates.
	API	Test data	Uses vendor or facility test data to calculate CO_2 and CH_4 emissions (N_2O are considered negligible by API). • More accurate than default emission factors; however, level of uncertainty is higher compared to using measured carbon content or HHV data because composition of waste gas sent to flares is known to vary considerably due to process upsets, maintenance activities, etc.
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; EU ETS = European Union Emission Trading System; API = American Petroleum Institute; CARB = California Air Resources Board.

Catalytic Cracking Units and Fluid Coking Units

Alternative	Analysis
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	The previously considered methods are included in part 98. However, larger units are not allowed to use emission factors to calculate CO_2 emissions (allowed only for units with throughputs less than 10,000 bbls/stream day), the only input reported for larger units is the molar volume conversion factor. Small units can use mass balance, CEMS, or emission factors (either site-specific or default).
Protocols and programs created after GHGRP	No new calculation methods identified.

Sulfur Recovery

Alternative	Analysis
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	All of the previously considered methods are included in part 98.
Protocols and programs created after GHGRP	No new calculation methods identified.

Coke Calcining

Alternative	Analysis
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	All of the previously considered methods are included in part 98.
Protocols and programs created after GHGRP	No new calculation methods identified.

Asphalt Blowing

Alternative	Analysis		
	Source	Method	Description
Methods in the Call for Information	No new calculation methods identified.		
Methods previously considered but not adopted in final GHGRP	API and CARB	Default emission factors	Use quantity of asphalt blown and default emission factors for calculating the emissions of CO_2 and CH_4 from asphalt blowing operations. Part 98 calculations methods for both controlled and uncontrolled asphalt blowing operations relies on site-specific emission factors from facility-specific test data (though default emission factors are also provided for facilities that do not have the necessary test data). • Still uses plant specific production rates, which was identified as having disclosure concerns in Step 2 of the evaluation. • Low cost to implement • Level of uncertainty is higher compared to using the site-specific emission factor approach in the rule • Default factors cannot reflect site-specific differences in characteristics such as operating conditions, etc. • More appropriate for sector wide estimates
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] API = American Petroleum Institute; CARB = California Air Resources Board.

Delayed Coking Units

Alternative	Analysis		
	Source	Method	Description
Methods in the Call for Information	No new calculation methods identified.		
Methods previously considered but not adopted in final GHGRP	EU ETS	Mass balance	No equation provided
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] EU ETS = European Union Emission Trading System.

Process Vents

Alternative	Analysis
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	All of the previously considered methods are included in part 98.
Protocols and programs created after GHGRP	No new calculation methods identified.

Blowdowns

Alternative	Analysis
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	All of the previously considered methods are included in part 98.
Protocols and programs created after GHGRP	No new calculation methods identified.

Equipment Leaks

Alternative	Analysis		
	Source	Method	Description
Methods in the Call for Information	No new calculation methods identified.		

Methods previously considered but not adopted in final GHGRP	API	Default emission factor	Use default emission factors for amount of crude feedstock and default emission factors. • Still uses plant specific production rates, which was identified as having disclosure concerns in Step 2 of the evaluation. • Low cost to implement • Level of uncertainty is high compared to the current methods • Default factors cannot reflect site-specific differences in characteristics such as operating conditions, effectiveness of LDAR programs, etc. • More appropriate for sector wide estimates
Protocols and programs created after GHGRP	UNFCCC	Direct measurements	Measure the flow rates of the physical leaks using Hi-Flow Samplers™, calibrated bag, or other suitable flow measurements technology and calculate the emissions using the rate x time period of leaking. • More accurate and less uncertainty than current option. • More costly due to large number of components to monitor. • May not be practical to monitor some components due to safety and accessibility issues. • Data used to calculate emissions does not contain information determined to have disclosure concerns in Step 2 of the evaluation.

[1] API = American Petroleum Institute; UNFCCC = United Nations Framework Convention on Climate Change

Storage Tanks – Unstablized Crude Oil

Alternative	Analysis		
	Source	**Method**	**Description**
Methods in the Call for Information	No new calculation methods identified.		
Methods previously considered but not adopted in final GHGRP	API	Default emission factor	Use default emission factors for CH_4 published by API multiplied by the quantity of crude oil. • Still uses the amount of unstabilized crude delivered, which was identified as having disclosure concerns in Step 2 of the evaluation. • Low cost to implement • Level of uncertainty is unknown but would likely be high compared to current methods • Default factors cannot reflect site-specific differences in characteristics such as the type of crude, operating conditions, etc. • More appropriate for sector wide estimates
	API	API E&P TANKS program	API E&P TANKS program, which uses pressure differential, API gravity, Reid vapor pressure, composition of the crude oil, and crude oil throughput. • Less accurate than current options • Would still require site specific information on methane composition data and quantity of unstabilized crude oil received, which was identified as having disclosure concerns in Step 2 of the evaluation.
	API	Correlation equations	Similar to one of the current methods. API recommends the Vasquez-Beggs Equation, standing correlation, or EUB rule of thumb. • No information regarding accuracy provided. • Would still require site specific information on methane composition data and quantity of unstabilized crude oil received, which was identified as having disclosure concerns in Step 2 of the evaluation.
	API	Other process simulators	No specific method provided.
Protocols and programs created after GHGRP	No new calculation methods identified.		

[1] API = American Petroleum Institute.

Storage Tanks – Products Other than Unstabilized Crude Oil

	Analysis

Alternative	
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	All of the previously considered methods are included in part 98.
Protocols and programs created after GHGRP	No new calculation methods identified.

Crude Oil, Intermediate, and Product Loading Operations

Alternative	Analysis
Methods in the Call for Information	No new calculation methods identified.
Methods previously considered but not adopted in final GHGRP	All of the previously considered methods are included in part 98.
Protocols and programs created after GHGRP	No new calculation methods identified.

Appendix A2. Subpart Z – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="3">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="3">None identified.</td></tr>
<tr><td rowspan="2">Methods previously considered but not adopted in final GHGRP</td><th>Source[1]</th><th>ID</th><th>Description</th></tr>
<tr><td>U.S. Inv</td><td>Option 1</td><td>Uses default factors based on regional chemical composition of phosphate rock. Less accurate than current method, but still requires monthly phosphate rock consumption, which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="3">None identified.</td></tr>
</table>

[1] U.S. Inv = U.S. Greenhouse Gas Emissions and Sinks: 1990-2006. USEPA 430-R-08-005.

Appendix A2. Subpart AA – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="4">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="4">No calculation methods identified.</td></tr>
<tr><td rowspan="4">Methods previously considered but not adopted in final GHGRP</td><th>Emission Source</th><th>Data Source</th><th>Method Type[2]</th><th>Description</th></tr>
<tr><td colspan="4">• No alternative calculation methodologies identified for makeup chemicals.
• All other emissions are from combustion sources.
• Emissions from power boilers are based on fossil fuel information and the calculation methodology in subpart C is referenced. No alternative methodologies were reviewed for these sources as they will be covered under the subpart C analysis.
• Subpart AA requires reporting of fossil fuel and biogenic emissions from recovery furnaces and lime kilns. The fossil fuel component of the emissions are calculated using methods in subpart C. Biogenic emissions are not calculated from lime kilns, as the emissions are accounted for in the recovery furnace calculations. Alternative calculation methodologies for the biogenic component in recovery furnaces are presented below.</td></tr>
<tr><td>Recovery furnace</td><td>GHG TSD</td><td>Emission factor</td><td>Method would allow use of default values for HHV for calculating emissions from kraft or soda recovery furnaces instead of site-specific data.
• Has high uncertainty and lower accuracy.
• Still requires black liquor solids federates as an input which was identified as having disclosure concerns in Step 2 of the evaluation.
• Dismissed at proposal because most facilities already analyze for HHV.
• Not applicable to sulfite or stand-alone semi-chemical facilities.</td></tr>
<tr><td>Recovery furnace operations</td><td>WRI/WBCSDI /ICFPA/NCAS I spreadsheet</td><td>Emission factor</td><td>Calculates total GHG emissions from a facility based on total energy of spent liquor combusted on lower heating value basis.
• High uncertainty in emissions.
• Difficult to verify results because no emissions per equipment.</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="4">CARB program refers to Subpart AA for calculations.</td></tr>
</table>

[1] GHG TSD = GHG technical support documents ; WRI/WBCSD = World Resources Institute/World Business Council for Sustainable Development; ICFPA/NCASI = International Council on Forest and Paper Association/National Council for Air and Stream Improvement; CARB = California Air Resources Board.

Appendix A2. Subpart BB – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	IPCC	Tier 1	Output based approach (using production information) and using default CO_2 and CH_4 emission factors from the 2006 IPCC guidelines, and silicon carbide output. Uncertainty estimated to 10%. Requires production as an input to the emissions calculation, which was identified as having disclosure concerns in Step 2 of the evaluation.
	IPCC	Tier 1	Input based approach (using feedstock information) using default CO_2 and CH_4 emission factors from the 2006 IPCC guidelines, and petroleum coke input. Uncertainty estimated to be 10% and still requires same inputs as current method, which was identified as having disclosure concerns in Step 2 of the evaluation.
Protocols and programs created after GHGRP	None identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006.

Appendix A2. Subpart CC – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	IPCC	Tier 2D	Use default factors. Slight decrease in accuracy, but quantity of trona used or soda ash produced is still an input, which were identified as having disclosure concerns in Step 2 of the evaluation.
	IPCC	Tier 2S	Uses an annual site-specific emission factor to estimate emissions. Annual stack test information may not capture variability in emissions associated with consumption of various fuels. Still requires quantity of trona used or soda ash produced as an input, which were identified as having disclosure concerns in Step 2 of the evaluation.
Protocols and programs created after GHGRP	None identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006.

Appendix A2. Subpart EE – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source[1]**	**ID**	**Description**
	IPCC	Tier 1	Uses default emission factor and production information, which was identified as having disclosure concerns in Step 2 of the evaluation. Uncertainty is estimated to be 15%.
	ANMGGRP		Uses default energy content and 2 default emission factors in combination with the total tonnage of the carbon reducing agent. Higher emissions uncertainty because default factors are used.
Protocols and programs created after GHGRP	None identified.		

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; ANMGGRP = Australian National Mandatory Greenhouse Gas Reporting Program.

Appendix A2. Subpart GG – Evaluation of Alternative Calculation Equations

<table>
<tr><th>Alternative</th><th colspan="3">Analysis</th></tr>
<tr><td>Methods in the Call for Information</td><td colspan="3">None identified.</td></tr>
<tr><td rowspan="6">Methods previously considered but not adopted in final GHGRP</td><th>Source[1]</th><th>ID</th><th>Description</th></tr>
<tr><td>IPCC</td><td>Tier 1</td><td>Uses default emission factor per unit of output and national productivity data. Has a high uncertainty. More appropriate for aggregated process information on a sector-wide or nationwide basis. If applied on a facility basis, would require production data which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>IPCC</td><td>Tier 1a</td><td>Same as Tier 1, but uses default emission factor specific to production processes. Better uncertainty, but still more appropriate for sector-wide or nationwide basis. If applied on a facility basis, would require production data which was identified as having disclosure concerns in Step 2 of the evaluation.</td></tr>
<tr><td>IPCC</td><td>Tier 2</td><td>Similar to Tier 1, but accounts for reducing agents, furnaces, and other process materials that affect emissions using emission factors based on aggregated plant statistics. More accurate than Tier 1 but would require production data which was identified as having disclosure concerns in Step 2 of the evaluation. Uncertainty is estimated to be 15%.</td></tr>
<tr><td>U.S. Inv</td><td></td><td>Uses default emission factors. High uncertainty in emission estimates. More appropriate for aggregated process information on a sector-wide or nationwide basis.</td></tr>
<tr><td>ANGGRP</td><td></td><td>Estimated based on the quantity of each carbon reductant used in production, the energy content of the reduction and a default fuel emission factor. The basic method has a high uncertainty in results.</td></tr>
<tr><td>Protocols and programs created after GHGRP</td><td colspan="3">None identified.</td></tr>
</table>

[1] IPCC = Intergovernmental Panel on Climate Change, 2006; U.S. Inv = U.S. National Inventory Report, 2008 Method; ANGGRP = Australian National Government Greenhouse and Energy Reporting Program.

Appendix A2. Subpart TT – Evaluation of Alternative Calculation Equations

Alternative	Analysis		
Methods in the Call for Information	None identified.		
Methods previously considered but not adopted in final GHGRP	**Source**[1]	**ID**	**Description**
	U.S. Inv		Reporters use the existing part 98 CH_4 calculation methodology. Higher uncertainty in emissions than the current method due to default factor. Still requires reporting of "inputs to equations" data elements that were identified as having disclosure concerns in Step 2 of the evaluation.
Protocols and programs created after GHGRP	None identified.		

[1] U.S. Inv = U.S. National Inventory Report 2008 Method (U.S. Inventory of Greenhouse Gas Emissions and Sinks 1990-2006).

Appendix B

Summary of CEMS Characterization for Each Subpart with "Inputs to Equations" Data Elements

Appendix B. General Stationary Fuel Combustion Sources – Subpart C

Industry Background

Stationary fuel combustion comprises many sources, including boilers, heaters, engines, furnaces, kilns, ovens, flares, incinerators, dryers, and any other equipment or machinery that burns fuel. From two regulatory databases, counts for certain sources are available: there are 14,142 industrial, commercial, and institutional boilers and 55 CISWI units. Based on 2011 annual report submissions, there were 1,985 facilities that reported to GHGRP under subpart C.

Under subpart C, sources must provide emission estimates for CO_2, CH_4, and N_2O for each combustion unit. Emissions must be reported separately for each type of fuel combusted. Sources may use emission factors, annual fuel usage data, and in some subparts use CEMS to calculate emissions.

Applicable NSPS and NESHAP for Combustion Sources

Table C-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart DDDDD - Boiler MACT	PM CEMS	Yes	Yes
Subpart Db - Boiler NSPS	PM, NO_X, SO_2 CEMS	Yes	Yes
Subparts CCCC and DDDD - CISWI NSPS and Emissions Guidelines	PM, NO_X, SO_2 CEMS	Yes	Yes

As shown in Table C-1, multiple CEMS are required for boilers and incinerators. The installation of this equipment is directly relatable to the installation of a GHG CEMS; all major equipment would already be installed and only the GHG CEMS analyzer would be necessary.

Summary of Available Data on Facilities Reporting the Use of CEMS

Non-GHG CEMS data for subpart C facilities were available in two databases compiled for rulemaking purposes - the Boiler MACT database and CISWI database. These databases showed what CEMS were installed at the unit level. This included CEMS for PM, CO, NO_X, and SO_2. Table C-2 provides the total number of units which have at least one CEMS installed. In addition, with new requirements in the Boiler MACT, there are an additional 95 units which would install a CEMS; this value is also shown in Table C-2. There were 177 facilities that reported under the GHGRP using a total of 311 CO_2 CEMS.

Table C-2. CEMS Data from GHGRP and Regulatory databases

Boiler MACT	Boiler MACT	CISWI NSPS	GHGRP
Total Boiler Count/Count of Boilers with non-GHG CEMS	Count of Additional Boilers Installing non-GHG CEMS to Comply	Total Incinerator Count/Count of Incinerators with non-GHG CEMS	Count of Facilities with CO_2 CEMS/Total Count of CO_2 CEMS
14,142/1025	95	55/31	177/311

Subpart C CEMS Count

Table C-3 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The potential count for non-GHG CEMS is based on the 95 facilities which would install CEMS after finalization of the Boiler MACT.

Table C-3. Subpart C CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[c]
Facilities	177[a]	0	-	-
Units	311[b]	0	1,056	1,151

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.

[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.

[c]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Adipic Acid Production – Subpart E

Industry Background

Based on 2011 annual report submissions, there were 3 facilities that reported to GHGRP under subpart E.

Under subpart E, facilities estimate N_2O process emissions from all adipic acid production units combined. For N_2O emissions, facilities may either use a site-specific emission factor applied to the annual adipic acid production, or directly measure the emissions using an EPA-approved alternative method to the site-specific emission factor.

Applicable NSPS and NESHAP for Adipic Acid Plants

Table E-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart NNN—NSPS for VOC Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Operations	If facility complies with TRE limit (>1 and not using VOC control device) and have an absorber, condenser, or carbon adsorber then organic monitoring is option	Yes	No
Subpart RRR—NSPS for VOC Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Reactor Processes	If facility complies with TRE limit (>1 and not using VOC control device) and have an absorber, condenser, or carbon adsorber then organic monitoring is option	Yes	No

The relevant monitoring from both the NESHAP and NSPS is organic monitoring. An organic monitoring device is used to indicate the concentration level of organic compounds exiting the recovery device based on a detection principle such as infra-red, photoionization, or thermal conductivity and each is equipped with a continuous recorder. Although the organic monitoring would have CEMS related equipment installed, it is only an option and is dependent on the method of compliance and control device; it is unlikely that facilities will use this method of compliance due to cost, and would likely use other options instead (e.g., temperature monitoring). Due to the amount of unknown variables, for this analysis it was assumed that no equipment is installed which would facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP. Subpart E facilities may also use an N_2O CEMS alternative monitoring option provided approval is granted.

Subpart E CEMS Count

Table E-2 summarizes the actual data collected for facilities using N_2O CEMS and non-GHG CEMS. No facilities were identified with pre-existing N_2O CEMS and CO_2 CEMS are not required for this subpart. No assumption could be made for a potential count based on lack of information on control devices.

Table E-2. Subpart E CEMS Counts

Basis	CO_2 CEMS for the GHGRP	Reporting non-CO_2 GHG CEMS for the GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.
[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Aluminum Production – Subpart F

Industry Background

Based on 2011 annual report submissions, there were 10 facilities that reported to GHGRP under subpart F.

Under subpart F, facilities estimate CF_4 and C_2F_6 process emissions from anode effects in all prebake and Søderberg electrolysis cells combined. Facilities also estimate CO_2 emissions from anode consumption and on-site anode baking. For CF_4 emissions, facilities must calculate the emissions using a mass balance approach. Emissions of C_2F_6 must be calculated from the CF_4 emissions using a tested ratio of C_2F_6 to CF_4 production. For CO_2 emissions, facilities may either use a mass balance approach for separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Aluminum Plants

Table F-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart S—NSPS for Primary Aluminum Reduction Plants	(No relevant monitoring requirements)	No	No
Subpart LL—NESHAP for Primary Aluminum Reduction Plants	(No relevant monitoring requirements)	No	No

The applicable NESHAP and NSPS for this subpart do not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

No data on CEMS usage in other EPA programs that would be applicable to subpart F facilities were available. A majority of the control devices used to comply with the NESHAP are scrubbers which do not typically require monitoring relevant to CEMS. No facilities reported the use of CEMS to the GHGRP

Subpart F CEMS Count

Table F-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CEMS. No assumption could be made for a potential count based on lack of information on control devices.

Table F-2. Subpart F CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.

[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Ammonia Manufacturing – Subpart G

Industry Background

Based on 2011 annual report submissions, there were 22 facilities that reported to GHGRP under subpart G.

Under subpart G, facilities estimate CO_2 process emissions from each ammonia manufacturing unit, and CO_2 emissions collected and either used on-site or transferred off-site following the requirements of subpart PP (CO_2 suppliers). For estimating CO_2 process emissions, facilities may either use a mass balance approach or use a CEMS.

Applicable NSPS and NESHAP for Ammonia Manufacturers

There is no NSPS or NESHAP specifically applicable to ammonia manufacturers.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.
Subpart G CEMS Count

Table G-1 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table G-1. Subpart G CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.
[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Cement Production – Subpart H

Industry Background

The Portland Cement Association's 2004 plant level summary included 107 integrated cement plants that house both kilns for producing clinker and mills for grinding cement from clinker. This latter number excludes plants that only grind clinker and do not have kilns. The 'Summary of Environmental and Cost Impacts for Final Portland Cement NESHAP and NSPS' (August 6, 2010) estimates there are 100 plants with 140 kilns. Based on 2011 annual report submissions, there were 96 facilities that reported to GHGRP under subpart H. These counts are used for the total facility and total unit counts (96 plants with 140 kilns).

Under subpart H, facilities estimate CO_2 process emissions from calcination in each kiln and CO_2 combustion emissions from each kiln. They are also required to estimate and report CH_4 and N_2O combustion emissions from each kiln. For CO_2 emissions, facilities may either use a mass balance approach for separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Cement Plants

Table H-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart LLL—NESHAP for the Portland Cement Manufacturing Industry[a]	Hg CEMS, PM CEMS, THC CEMS; HCl CEMS if not using a scrubber; Flow rate monitor if using a PM or Hg CEMS.	Yes	No
Subpart EEE—NESHAP for Hazardous Waste Combustors (applies to both major and area sources)	CO CEMS or THC CEMS, both using an O_2 CEMS to correct to constant O_2.	Yes	No
Subpart F—NSPS for Portland Cement Plants	PM CEMS, NO_X CEMS, SO_2 CEMS, including flow a rate monitor to determine mass emission rates. (CEMS requirements apply only to kilns constructed, reconstructed, or modified after 2008)	Yes	No

[a] Applies to each kiln including alkali bypasses at all major and area sources, except for kilns that burn hazardous waste and are subject to and regulated under 40 CFR 63, subpart EEE.

Summary of Available GHGRP and Other Data on Facilities Reporting the Use of CEMS

Table H-2. CEMS Data from Databases

GHGRP	Cement NSPS Database
Count of Facilities with CO_2 CEMS/Total Count of CO_2 CEMS	**Total Kiln Count/Count of Kilns with CEMS; Total Facility Count/Count of Facilities with non-CO_2 CEMS**
82/112	121/50; 64/36

- The cement NSPS database only provides CEMS counts for SO_2, NO_X, and THC CEMS, while data on Hg, PM, and HCl CEMS were not provided. As such, the count from the cement database is a low estimate.
- In comparison to the cement database, the GHGRP database contains an additional 46 facilities with CEMS data.
- From the 'Summary of Environmental and Cost Impacts for Final Portland Cement NESHAP and NSPS' (August 6, 2010) there are 100 plants with 140 kilns.
- The data from GHGRP and the cement database are combined for the recommended CEMS count to provide both a facility and unit level estimate.
- Since Hg, PM, and THC CEMS are applicable according to the NESHAP, although documentation for this is not available, we also assumed that all kilns have CEMS for a potential estimate.

Subpart H CEMS Count

Table H-3 summarizes the actual data collected for facilities and units using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements.

Table H-3. Subpart H Facility and Unit CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[f]
Facilities	82[a]	0[c]	0[c]	14[d]
Units	112[b]	0[c]	0[c]	28[e]

NA = No estimate is available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.

[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.

[c] No units or facilities are known to be using non-CO_2 GHG CEMS (e.g., for CH_4 or N_2O).

[d] Based on assuming that all kilns will have a non-GHG CEMS to comply with the NESHAP, and using 96 as the number of operating plants, minus the 82 that reported to GHGRP that they are using GHG CEMS.

[e] Based on assuming that all kilns will have a non-GHG CEMS to comply with the NESHAP, and using the estimated number of units (140) in the "Summary of Environmental and Cost Impacts for Final Portland Cement NESHAP and NSPS" (August 6, 2010), minus the 112 that reported to GHGRP that they are using GHG CEMS.

[f] Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Ferroalloy Production – Subpart K

Industry Background

Based on 2011 annual report submissions, there were 10 facilities that reported to GHGRP under subpart K.

Under subpart K, facilities estimate CO_2 process emissions from each electric arc furnace that is used for any type of ferroalloy production. Facilities also estimate CH_4 emissions from each electric arc furnace that is used for the production of silicon metal or ferrosilicon (65%, 75%, or 90%). For estimating CO_2 process emissions, facilities may either use a mass balance approach or use a CEMS. Emissions of CH_4 must be estimated by multiplying the annual production of silicon metal or ferrosilicon and applying an applicable emission factor provided in the subpart.

Applicable NSPS and NESHAP for Ferroalloy Plants

Table K-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart Z—NSPS for Ferroalloy Production Facilities	To ensure furnace hood capture efficiency, sources must monitor volumetric flow rate in ducts from furnace hoods	No	No
Subpart XXX—NESHAP for Ferroalloys Production: Ferromanganese and Silicomanganese	If a source has a venturi scrubber, the source has the option of monitoring the flow rate through each separately ducted hood or at the inlet to the control device	No	No
Subpart YYYYYY—NESHAP for Area Sources: Ferroalloys Production Facilities	(No relevant monitoring requirements)	No	No

While monitoring of flow rate is required, the location of the flow monitors is not appropriate for monitoring flow as it relates to CEMS. For this analysis it was assumed that no equipment is installed which would facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.
Subpart K CEMS Count

Table K-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CEMS. No assumption could be made for a potential count based on lack of information on control devices.

Table K-2. Subpart K CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.

[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Fluorinated Gas Production – Subpart L

Industry Background

Based on 2011 annual report submissions, there were 16 facilities that reported to GHGRP under subpart L.

Under subpart L, facilities estimate emissions of HFCs, PFCs, SF_6, NF_3, and HFEs from each fluorinated gas production process and all fluorinated gas production processes combined, each fluorinated gas transformation process that is not a part of a fluorinated gas production process, each fluorinated GHG destruction process that is not a part of a fluorinated gas production process, and venting of residual fluorinated GHGs from contains returned to the field. For estimating fluorinated GHG emissions, facilities must use either a mass balance approach or an emission factor or emission calculator factor approach.

Applicable NSPS and NESHAP for Fluorinated Gas Production Plants

Table L-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart FFFF—NESHAP for Miscellaneous Organic Chemical Manufacturing	CEMS is option; CPMS required dependent on control device	Yes	No

Subpart L facilities may have CEMS installed to monitor HF emissions. However, this is only an alternative and no data were provided to determine how many (if any) would comply using this method. Since more economical options are available it is not anticipated any facilities would comply using CEMS. In addition, CPMS requirements would not be applicable to installation of CEMS equipment (e.g., CPMS includes monitoring temperature or liquid flow rate).

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP. From the response to comments document for Subpart L proposal, there was a specific request for allowance of CEMS to monitor fluorinated gases. The commenter stated that FTIR CEMS were a mature technology and were currently used in the fluorinated gas manufacturing industry. Specific discussion on current installations was provided with discussion on how all equipment was able to withstand the corrosive environment. The commenter stated that five FTIR CEMS were installed at this facility. Note that discussion on CEMS installations was specific to a particular facility; the commenter did not imply that all facilities used CEMS. In the EPA’s response it was noted that CEMS would not be required partly due to the unknown costs.

Subpart L CEMS Count

Table L-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. Based on the public comment, one facility was identified as having a CEMS installed to measure fluorinated gases. No other data on CEMS installations were available.

Table L-2. Subpart L CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	1[b]	NA	NA
Units	0	5[b]	NA	NA

NA = No information available.

[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.
[b]Counts based on response to subpart L comments, not on data reported to GHGRP. See discussion on previous page.

Appendix B. Glass Production – Subpart N

Industry Background

Based on 2011 annual report submissions, there were 110 facilities that reported to GHGRP under subpart N.

Under subpart N, facilities estimate CO_2 process emissions from each continuous glass melting furnace and CO_2 combustion emissions from each continuous glass melting furnace. They are also required to estimate and report CH_4 and N_2O combustion emissions from each continuous glass melting furnace. For CO_2 emissions, facilities may either use a mass balance approach for separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Glass Plants

Table N-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart CC—NSPS for Glass Manufacturing Plants	(No relevant monitoring requirements)	No	No
Subpart PPP—NSPS for Wool Fiberglass Insulation Manufacturing Plants	(No relevant monitoring requirements)	No	No
Subpart NNN—NESHAP for Wool Fiberglass Manufacturing	(No relevant monitoring requirements)	No	No
Subpart HHHH—NESHAP for Wet-Formed Fiberglass Mat Production	(No relevant monitoring requirements)	No	No
Subpart SSSSSS—NESHAP for Glass Manufacturing Area Sources	(No relevant monitoring requirements)	No	No
Subpart N—National Emission Standard for Inorganic Arsenic Emissions From Glass Manufacturing Plants	(No relevant monitoring requirements)	No	No

The applicable NESHAP and NSPS for this subpart do not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

There were three facilities which reported CO_2 CEMS in GHGRP and each only reported one CEMS.

Subpart N CEMS Count

Table N-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The only source with data regarding CEMS installations was the CO_2 CEMS counts from GHGRP. No assumption could be made for a potential count based on rule requirements.

Table N-2. Subpart N CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[c]
Facilities	3[a]	0	NA	NA
Units	3[b]	0	NA	NA

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.
[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.
[c]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. HCFC-22 Production and HFC-23 Destruction Plants – Subpart O

Industry Background

Based on 2011 annual report submissions, there were 5 facilities that reported to GHGRP under subpart O.

Under subpart O, facilities estimate HFC-23 process emissions from all HCFC-22 production processes and HFC-23 destruction processes at the facility. For estimating HFC-23 process emissions, facilities must use a mass balance approach for all HCFC-22 production processes and HFC-23 destruction processes.

Applicable NSPS and NESHAP for HCFC-22 Production and HFC-23 Destruction Plants

Table O-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart FFFF—NESHAP for Miscellaneous Organic Chemical Manufacturing	CEMS is option; CPMS required dependent on control device	Yes	No

Subpart O facilities may have CEMS installed to monitor HF emissions. However, this is only an alternative and no data were provided to determine how many (if any) would comply using this method. Since more economical options are available it is not anticipated any facilities would comply using CEMS. In addition, CPMS requirements would not be applicable to installation of CEMS equipment (e.g., CPMS includes monitoring temperature for thermal oxidizers which was a control device specifically mentioned in subpart O rule language).

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP. Of note, subpart L facilities specifically requested the use of CEMS to measure fluorinated gases. However, a similar request was not made for subpart O. Since FTIR CEMS were shown to measure fluorinated gases in the Subpart L comments, it may also be feasible for subpart O. The ability of the CEMS to directly measure HFC-23 was not discussed and as such its applicability to subpart O is unknown.

Subpart O CEMS Count

Table O-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CEMS. No assumption could be made for a potential count based on lack of information.

Table O-2. Subpart O CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.

[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Hydrogen Production – Subpart P

Industry Background

Based on 2011 annual report submissions, there were 103 facilities that reported to GHGRP under subpart P.

Under subpart P, facilities estimate CO_2 process and combustion emissions from each hydrogen production unit. CO_2 collected and either used on site or transferred off site must also be estimated. Facilities also estimate CH_4 and N_2O combustion emissions from each hydrogen production unit. For CO_2 emissions, facilities may either use a mass balance approach for separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Hydrogen Production Plants

Table P-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart CC—NESHAP for Petroleum Refineries	(No relevant monitoring requirements)	No	No

The applicable NESHAP for this subpart does not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

There were three facilities which reported CO_2 CEMS in GHGRP and each reported only one CEMS.

Subpart P CEMS Count

Table P-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The only source with data regarding CEMS installations was the CO_2 CEMS counts from GHGRP. No assumption could be made for a potential count based on rule requirements.

Table P-2. Subpart P CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[c]
Facilities	3[a]	0	NA	NA
Units	3[b]	0	NA	NA

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.
[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.
[c]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Iron and Steel Production – Subpart Q

Industry Background

The iron and steel production source category under subpart Q consists of facilities with any of the following processes:

- Taconite iron ore processing.
- Integrated iron and steel manufacturing (production of steel from iron ore or iron ore pellets).
- Coke making not co-located with an integrated iron and steel manufacturing process.
- Electric arc furnace (EAF) steelmaking not co-located with an integrated iron and steel manufacturing process.

Under subpart Q, process CO_2 emissions are estimated from the following processes at an iron and steel facility:

- Taconite indurating furnaces
- Basic oxygen process furnaces (BOPF)
- Non-recovery coke oven batteries
- Sintering process
- Electric arc furnaces (EAF)
- Argon-oxygen decarburization (AOD) vessels
- Direct reduction ironmaking (DRI) furnaces

Facilities are required to determine process CO_2 emissions using either a carbon mass balance method, a site-specific emission factor, or by a CO_2 CEMS that meets the Tier 4 calculation methodology requirements of subpart C. Facilities are not required to determine CH_4, N_2O or other process GHG emissions from the sources subject to subpart Q. For other stationary combustion units located at iron and steel facilities, the facility must estimate and report GHG emissions under subpart C.

Based on 2011 annual report submissions, there were 128 facilities that reported to GHGRP under subpart Q.

Applicable NSPS and NESHAP for Iron and Steel Facilities

The NSPS and NESHAP were reviewed that are applicable to the processes for which GHG emissions must be determined under subpart Q. We evaluated whether complying with the monitoring requirements in those rules would require the use of a non-GHG or GHG CEMS that could be used to estimate GHG emissions, or that would require associated equipment, such as flow meters, that would facilitate and reduce the cost of using a GHG CEMS to comply with subpart Q. The results of that analysis are summarized in Table Q-1.

Table Q-1. Summary of NSPS and NESHAP Monitoring Requirements Applicable to Subpart Q Processes and Facilities

Iron and Steel Process Category	Applicable NSPS or NESHAP	Relevant Monitoring Required by the NSPS or NESHAP	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NSPS or NESHAP?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Taconite indurating furnaces	40 CFR 63, subpart RRRRR (major sources)	(No relevant monitoring requirements)	No	No
Basic oxygen process furnaces	40 CFR 63, subpart FFFFF[a] (major sources)	To ensure furnace hood capture efficiency, sources have the option to monitor volumetric flow rate in ducts from furnace hoods or at the inlet to the control device; or to monitor system fan amperes and damper position.	Some facilities may monitor flow rate, but the flow rate monitors probably would not meet the specifications for a CEMS flow monitor.	No
Non-recovery coke oven batteries	40 CFR 63, subpart L (area and major sources)	(No relevant monitoring requirements)	No	No
	40 CFR 63, subpart CCCCC (major sources)	Pushing operations capture hoods: monitor volumetric flow rate at inlet to control, monitor system fan amperes, or monitor static pressure in capture device.	Some facilities may monitor flow rate, but the flow rate monitors probably would not meet the specifications for a CEMS flow monitor.	No
Sintering process	40 CFR 63, subpart FFFFF[a] (major sources)	To ensure furnace hood capture efficiency, sources have the option to monitor volumetric flow rate in ducts from furnace hoods or at the inlet to the control device; or to monitor system fan amperes and damper position.	Some facilities may monitor flow rate, but the flow rate monitors probably would not meet the specifications for a CEMS flow monitor.	No
Electric arc furnaces (EAF)	40 CFR 60, subparts AA and AAa	To ensure EAF furnace hood capture efficiency, sources have the option to monitor volumetric flow rate in ducts from furnace hoods or at the inlet to the control device; or to monitor system fan amperes and damper position. Flow rate monitors only need to have ±10% accuracy and may be calibrated according to manufacturer's specifications.	Flow monitors specified by AA and AAa probably would not meet the specifications for a CEMS flow monitor.	No
	40 CFR 63, subpart YYYYY (area sources)	(No relevant monitoring requirements)	No	No
Argon-oxygen decarburization vessels	40 CFR 60, subpart AAa	To ensure hood capture efficiency, sources have the option to monitor volumetric flow rate in ducts from furnace hoods or at the inlet to the control device; or to monitor system fan amperes and damper position.	Flow monitors specified by AAa probably would not meet the specifications for a CEMS flow monitor.	No

		Flow rate monitors only need to have ±10% accuracy and may be calibrated according to manufacturer's specifications.		
	40 CFR 63, subpart YYYYY (area sources)	(No relevant monitoring requirements)	No	No
Direct reduction furnaces	No applicable NSPS or NESHAP were identified			

[a] 40 CFR 63, subpart FFFFF also regulates emissions from steel making blast furnaces, but these are not included in the processes in 40 CFR part 98, subpart Q. Subpart Q includes blast furnaces among the units that produce GHG emissions only from fuel combustion and not from raw materials. Therefore, GHG emissions would be estimated under subpart C and not under subpart Q.

None of the applicable NSPS or NESHAP required the use of monitoring equipment that could be used as a GHG CEMS, or that would facilitate the use of GHG CEMS. As shown in Table Q-2, some of the rules included an option to monitor volumetric flow rates in ducts to ensure that a sufficient volume of air is being drawn into furnace hoods to maintain good capture efficiency. These same rules also included an option to monitor system fan amperes and damper position as an alternative to flow rate. It is not known if the flow rate monitors used to comply would meet the performance specifications needed for a flow rate monitor used as part of a GHG CEMS, either based on location or on the accuracy and calibration requirements. Furthermore, the applicable rules do not specify that the flow rate monitors meet any applicable EPA performance specification, such as EPA Performance Specification 6 for flow rate, or be calibrated against an EPA stack testing reference method. Therefore, we could assume that these rules do not establish monitoring requirements that would facilitate the use of CEMS to determine GHG emissions.

Summary of Available GHGRP Data on Facilities Reporting the Use of CEMS

A total of 11 subpart Q facilities have reported to GHGRP as using a CO_2 CEMS with a total of 14 CEMS. These 11 facilities are owned by two companies; two facilities are owned by ArcelorMittal and nine by Nucor.

- One of the ArcellorMittal facilities (Indiana) is an integrated steel facility, and the other (Pennsylvania) is an EAF facility, based on online company information.
- The nine facilities owned by Nucor all appear to be EAF facilities, based on online company information.
- The non-CBI information provided by the EPA from GHGRP does not indicate which process units at each facility are using a CEMS to determine GHG emissions, or the number of units.
- We assume that the majority of process units with CEMS are EAFs or AODs, because these are the only units present at EAF facilities for which GHG emissions must be determined under subpart Q.
- We do not know which units at the ArcellorMittal facility are using a CEMS.

Subpart Q CEMS Count

Table Q-2 summarizes the actual data collected for facilities and units using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements and using the background information.

Table Q-2. Subpart Q CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[c]
Facilities	11[a]	0	NA	NA
Units	14[b]	0	NA	NA

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.
[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.
[c]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Lead Production – Subpart R

Industry Background

Based on 2011 annual report submissions, there were 13 facilities that reported to GHGRP under subpart R.

Under subpart R, facilities estimate CO_2 process emissions from each smelting furnace and CO_2 combustion emissions from each smelting furnace. They are also required to estimate and report CH_4 and N_2O combustion emissions from each smelting furnace. For CO_2 emissions, facilities may either use a mass balance approach for separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Lead Plants

Table R-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart L—NSPS for Secondary Lead Smelters	(No relevant monitoring requirements)	No	No
Subpart R—NSPS for Primary Lead Smelters	SO_2 CEMS required for all primary lead smelters	Yes	No
Subpart X—NESHAP from Secondary Lead Smelting	(No relevant monitoring requirements)	No	No
Subpart TTT—NESHAP for Primary Lead Smelting	Sources must monitor volumetric flow rate through each separately ducted hood or at the inlet to the control device	Yes	No

The NSPS and NESHAP for secondary lead smelters do not contain any relevant monitoring requirements. The NSPS for primary lead smelters requires SO_2 monitoring, but applies only to primary lead smelters constructed after October 16, 1974. There have been no lead smelters constructed since 1974. Specifics of the one primary lead smelter in the United States are not known, and thus we are not certain if the facility operates an SO_2 CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.

Subpart R CEMS Count

Table R-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table R-2. Subpart R CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.

[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Lime Manufacturing – Subpart S

Industry Background

Based on 2011 annual report submissions, there were 73 facilities that reported to GHGRP under subpart S.

Under subpart S, facilities estimate CO_2 process emissions from each lime kiln and CO_2 combustion emissions from each lime kiln. They are also required to estimate and report CH_4 and N_2O combustion emissions from each lime kiln. For CO_2 emissions, facilities may either use a mass balance approach for separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Lime Plants

Table S-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart HH—NSPS for Lime Manufacturing Plants	(No relevant monitoring requirements)	No	No
Subpart AAAAA—NESHAP for Lime Manufacturing Plants	(No relevant monitoring requirements)	No	No

The applicable NESHAP and NSPS for this subpart do not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

One facility was reported to use CO2 CEMS in the 2011 GHGRP. The RIA for part 98 identified that all facilities would meet the Tier 4 criteria to install CEMS. Therefore, the remaining 72 facilities are assumed to meet Tier 4 criteria.

Subpart S CEMS Count

Table S-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements and using the background information.

Table S-2. Subpart S CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for	Reporting non-GHG CEMS for Other EPA Programs

		GHGRP	Actual	Potential[b]
Facilities	1[a]	0	NA	72
Units	0	0	NA	NA

NA = No information available.

[a] Number of facilities that reported to GHGRP in 2011 that they were using a CEMS to report CO_2 emissions.

[b]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Miscellaneous Uses of Carbonates Facilities – Subpart U

Industry Background

Based on 2011 annual report submissions, there were 18 facilities that reported to GHGRP under subpart U.

Under subpart U, facilities estimate CO_2 process emissions for all miscellaneous carbonate use at the facility. For estimating CO_2 process emissions, facilities must use a mass balance approach.

Applicable NSPS and NESHAP for the Miscellaneous Use of Carbonates

There is no NSPS or NESHAP specifically applicable to miscellaneous use of carbonates.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.
Subpart U CEMS Count

Table U-1 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table U-1. Subpart UCEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.
[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Nitric Acid Production – Subpart V

Industry Background

In the TSD for subpart V, the EPA estimated that 45 nitric acid production plants with a total of 65 production units were operating in the United States, based on the *1990-2006 Inventory of U.S. Greenhouse Gas Emissions and Sinks*. These 45 plants are spread across 25 states, and 18 of the plants qualify as small businesses. Based on 2011 annual report submissions, there were 36 facilities that reported to GHGRP under subpart V.

Under subpart V, facilities estimate N_2O process emissions from each nitric acid train. For N_2O emissions, facilities may either use a mass balance and emission factor approach, or use a CEMS to directly measure process emissions.

Applicable NSPS and NESHAP for Nitric Acid Plants

Table V-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart G—Standards of Performance for Nitric Acid Plants	NO_X CEMS required for units constructed or modified after August 17, 1971	Yes	No

Each emission point for nitric acid production shall install NO_X CEMS if constructed or modified after 1971; no alternatives are provided.

Summary of Available Data on Facilities Reporting the Use of CEMS

Table V-2. Available CEMS Data

1990-2006 Inventory of U.S. GHG Emissions and Sinks (from TSD)
Total Unit Count/Count of Units with NOx CEMS; Total Facility Count/Count of Facilities with NOx CEMS
65/36; 45/20

As shown in the TSD to subpart V, several facilities have NO_X CEMS installed. Of the 45 nitric acid production plants, 20 nitric acid production plants employ CEMS for NO_X emissions. At these 20 nitric acid plants there are 36 processes which have NO_X CEMS; this is approximately 58 percent of the total processes. It is presumed that the processes which do not have NO_X CEMS installed were built prior to 1971. No facilities reported the use of CEMS to the GHGRP.

Subpart V CEMS Count

Table V-3 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements and using the background information.

Table V-3. Subpart V CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[b]
Facilities	0	0	20 [a]	NA
Units	0	0	36[a]	NA

NA = No information available.

[a] Based on data reported as a part of the *1990-2006 Inventory of U.S. Greenhouse Gas Emissions and Sinks*, which is shown in the TSD to subpart V. A potential estimate was not generated since the inventory data were reported by the facility and presumed to be the actual count of units with NO_X CEMS.

[b]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Petrochemical Production – Subpart X

Industry Background

The petrochemical production subcategory consists of each process that produces:

- Acrylonitrile
- Carbon black
- Ethylene
- Ethylene Dichloride
- Ethylene Oxide
- Methanol

Each petrochemical facility must report CO_2 process emissions and CO_2, CH_4, and N_2O emissions generated by combustion of process off-gas in stationary combustion units and flares. GHG estimates are also necessary for CO_2, CH_4, and N_2O emissions from burning supplemental fuel in stationary combustion units that also burn process off-gas. If Tier 4 criteria are met then CO_2 emissions must be estimated by CEMS, otherwise the mass balance method is required. For CH_4 and N_2O the emission factor method is used. For ethylene processes only CO_2 emissions may be estimated using Tier 3 or Tier 4 for combustion of process off-gas.

Based on 2011 annual report submissions, there were 64 facilities that reported to GHGRP under subpart X.

Applicable NSPS and NESHAP for Petrochemical Plants and Facility Counts

Table X-1 shows the applicable NESHAP and NSPS for each facility type. Table X-2 shows the monitoring required by each of the NESHAP and NSPS and whether this monitoring is relevant to installing GHG CEMS.

Table X-1. Applicable NESHAP/NSPS to Petrochemical Facilities for Subpart X

Petrochemical	Number of facilities	Applicable NESHAP/NSPS	
		NESHAP	NSPS
Acrylonitrile	5	Subparts F, G	Subparts III, NNN, RRR
Carbon Black	21	Subpart YY	
Ethylene	39	Subpart YY	Subparts NNN, RRR
Ethylene Dichloride	16	Subparts F, G	Subparts III, NNN, RRR
Ethylene Oxide	12	Subparts F, G	Subparts III, NNN, RRR
Methanol	5	Subparts F, G	Subparts III, NNN, RRR

Table X-2. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
(HON) Subpart F—NESHAP From the Synthetic Organic Chemical Manufacturing Industry Subpart G—NESHAP From the Synthetic Organic Chemical Manufacturing Industry for Process Vents, Storage Vessels, Transfer Operations, and Wastewater	Organic monitoring is an option if a recovery device is installed for process vents with a TRE index value greater than 1.0	Yes	No
Subpart YY—NESHAP for Source Categories: Generic Maximum Achievable Control Technology Standards	No relevant monitoring	No	No
Subpart III—NSPS for Volatile Organic Compound (VOC) Emissions From the Synthetic Organic Chemical Manufacturing Industry (SOCMI) Air Oxidation Unit Processes	If facility complies with TRE limit (>1 and not using VOC control device) and have an absorber, condenser, or carbon adsorber then organic monitoring is option	Yes	No
Subpart NNN—NSPS for Volatile Organic Compound (VOC) Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Operations	If facility complies with TRE limit (>1 and not using VOC control device) and have an absorber, condenser, or carbon adsorber then organic monitoring is option	Yes	No
Subpart RRR—NSPS for Volatile Organic Compound Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Reactor Processes	If facility complies with TRE limit (>1 and not using VOC control device) and have an absorber, condenser, or carbon adsorber then organic monitoring is option	Yes	No

The relevant monitoring from both the NESHAP and NSPS is organic monitoring. An organic monitoring device is used to indicate the concentration level of organic compounds exiting the recovery device based on a detection principle such as infra-red, photoionization, or thermal conductivity and each is equipped with a continuous recorder. Although the organic monitoring would have CEMS related equipment installed, it is only an option and is dependent on the method of compliance and control device; it is unlikely that facilities will use this method of compliance due to cost, and would likely use other options instead (e.g., temperature monitoring). Due to the amount of unknown variables, for this analysis it was assumed that no equipment is installed which would facilitate the installation of GHG CEMS.

Summary of Available GHGRP Data on Facilities Reporting the Use of CEMS

There were two facilities which reported CO_2 CEMS in GHGRP and each only reported one CEMS. The products at these two petrochemical facilities were not identified.

Subpart X CEMS Count

Table X-3 summarizes the actual data collected for facilities and units using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The only source with data regarding CEMS installations was the CO_2 CEMS counts from GHGRP. No assumption could be made for a potential count based on rule requirements.

Table X-3. Subpart X CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[c]
Facilities	2[a]	0	NA	NA
Units	2[b]	0	NA	NA

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.
[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.
[c]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Also note that in comments to the GHGRP, commenters stated that for ethylene plants specifically there are no CEMS currently installed.

Appendix B. Petroleum Refineries – Subpart Y

Industry Background

Under subpart Y, petroleum refineries are classified as those which produce gasoline, gasoline blending stocks, naphtha, kerosene, distillate fuel oils, residual fuel oils, lubricants, or asphalt. When reporting their GHG emissions the following processes at each facility must report data for:

- Flares
- Catalytic cracking
- Fluid coking
- Coke calcining
- Delayed coking
- Catalytic reforming
- Sulfur recovery
- Asphalt blowing
- Equipment leaks
- Storage tanks
- Other process vents
- Uncontrolled blowdown systems
- Loading operations
- Stationary combustion

The database developed for the refinery NESHAP contains a total of 148 refineries, excluding the 2 refineries in U.S. territories. Based on 2011 annual report submissions, there were 145 facilities that reported to GHGRP under subpart Y.

Applicable NSPS and NESHAP for Petroleum Refineries, Refinery Database Counts, and GHG Reporting Requirements

Table Y-1 provides a general overview of the NESHAP and NSPS rules applicable to petroleum refineries and the applicable CEMS requirements. Table Y-2 shows the specific CEMS requirements for each applicable refinery process (based on NESHAP/NSPS requirements), and also shows the greenhouse gases which must be reported under subpart Y for each process. Table Y-2 also shows process unit counts based on information in the petroleum refinery NESHAP database. The petroleum refinery database was provided by the EPA/OAQPS. Data detailing how many CEMS are installed were not available in the database, but process unit information was available that correlated with the NESHAP/NSPS rules.

Table Y-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS
Subpart CC—NESHAP for Petroleum Refineries	No relevant monitoring
Subpart UUU—NESHAP for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units	Flow rate, CO CEMS, O_2 monitor
Subpart J—NSPS for Petroleum Refineries	Flow rate, CO CEMS, O_2 monitor, SO_2 monitor

Table Y-2. GHGs Reported for Each Refinery Process, Process Unit Counts, and Monitoring Information from Applicable NESHAP/NSPS Rules

Refinery Process	Greenhouse Gases Which Shall Be Reported For Subpart Y Facilities			Count of Process Units from Refinery NESHAP Database	Is Process Required in NESHAP/NSPS to Have CEMS Monitoring?	Monitoring Requirements per NESHAP/NSPS
	CO_2	CH_4	N_2O			
Flares	Y	Y	Y	439	N	NA
Catalytic Cracking	Y	Y	Y	**130**	Y	CO monitoring if catalytic cracking unit catalyst regenerators were constructed, reconstructed, or modified after 1973. Otherwise monitor O_2, temperature, or operation of flare pilot. Flow monitoring required if modified before 1973 and control device is an ESP.
Fluid Coking	Y	Y	Y	**132**[a]	N	NA
Coke Calcining	Y	Y	Y		N	NA
Delayed Coking	N	Y	N		N	NA
Catalytic Reforming	Y	Y	Y	120	N	NA
Sulfur Recovery	Y	N	N	**187**	Y	SO_2 and O_2 monitors
Asphalt Blowing	Y	Y	N		N	NA
Equipment Leaks	N	Y	N	2593	N	NA
Storage Tanks	N	Y	N	8107	N	NA
Other Process Vents	Y	Y	Y	588	N	NA
Uncontrolled Blowdown Systems	N	Y	N		N	NA
Stationary Combustion	Y	Y	Y	3228	N	NA
Loading Operations	N	Y	N	301	N	NA
Total Count of Process Units				15825		
Count of Process Units With Applicable Monitoring				**317**		
Count of Process Units for CEMS Installation				1,580	Includes fluid coking, coke calcining, catalytic reforming, flares, loading operations, and other process vents	

[a] The refinery database only provides a count for 'coking unit vents'. This count was applied to all processes which refer to coke operations.

The refinery database provided a total facility count of 148 refineries, and contains 317 catalytic cracking and sulfur recovery units. For catalytic cracking processes, CO CEMS are only applicable to catalytic cracking unit catalyst regenerators. Each catalytic cracking process has an associated catalyst regenerator; the value of 130 will be used as a potential estimate. The 130 units are at 88 facilities. 187 sulfur recovery units are in place at 75 facilities; all 187 units must have an SO_2/O_2 monitor associated with it. For CEMS installation cost estimates, a unit count of 1,580 was used and only considers those processes which are relevant to CEMS. For example, a CEMS would not be used to monitor equipment leak emissions.

Summary of Available GHGRP and Boiler Data on Facilities Reporting the Use of CEMS

There were 21 facilities that reported the use of CO_2 CEMS within GHGRP, with a total of 24 CO_2 CEMS. From the boiler MACT database, a total of 2,096 units were reported with 346 of those currently operating non-GHG CEMS. For the boiler data, it is not known if subpart Y process emissions are exhausted through the same stacks as boilers and without this determination we will not include the boiler data in the subpart Y CEMS counts.

Subpart Y CEMS Count

Table Y-3 summarizes the actual data collected for facilities and units using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements.

Table Y-3. Subpart Y CEMS Counts

Process	Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
				Actual	Potential[f]
Catalytic Cracking and Sulfur Recovery	Facilities	21[a]	0	NA	104[c]
	Units	26[b]	0	NA	317[d]
All Other Process Units (except stationary combustion)[e]	Facilities	0	0	NA	NA
	Units	0	0	NA	NA

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.

[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS in GHGRP.

[c] Count of facilities which have catalytic cracking and/or sulfur recovery processes. Some facilities have both.

[d] Unit count assumes all catalytic cracking processes have catalyst regenerators (130+187), and all will use CEMS to comply with the NESHAP/NSPS.

[e] Includes fluid coking, coke calcining, catalytic reforming, asphalt blowing, other process vents. Stationary combustion units are covered under subpart C.

[f]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Phosphoric Acid Production – Subpart Z

Industry Background

Based on 2011 annual report submissions, there were 13 facilities that reported to GHGRP under subpart Z.

Under subpart Z, facilities estimate CO_2 process emissions from each wet-process phosphoric acid process line. For CO_2 emissions, facilities may either use a mass balance approach or use a CEMS to directly measure process emissions.

Applicable NSPS and NESHAP for Phosphoric Acid Plants

Table Z-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart AA—NESHAP From Phosphoric Acid Manufacturing Plants	(No relevant monitoring requirements)	No	No
Subpart T—Standards of Performance for the Phosphate Fertilizer Industry: Wet-Process Phosphoric Acid Plants	(No relevant monitoring requirements)	No	No

The applicable NESHAP and NSPS for this subpart do not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP. Based on the ICR survey responses associated with NESHAP development, it is unlikely that any of the non-combustion processes use CO_2 CEMS. Phosphoric acid process emissions are combined with combustion emissions for calciners and dryers at 7 facilities. The ICR indicates that the 7 measure O_2 instead of CO_2.

Subpart Z CEMS Count

Table Z-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements and using the background information.

Table Z-2. Subpart Z CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[b]
Facilities	0	0	7[a]	7[a]
Units	0	0	NA	NA

NA = No information available.

[a] Counts are based on data reported in the NESHAP ICR responses.

[b]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Pulp and Paper Manufacturing – Subpart AA

Industry Background

The pulp and paper manufacturing source category under subpart AA consists of facilities that do the following:

- Produce market pulp (i.e., stand-alone pulp facilities),
- Manufacture pulp and paper (i.e., integrated facilities),
- Produce paper products from purchased pulp,
- Produce secondary fiber from recycled paper,
- Convert paper into paperboard products (e.g., containers), or
- Operate coating and laminating processes.

Under subpart AA, process emissions are estimated from the following emission units:

- Chemical recovery furnaces at kraft and soda mills (including recovery furnaces that burn spent pulping liquor produced by both the kraft and semichemical process).
- Chemical recovery combustion units at sulfite facilities.
- Chemical recovery combustion units at stand-alone semichemical facilities.
- Pulp mill lime kilns at kraft and soda facilities.
- Systems for adding makeup chemicals ($CaCO_3$, Na_2CO_3) in the chemical recovery areas of chemical pulp mills.

Approximately 425 pulp and paper mills operated stationary combustion units (e.g., boilers, gas turbines, lime kilns, recovery furnaces, thermal oxidizers) in 2005, based on an industry survey by the National Council for Air and Stream Improvement (NCASI) (NCASI 2006). The results of this survey were cited in the TSD for subpart AA of part 98. The survey also reported the number of units by the process unit categories that are included in subpart AA. The survey estimated about 400 units would be subject to GHG emissions reporting under subpart AA. Based on 2011 annual report submissions, there were 110 facilities that reported to GHGRP under subpart AA.

Applicable GHGRP, NSPS, and NESHAP Monitoring Requirements for Pulp and Paper Facilities

Table AA-1 summarizes the number of process units identified by the NCASI survey, and also summarizes the monitoring requirements for pulp and paper facilities under subpart AA of part 98, and under the relevant NSPS and NESHAP.

Table AA-1. Summary of Emission Units and Relevant GHGRP, NSPS, and NESHAP Monitoring Requirements Applicable to Subpart AA Facilities

Mill Type Subject to Subpart AA	Process Units Subject to Subpart AA	GHG to be Monitored Under Subpart AA	Estimated Number of Units (NCASI Survey)[a]	Monitoring Required by 40 CFR 60, subpart BB[b]	Monitoring Required by 40 CFR 63, subpart S	Monitoring Required by 40 CFR 63, subpart MM
Kraft or Soda Mill	Each chemical recovery furnace	CO_2, biogenic CO_2, CH_4, N_2O	168	Total reduced sulfur (TRS) CEMS, O_2 CEMS, percent volume dry basis [60.284(a)(2)]	No relevant monitoring	No relevant monitoring
Kraft or Soda Mill	Lime Kilns, fossil fuel combustion	CO_2, biogenic CO_2, CH_4, N_2O	164	TRS CEMS, O_2 CEMS, percent volume dry basis [60.284(a)(2)]	No relevant monitoring	No relevant monitoring
Sulfite Pulp Mills	Each chemical recovery furnace	CO_2, biogenic CO_2, CH_4, N_2O	13	No relevant monitoring	No relevant monitoring	No relevant monitoring
Stand Alone Semichemical Mills	Each chemical recovery furnace	CO_2, biogenic CO_2, CH_4, N_2O	12	No relevant monitoring	No relevant monitoring	No relevant monitoring
Chemical pulp mills	Makeup chemical addition to chemical recovery area	CO_2	≤55	No relevant monitoring	No relevant monitoring	No relevant monitoring
		Total estimated number of units	≤412			

[a] From TSD for subpart AA, Table 3-1, on page 8; based on an industry survey by the National Council for Air and Stream Improvement (NCASI) (NCASI 2006. Pulp and Paper Mill Emissions of SO_2, NO_X, and Particulate Matter in 2005. NCASI Special Report No. 06-07. December 2006.)

[b] Applies to any kraft pulp mill facility that commenced construction or modification after September 24, 1976.

Although the applicable NSPS and NESHAP for the pulp and paper industry do require monitoring using non-GHG CEMS, information on the number of units performing that monitoring was not available. The NSPS (subpart BB) requires oxygen monitoring only for chemical recovery furnaces and pulp mill lime kilns at kraft pulp mills. The two Pulp and Paper NESHAP (subparts S and MM) do not require any relevant non-GHG CEMS monitoring, except that subpart S allows for an alternative of using a CEMS to monitor total HAP or methanol emissions, but we do not have information on the number of facilities that have taken this alternative.

Under the subpart BB NSPS, all of the chemical recovery furnaces and lime kilns at kraft or soda mills that have been built or modified since September 24, 1976 should have CEMS for total reduced sulfur (TRS), O_2, and moisture. This could be a maximum of 332 units (168 + 164), based on the information from the NCASI survey. The presence of a TRS, O_2, and moisture CEMS would mean that these units would also have the basic CEMS infrastructure in place, such as platforms, sampling lines, and data acquisition systems, and this would lower the cost of adding GHG CEMS equipment, such as a CO_2 analyzer and flow monitor, at these facilities.

Summary of Data on Facilities Reporting the Use of CEMS

Data on the number of affected process units at pulp and paper facilities using CEMS (either GHG or non-GHG) are available from the GHGRP database, and from data that were collected to develop the standards for commercial/industrial solid waste incinerators (CISWI) and the boiler and process heater NESHAP. Table AA-2 summarizes these data for the total number of units and those with a CEMS.

Table AA-2. Summary of CEMS Data from Other EPA Databases

GHGRP	CISWI Database	Boiler and Process Heater NESHAP Database
Count of Facilities Which Reported CO_2 CEMS as Option Within GHGRP	**Total Unit Count/Count of Energy Recovery Units (ERUs) and Kilns with CEMS; Total Facility Count/Count of Facilities with non-GHG CEMS**	**Total Unit Count/Count of Boilers and Process Heaters with non-GHG CEMS**
--	13/9; 9/6 None of the units appear to be in the source category for subpart AA.	533/160

No facilities reported the use of CEMS to the GHGRP.

In the CISWI and the boiler and process heater survey data, we can identify units that are located at pulp and paper facilities using the three-digit NAICS (322, paper manufacturing). From the CISWI data we identified nine energy recovery units (ERUs) or kilns at pulp and paper facilities that have some sort of CEMS; however, none of the units appear to be process units in the source category for subpart AA.

In the boiler and process heater NESHAP database, we identified a total of 533 units at pulp and paper facilities, and 160 of these units have some sort of CEMS. However, we cannot determine from the information in those survey data whether any of those units are process units in the source category for subpart AA.

Subpart AA CEMS Count

Table AA-4 summarizes the actual data collected for facilities and units using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. The table also shows a potential estimate of CEMS usage based on assumptions regarding the applicability of NSPS and NESHAP requirements and using the background information.

Table AA-4. Subpart AA CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	**Potential**[b]

Facilities	0	0	NA	NA
Units	0	0	266[a]	266[a]

NA = No information available.

[a] The NCASI survey provided process unit data and the 2009 RIA estimated that units were subject to Tier 4 requirements. However, these count data and the count for facilities that reported to GHGRP in 2011 (110) could not be directly related. Therefore, based on the data, unit and facility counts were estimated.

[b]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Based on the NSPS requirements, a large percentage of subpart AA units are likely to have TRS and O_2 CEMS and, therefore, already have some basic infrastructure for a CEMS that could be used to estimate GHG emissions with the addition of a flow meter and CO_2 analyzer. Similarly, the RIA estimates that a large portion of the sources will meet Tier 4 requirements. However, because the number of facilities reporting to GHGRP (110) is substantially lower than the number reported through the NCASI survey (425), an adjustment to the unit data was necessary. It was estimated that each facility would have at least three units; this is based on data from the NCASI survey. Therefore, 330 total units were estimated for the 110 facilities. Of these, approximately 80% of the units were assumed to have a CEMS installed. This was calculated as the number of units at kraft and soda mills (168+164 = 332) which may have CEMS to comply with subpart BB, divided by the total unit count (412). Performing this calculation yields approximately 266 units with non-GHG CEMS.

Appendix B. Silicon Carbide Production – Subpart BB

Industry Background

Based on 2011 annual report submissions, there was 1 facility that reported to GHGRP under subpart BB.

Under subpart BB, facilities estimate CO_2 and CH_4 process emissions from all silicon carbide process units or furnaces combined. For estimating CO_2 process emissions, facilities may either use a mass balance approach or use a CEMS. Process emissions of CH_4 are estimated using emission factors relevant to the monthly amount of petroleum coke consumed at the facility.

Applicable NSPS and NESHAP for Silicon Carbide Manufacturers

There is no NSPS or NESHAP specifically applicable to silicon carbide manufacturers.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.
Subpart BB CEMS Count

Table BB-1 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table BB-1. Subpart BB CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.
[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Soda Ash Manufacturing – Subpart CC

Industry Background

Based on 2011 annual report submissions, there were 4 facilities that reported to GHGRP under subpart CC.

Under subpart CC, facilities estimate CO_2 process emissions from each soda ash manufacturing line and CO_2 combustion emissions from each soda ash manufacturing line. They are also required to estimate and report CH_4 and N_2O combustion emissions from each soda ash manufacturing line. For CO_2 emissions, facilities may use a mass balance or emission factor approach to estimate separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Soda Ash Plants

Table CC-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart OOO—Standards of Performance for Nonmetallic Mineral Processing Plants	(No relevant monitoring requirements)	No	No
Subpart UUU—Standards of Performance for Calciners and Dryers in Mineral Industries	(No relevant monitoring requirements)	No	No

The applicable NESHAP and NSPS for this subpart do not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

One facility reported the use of one CO_2 CEMS to report emissions in the GHGRP.

Subpart CC CEMS Count

Table CC-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. One facility was identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table CC-2. Subpart CC CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[c]
Facilities	1[a]	0	NA	NA
Units	1[b]	0	NA	NA

NA = No information available.

[a] Number of facilities reporting to GHGRP in 2011 that they are using a CEMS to report CO_2 emissions.
[b] The total number of CO_2 CEMS at the facilities which reported CO_2 CEMS.
[c]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Titanium Dioxide Production – Subpart EE

Industry Background

Based on 2011 annual report submissions, there were 7 facilities that reported to GHGRP under subpart EE.

Under subpart EE, facilities estimate CO_2 process emissions from each chloride process line. For estimating CO_2 process emissions, facilities may either use a mass balance approach or use a CEMS.

Applicable NSPS and NESHAP for Titanium Dioxide Plants

Table EE-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart LL—Standards of Performance for Metallic Mineral Processing Plants	(No relevant monitoring requirements)	No	No

The applicable NESHAP and NSPS for this subpart do not require monitoring which is related to CEMS equipment and would thus not facilitate the installation of GHG CEMS.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.
Subpart EE CEMS Count

Table EE-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table EE-2. Subpart EE CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.
[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Zinc Production – Subpart GG

Industry Background

Based on 2011 annual report submissions, there were 6 facilities that reported to GHGRP under subpart GG.

Under subpart GG, facilities estimate CO_2 process emissions from each Waelz kiln and electrothermic furnace, and CO_2 combustion emissions from each Waelz kiln and electrothermic furnace. They are also required to estimate and report CH_4 and N_2O combustion emissions from each Waelz kiln and electrothermic furnace. For CO_2 emissions, facilities may use a mass balance or emission factor approach to estimate separate process and combustion emissions, or use a CEMS to determine combined process and combustion emissions.

Applicable NSPS and NESHAP for Zinc Plants

Table GG-1. Applicable NESHAP and NSPS Rules

NESHAP/NSPS Subparts Reviewed	Monitoring Required by the NESHAP or NSPS	Would Monitoring Equipment Relevant to Part 98 be Installed to Comply With NESHAP or NSPS?	Were Data on CEMS Counts Available in NESHAP or NSPS docket?
Subpart Q—Standards of Performance for Primary Zinc Smelters	SO_2 CEMS required for facilities constructed or modified after October 16, 1974	No	No
Subpart LL—Standards of Performance for Metallic Mineral Processing Plants	(No relevant monitoring requirements)	No	No
Subpart GGGGGG—NESHAP for Primary Nonferrous Metals Area Sources—Zinc, Cadmium, and Beryllium	(No relevant monitoring requirements)	No	No
Subpart TTTTTT—NESHAP for Secondary Nonferrous Metals Processing Area Sources	(No relevant monitoring requirements)	No	No

SO_2 CEMS is only applicable for roasters at primary zinc smelters which are not applicable to GHG reporting and are thus not related to GHG CEMS installation.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP.

Subpart GG CEMS Count

Table GG-2 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CO_2 CEMS. No assumption could be made for a potential count based on lack of information on control devices and monitoring requirements.

Table GG-2. Subpart GG CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.

[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix B. Industrial Waste Landfills – Subpart TT

Industry Background

Based on 2011 annual report submissions, there were 173 facilities that reported to GHGRP under subpart TT.

Under subpart TT, facilities must estimate annual CH_4 generation, emission, and destruction from the landfill. For estimating CH_4 generation, facilities may measure the generation directly or estimate a value based on historic annual waste disposal quantities. Facilities that collect and control landfill gas must calculate CH_4 emissions using two methods: First, a mass balance method using the equations provided in subpart TT; and second, by applying a gas collection efficiency to the measured amount of CH_4 recovered.

Applicable NSPS and NESHAP for Industrial Waste Landfills

There are no NSPS or NESHAP which are applicable to industrial waste landfills. The definition of industrial waste landfills for purposes of the GHGRP specifically excludes municipal waste landfills, so part 60 subpart WWW (NSPS for MSW Landfills) is not applicable.

Summary of Available Data on Facilities Reporting the Use of CEMS

No facilities reported the use of CEMS to the GHGRP. It is noted in subpart TT that industrial waste landfills may collect methane with a gas collection system. If they do the rule requires them to report the annual CH_4 recovered. The method of recording the amount of methane recovered using the gas collection system is unknown, so the applicability of CH_4 CEMS is also unknown. For these purposes it will be assumed that no facility uses CEMS to monitor CH_4 recovery. Also, for those industrial waste landfills which have gas collection systems, the facility is required to monitor the flow rate and temperature; the applicability of this equipment to installing CEMS (e.g., is the flow monitor located at a position which would also meet flow monitor requirements for CEMS) is also unknown.

Subpart TT CEMS Count

Table TT-1 summarizes the actual data collected for facilities using CO_2 CEMS, non-CO_2 GHG CEMS, and non-GHG CEMS. No facilities were identified with pre-existing CH_4 CEMS. No assumption could be made for a potential count based on lack of information.

Table TT-1. Subpart TT CEMS Counts

Basis	CO_2 CEMS for GHGRP	Reporting non-CO_2 GHG CEMS for GHGRP	Reporting non-GHG CEMS for Other EPA Programs	
			Actual	Potential[a]
Facilities	0	0	NA	NA
Units	0	0	NA	NA

NA = No information available.
[a]Potential facilities or process units that may have equipment installed that could be modified for use in the GHGRP.

Appendix C
Detailed CEMS Costing for Subparts with "Inputs to Equations" Data Elements

Appendix C

Detailed GHG CEMS Cost Analysis

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C.1 GHG CEMS Cost Assumptions

To determine the economic impact of installing GHG CEMS for each subpart, a determination of the applicable population of sources for each subpart was needed. This included the total count of facilities and process units in each subpart and the count of CEMS which are currently installed. Data for current CEMS included installations of GHG CEMS (CO_2, CH_4, or N_2O) and non-GHG CEMS (NO_X, PM, CO, etc.). When determining the GHG CEMS cost for each subpart, data at the process unit level is the most relevant. A facility may have multiple process units and thus multiple emission sources (e.g., multiple stacks) which would each need their own CEMS. However, for some subparts this level of detail was not available and only facility counts were known. In those instances, only the facility count was used to determine the CEMS cost; while this may underestimate costs for certain subparts, due to a lack of data, it was not possible to provide a reliable count for number of process units. To determine counts the following sources were used: GHGRP data, part 98 GHG technical support documents for each subpart, a review of applicable NESHAP and NSPS rule requirements and associated databases and supporting documentation for each subpart, and the part 98 GHG Regulatory Impact Analysis (RIA). See Appendix B for a review of the information obtained.

To keep this CEMS cost analysis consistent with the GHG RIA, the same method of determining capital and annual costs was used. As shown in section 3.1, the following CEMS usages were identified:

- Source has CO_2 CEMS
- Source has non-CO_2 GHG CEMS (such as N_2O CEMS) or has non-GHG CEMS (such as NO_X or CO monitors)
- Source has no CEMS

Five different cost scenarios were identified from the usage information and are summarized in Table C-1. Cost scenario 1 is a complete GHG CEMS installation for sources which do not have any CEMS related equipment installed. Cost scenarios 2 through 4 are reduced costs for sources which have current CEMS installations and would need to install minimal equipment (e.g., a CO_2 analyzer and/or flow meter). The decision to apply scenarios 2, 3, or 4 costs to a particular subpart is based off applicable NSPS/NESHAP regulation knowledge and information provided in the GHG RIA. It was determined that no facilities/process units met the requirements for scenario 4 (see Appendix B for regulatory review results for each subpart). Therefore, no costs were estimated for scenario 4. Scenario 5 is a facility/process unit that already has CO_2 CEMs and no costs are calculated.

Table C-1. Summary of Costs for CO_2 CEMS Modifications

Scenario #	Scenario	Total annual costs
1	Source has no CEMS -- Add CO_2 analyzer, flow meter, and infrastructure	$ 70,265
2	Source has CEMS for other pollutants -- Add CO_2 analyzer and flow meter	$ 56,040
3	Source has CEMS for other pollutants -- Add CO_2 analyzer only	$ 20,593
4[a]	Source has CEMS for other pollutants -- Add flow monitor only	$ 24,511
5	Source has CO_2 CEMS	No Cost

[a]No facilities/process units were determined to meet the scenario.

Within each scenario, multiple cost scenarios were calculated because each subpart may require one analyzer or a combination of analyzers to measure GHGs. The most common GHG to report is CO_2, however CH_4 and N_2O are also applicable depending on the subpart. While the GHG RIA provided a cost estimate for a CO_2 CEMS, CH_4 and N_2O CEMS costs were not available. For this analysis, vendors were contacted and cost estimates were developed for these methods as well. With these additional data, costs were estimated for installing each CEMS analyzer on a stand-alone basis and costs were also calculated for installing all three analyzers at one source or a combination of two analyzers at one source. Subpart O requires reporting of fluorinated gases; the applicability of CEMS for fluorinated gases was not analyzed, and therefore no costs were calculated for subpart O. Table C-2 summarizes the vendor cost information.

Costs for each subpart were determined based on the count information identified (see Appendix B for subpart-specific details) and the scenario cost options. Costs were determined based on the following hierarchy:

- If no current CEMS installations were identified then the total facility/process unit count was multiplied by the scenario 1 cost for installing the appropriate GHG CEMS.
- If current non-CO_2 CEMS installations were identified for a subpart then either scenario 2 or 3 costs were applied for these counts depending on the type of CEMS identified. For facility/process units without current non-CO2 CEMs, the scenario 1 costs were applied. These two costs were added together to get the total cost for the facility.
- For subparts which have a CO_2 CEMS installed but would also report CH_4 and/or N_2O, only the cost associated with installing a CH_4 and/or N_2O analyzer was incorporated, and no costs for CO_2 analyzers were included.

Costs are shown for each subpart based on two count options: actual and potential CEMS counts. The actual count and associated CEMS costs correspond to the actual CEMS installation counts which were able to be identified from the various sources discussed previously. The potential count and associated CEMS costs correspond to the potential CEMS installation counts which were estimated based on requirements in NSPS and NESHAP rules. The potential counts include the actual counts plus the additional units/facilities that may be affected by NSPS or NESHAP requirements. The costs associated with the actual count resulted in higher costs than the potential count scenario, as fewer current CEMS installations were estimated which results in a higher number of scenario 1 (complete installation) costs. For the costs associated with the potential count, the resulting costs were lower than the actual count scenario because more CEMS installations were estimated which resulted in fewer units in scenario 1 and more in scenarios 2 or 3. For many subparts, the actual and potential CEMS counts are identical, however.

Table C-2. Summary of Vendor Cost Information Collected

Equipment	Altech Environmental	CEMS Experts (GK Associates)	EnviroServ	Cemtek Environmental	Average	Average (Rounded)
CO_2 analyzer	\$5,000 (a)	\$15,000-\$20,000	\$12,000	\$7,917	\$12,472	**\$13,000**
N_2O analyzer	\$5,000 (a)	\$15,000-\$20,000	\$15,000	\$10,096	\$14,199	**\$14,000**
CH_4 analyzer	\$5,000 (a)	\$15,000-\$20,000	\$12,000	\$18,019	\$15,840	**\$16,000**
Sampling system	--	--	--	\$9,766	\$9,766	**\$10,000**
DAS, including software	\$30,000-\$40,000	--	--	\$19,931	\$27,466	**\$28,000**
Flow monitors	\$27,000	\$15,000-\$20,000	--	\$26,250	\$23,583	**\$24,000**

Notes:

- When cost ranges were provided, the average of the range was used to estimate costs.

(a) Did not include Altech analyzer costs in average per note from Altech that their analyzer costs are typically lower than normal due to the method by which they price their equipment.

C.2 GHG CEMS Cost Results

Based on the counts for each subpart and their breakdown into counts for each scenario, costs for installing GHG CEMS were estimated. Section C.2 summarizes the estimated costs for each subpart and the overall cost to industry.

Tables C-3 through C-11 show the resultant total capital investment and annualized CEMS costs (actual and potential) for each subpart, the number of sources with existing GHG or non-GHG CEMS for each subpart, and the division of affected sources into the four cost scenarios for each subpart. Tables C-3 and C-4 summarize capital and annual costs for installation of CO_2 CEMS only (similar to the GHG RIA). Tables C-5 through C-7 summarize the count information for actual and potential units/facilities with CEMS control, and the assumptions used in the count determination. Tables C-8 through C-11 provide data on all three types of GHG CEMS (CO_2, N_2O, and CH_4). Tables C-8 and C-9 show the capital and annual cost estimates based on actual counts. Tables C-10 and C-11 show the capital and annual cost estimates based on potential counts.

For subparts which require multiple GHG CEMS, distributing the total unit installation cost between two or three CEMS is not appropriate; there are redundant component costs associated with CO_2, CH_4, and N_2O CEMS. If a facility were to install CEMS for all three GHGs, for example, the total cost incurred by the facility would not equal the sum of the CO_2, CH_4, and N_2O individual monitor costs. Instead, cost estimates were developed based on vendor quotes for each possible combination of CO_2, CH_4, and N_2O CEMS for each cost scenario. For this reason, the CO_2, N_2O, and CH_4 costs in Tables C-8 through C-11 do not equal the total cost column; the CO_2, N_2O, and CH_4 costs shown are the cost for installing individual GHG CEMS while the total cost is the more representative cost for installing multiple GHG CEMS.

Table C-3. Capital Cost Breakdown into Each Costing Scenario for Installation of CO_2 CEMS Only, Based on Actual Counts and Potential Counts

Subpart	Capital Investment							
	Scenario 1		Scenario 2		Scenario 3		Total	
	Actual[a]	Potential[b]	Actual[a]	Potential[b]	Actual[a]	Potential[b]	Actual[a]	Potential[b]
C	$1,578,065,753	$1,578,065,753	$102,182,259	$111,374,792	$0	$0	$1,680,248,013	$1,689,440,545
E	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
F	$1,229,981	$1,229,981	$ -	$ -	$ -	$ -	$1,229,981	$1,229,981
G	$2,705,958	$2,705,958	$ -	$ -	$ -	$ -	$2,705,958	$2,705,958
H	$3,443,947	$ -	$ -	$ -	$560,101	$560,101	$4,004,048	$560,101
K	$1,229,981	$1,229,981	$ -	$ -	$ -	$ -	$1,229,981	$1,229,981
L	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
N	$13,160,798	$13,160,798	$ -	$ -	$ -	$ -	$13,160,798	$13,160,798
O	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
P	$12,299,811	$12,299,811	$ -	$ -	$ -	$ -	$12,299,811	$12,299,811
Q	$18,572,715	$18,572,715	$ -	$ -	$ -	$ -	$18,572,715	$18,572,715
R	$1,598,975	$1,598,975	$ -	$ -	$ -	$ -	$1,598,975	$1,598,975
S	$8,855,864	$ -	$ -	$ -	$ -	$ -	$8,855,864	$ -
U	$2,213,966	$2,213,966	$0	$0	$0	$0	$2,213,966	$2,213,966
V	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
X	$7,625,883	$7,871,879	$ -	$ -	$ -	$ -	$7,625,883	$7,871,879
Y	$191,139,063	$155,346,613	$ -	$18,094,775	$ -	$2,080,376	$191,139,063	$175,521,765
Z	$737,989	$737,989	$ -	$ -	$140,025	$140,025	$878,014	$878,014
AA	$7,881,432	$7,881,432	$25,731,576	$25,731,576	$ -	$ -	$33,613,009	$33,613,009
BB	$122,998	$122,998	$ -	$ -	$ -	$ -	$122,998	$122,998
CC	$368,994	$368,994	$ -	$ -	$ -	$ -	$368,994	$368,994
EE	$860,987	$860,987	$ -	$ -	$ -	$ -	$860,987	$860,987
GG	$737,989	$737,989	$ -	$ -	$ -	$ -	$737,989	$737,989
TT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	**$1,852,853,085**	**$1,800,578,888**	**$127,913,836**	**$158,684,630**	**$700,127**	**$2,780,503**	**$1,981,467,047**	**$1,962,044,020**

[a]Costs are based on the actual number of units/facilities for which information was available indicating current use of CEMS. See Appendix B for detailed information for each subpart.
[b]Costs are based on potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. Costs include actual number of units/facilities where information is known as well as the additional potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. See Appendix B for detailed information for each subpart.

Table C-4. Annual Cost Breakdown into Each Costing Scenario for Installation of CO_2 CEMS Only, Based on Actual Counts and Potential Counts

Subpart	Annual Cost							
	Scenario 1		Scenario 2		Scenario 3		Total	
	Actual[a]	Potential[b]	Actual[a]	Potential[b]	Actual[a]	Potential[b]	Actual[a]	Potential[b]
C	$901,499,950	$901,499,950	$59,178,240	$64,502,040	$ -	$ -	$960,678,190	$966,001,990
E	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
F	$702,650	$702,650	$ -	$ -	$ -	$ -	$702,650	$702,650
G	$1,545,830	$1,545,830	$ -	$ -	$ -	$ -	$1,545,830	$1,545,830
H	$1,967,420	$ -	$ -	$ -	$576,604	$576,604	$2,544,024	$576,604
K	$702,650	$702,650	$ -	$ -	$ -	$ -	$702,650	$702,650
L	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
N	$7,518,355	$7,518,355	$ -	$ -	$ -	$ -	$7,518,355	$7,518,355
O	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
P	$7,026,500	$7,026,500	$ -	$ -	$ -	$ -	$7,026,500	$7,026,500
Q	$10,610,015	$10,610,015	$ -	$ -	$ -	$ -	$10,610,015	$10,610,015
R	$913,445	$913,445	$ -	$ -	$ -	$ -	$913,445	$913,445
S	$5,059,080	$ -	$ -	$ -	$ -	$ -	$5,059,080	$ -
U	$1,264,770	$1,264,770	$0	$0	$0	$0	$1,264,770	$1,264,770
V	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
X	$4,356,430	$4,496,960	$ -	$ -	$ -	$ -	$4,356,430	$4,496,960
Y	$109,191,810	$88,744,695	$ -	$10,479,480	$ -	$2,141,672	$109,191,810	$101,365,847
Z	$421,590	$421,590	$ -	$ -	$144,151	$144,151	$565,741	$565,741
AA	$4,502,417	$4,502,417	$14,902,287	$14,902,287	$ -	$ -	$19,404,705	$19,404,705
BB	$70,265	$70,265	$ -	$ -	$ -	$ -	$70,265	$70,265
CC	$210,795	$210,795	$ -	$ -	$ -	$ -	$210,795	$210,795
EE	$491,855	$491,855	$ -	$ -	$ -	$ -	$491,855	$491,855
GG	$421,590	$421,590	$ -	$ -	$ -	$ -	$421,590	$421,590
TT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	**$1,058,477,417**	**$1,031,144,332**	**$74,080,527**	**$89,883,807**	**$720,755**	**$2,862,427**	**$1,133,278,700**	**$1,123,378,467**

[a]Costs are based on the actual number of units/facilities for which information was available indicating current use of CEMS. See Appendix B for detailed information for each subpart.

[b]Costs are based on potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. Costs include actual number of units/facilities where information is known as well as the additional potential number of units/facilities that may be using CEMS based on NESHAP and NSPS rule requirements. See Appendix B for detailed information for each subpart.

Table C-5. Total Facility and Units Counts and Current CEMS Installation Counts[a]

Subpart	Number of Affected…		Does Subpart Require Reporting Emissions of:			Number with CO_2 CEMS		Number with non-CO_2 GHG CEMS		Number with non-GHG CEMS	
	Facilities	Units	CO_2?	N_2O?	CH_4?	Facilities	Units	Facilities	Units	Facilities	Units
C	1,985	14,197	YES	YES	YES	177	311	0	0	unknown	1,056 to 1,151
E	3	3	NO	YES	NO	0	0	0	0	unknown	unknown
F	10	10	YES	NO	NO	0	0	0	0	unknown	unknown
G	22	22	YES	NO	NO	0	0	0	0	unknown	unknown
H	96	140	YES	YES	YES	82	112	0	0	0 to 14	0 to 28
K	10	10	YES	NO	YES	0	0	0	0	unknown	unknown
L	16	16	NO	NO	NO	0	0	1	5	unknown	unknown
N	110	110	YES	YES	YES	3	3	0	0	unknown	unknown
O	5	5	NO	NO	NO	0	0	0	0	unknown	unknown
P	103	103	YES	YES	YES	3	3	0	0	unknown	unknown
Q	128	165	YES	YES	YES	11	14	0	0	unknown	unknown
R	13	13	YES	YES	YES	0	0	0	0	unknown	unknown
S	73	73	YES	YES	YES	1 to 73	1 to 73	0	0	unknown	unknown
U	18	18	YES	NO	NO	0	0	0	0	unknown	unknown
V	36	65	NO	YES	NO	0	0	0	0	20	36
X	64	64	YES	YES	YES	2	2	0	0	unknown	unknown
Y	145	1,580	YES	YES	YES	21	26	0	0	≤ 104	≤ 317
Z	13	13	YES	NO	NO	0	0	0	0	7	≥ 7
AA	110	330	YES	YES	YES	0	0 to 36	0	0	89	266
BB	1	1	YES	NO	YES	0	0	0	0	unknown	unknown
CC	4	4	YES	YES	YES	1	1	0	0	unknown	unknown
EE	7	7	YES	NO	NO	0	0	0	0	unknown	unknown
GG	6	6	YES	YES	YES	0	0	0	0	unknown	unknown
TT	173	173	NO	NO	YES	0	0	0	0	unknown	unknown

[a] See Appendix B for detailed summary for each subpart.

Table C-6. Counts Used to Determine Costs for Each Scenario, Actual CEMS Counts[a]

Subpart	Number in Scenario 1								Number in Scenario 2								Number in Scenario 3							
	Facilities				Units				Facilities				Units				Facilities				Units			
	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total
C	NA	NA	NA	NA	12,830	12,830	12,830	12,830	NA	NA	NA	NA	1,056	1,056	1,056	1,056	0	177	177	177	0	311	311	311
E	0	3	0	3	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	10	0	0	10	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	22	0	0	22	22	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H	14	14	14	14	28	28	28	28	0	0	0	0	0	0	0	0	14	82	82	82	28	112	112	112
K	10	0	10	10	10	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	107	107	107	107	107	107	107	107	0	0	0	0	0	0	0	0	0	3	3	3	0	3	3	3
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	100	100	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	3	3	3	0	3	3	3
Q	117	117	117	117	151	151	151	151	0	0	0	0	0	0	0	0	0	11	11	11	0	14	14	14
R	13	13	13	13	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	72	72	72	72	72	72	72	72	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1
U	18	0	0	18	18	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V	0	16	0	16	0	29	0	29	0	0	0	0	0	0	0	0	0	20	0	20	0	36	0	36
X	62	62	62	62	62	62	62	62	0	0	0	0	0	0	0	0	0	2	2	2	0	2	2	2
Y	NA	NA	NA	NA	1,554	1,554	1,554	1,554	0	0	0	0	0	0	0	0	NA	NA	NA	NA	0	26	26	26
Z	6	0	0	6	6	0	0	6	0	0	0	0	0	0	0	0	7	0	0	7	7	0	0	7
AA	21	21	21	21	64	64	64	64	89	89	89	89	266	266	266	266	0	0	0	0	0	0	0	0
BB	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1
EE	7	0	0	7	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GG	6	6	6	6	6	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TT	0	0	173	173	0	0	173	173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] See Appendix B for detailed summary for each subpart.
NA = Data not available on basis.

Table C-6 (cont.) Notes Explaining the Actual CEMS Count Distribution for Each Subpart

Subpart	NOTES – Actual CEMS Counts
C	Boiler and CISWI databases reviewed to get count of units with CEMS (1,056). None of the relevant regulations require CO2 or flow monitors, but they do require CEMS systems for other pollutants. Assumed that all 1,056 Tier 4 units would be in scenario 2 and units with known CO2 CEMS would be in scenario 3.
E	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
F	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
G	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
H	Assumed units with current CEMS installations would be in scenario 3.
K	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
L	CO2, N2O, and CH4 not required to be reported for this subpart, thus no associated costs or unit counts.
N	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
O	CO2, N2O, nor CH4 required to be reported for this subpart, thus no associated costs or unit counts.
P	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
Q	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
R	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
S	The RIA for part 98 identified all facilities being applicable to Tier 4 requirements and would thus install a CO2 CEMS. Note, however, that this count may not be exclusive to subpart S emissions sources and, for example, some of the identified units may fall under subpart C. For the actuals count, it was assumed all units would be in scenario 1 (except the 1 facility with a known CO2 CEMS).
U	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
V	Scenario 3 costs applied to facilities with CEMS, others assumed to be in scenario 1.
X	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
Y	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. For actual CEMS count, assumed zero facilities have non-GHG CEMS installed.
Z	Scenario 3 costs applied to facilities with CEMS, others assumed to be in scenario 1.
AA	Scenario 2 costs applied for facilities with CEMS; based off GHG RIA estimate that most facilities would meet this for Tier IV requirements.
BB	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
CC	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
EE	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
GG	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
TT	Current CEMS installation unknown; assumed all facilities/units in scenario 1.

Table C-7. Counts Used to Determine Costs for Each Scenario, Potential CEMS Counts[a]

Subpart	Number in Scenario 1								Number in Scenario 2								Number in Scenario 3							
	Facilities				Units				Facilities				Units				Facilities				Units			
	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total
C	NA	NA	NA	NA	12,830	12,830	12,830	12,830	NA	NA	NA	NA	1,151	1,151	1,151	1,151	0	177	177	177	311	0	311	311
E	0	3	0	3	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	10	0	0	10	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	22	0	0	22	22	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	96	96	96	28	140	140	140
K	10	0	10	10	10	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	107	107	107	107	107	107	107	107	0	0	0	0	0	0	0	0	0	3	3	3	0	3	3	3
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	100	100	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	3	3	3	0	3	3	3
Q	117	117	117	117	151	151	151	151	0	0	0	0	0	0	0	0	0	11	11	11	0	14	14	14
R	13	13	13	13	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	73	73	73	0	73	73	73	0	0	0	0	0	0	0	0
U	18	0	0	18	18	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V	0	16	0	16	0	29	0	29	0	0	0	0	0	0	0	0	0	20	0	20	0	36	0	36
X	64	64	64	64	64	64	64	64	0	0	0	0	0	0	0	0	0	2	2	2	0	2	2	2
Y	NA	NA	NA	NA	1,263	1,263	1,263	1,263	NA	NA	NA	NA	187	187	187	187	NA	NA	NA	NA	104	130	130	130
Z	6	0	0	6	6	0	0	6	0	0	0	0	0	0	0	0	7	0	0	7	7	0	0	7
AA	21	21	21	21	28	28	28	28	89	89	89	89	302	302	302	302	0	0	0	0	0	0	0	0
BB	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1
EE	7	0	0	7	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GG	6	6	6	6	6	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TT	0	0	173	173	0	0	173	173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] See Appendix B for detailed summary for each subpart.
NA = Data not available on basis.

Table C-7 (cont.) Notes Explaining the Potential CEMS Count Distribution for Each Subpart

Subpart	NOTES – Potential CEMS counts
C	Boiler and CISWI databases reviewed to get count of units with CEMS (1,151). None of the relevant regulations require CO2 or flow monitors, but they do require CEMS systems for other pollutants. Assumed that all 1,151 Tier 4 units would be in scenario 2 and units with known CO2 CEMS would be in scenario 3.
E	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
F	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
G	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
H	Assumed units with current CEMS installations would be in scenario 3.
K	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
L	CO2, N2O, and CH4 not required to be reported for this subpart, thus no associated costs or unit counts.
N	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
O	CO2, N2O, nor CH4 required to be reported for this subpart, thus no associated costs or unit counts.
P	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
Q	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
R	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
S	The RIA for part 98 identified all facilities being applicable to Tier 4 requirements and would thus install a CO2 CEMS. Note, however, that this count may not be exclusive to subpart S emissions sources and, for example, some of the identified units may fall under subpart C. For the potential count, it was assumed all units would be in scenario 2, per the RIA.
U	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
V	Scenario 3 costs applied to facilities with CEMS, others assumed to be in scenario 1.
X	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. Assumption made that the facilities with CO2 CEMS have only one unit.
Y	Scenario 3 costs applied to facilities with CO2 CEMS, others assumed to be in scenario 1. For potential CEMS count, distributed non-GHG CEMS in scenario 2 and 3 based on engineering judgment.
Z	Scenario 3 costs applied to facilities with CEMS, others assumed to be in scenario 1.
AA	Scenario 2 costs applied for facilities with CEMS; based off GHG RIA estimate that most facilities would meet this for Tier IV requirements.
BB	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
CC	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
EE	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
GG	Current CEMS installation unknown; assumed all facilities/units in scenario 1.
TT	Current CEMS installation unknown; assumed all facilities/units in scenario 1.

Table C-8. Capital Costs (million dollars) for Each Scenario, Based on Actual CEMS Counts[a]

Subpart	Capital Costs (Million Dollars)												
	Scenario 1				Scenario 2				Scenario 3				Total - All Scenarios
	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	
C	$ 1,578	$ 1,603	$ 1,640	$ 1,960	$ 102	$ 104	$ 107	$ 134	$	$ 6.8	$ 7.7	$ 11.9	$ 2,106
E	$	$ 0.37	$	$ 0.37	$	$	$	$	$ -	$	$	$	$ 0.4
F	$ 1.2	$	$	$ 1.2	$	$	$	$	$ -	$	$	$	$ 1.2
G	$ - 2.7	$	$ -	$ 2.7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2.7
H	$ 3.4	$ - 3.5	$ - 3.6	$ 4.3	$ -	$ -	$ -	$ -	$ - 0.56	$ - 2.5	$ - 2.8	$ - 5.6	$ 9.9
K	$ 1.2	$ -	$ - 1.3	$ 1.4	$ -	$ -	$ -	$ -	$	$ -	$ -	$ -	$ 1.4
L	$	$	$	$	$ -	$ -	$ -	$ -	$ -	$	$	$	$
N	$ 13.2	$ - 13.4	$ 13.7	$ 16.3	$ -	$ -	$ -	$ -	$ -	$ - 0.066	$ - 0.074	$ - 0.11	$ 16.5
O	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
P	$ 12.3	$ 12.5	$ 12.8	$ 15.3	$ -	$ -	$ -	$ -	$ -	$ 0.066	$ 0.074	$ 0.11	$ 15.4
Q	$ - 18.6	$ - 18.9	$ - 19.3	$ - 23.1	$ -	$ -	$ -	$ -	$ -	$ - 0.31	$ - 0.35	$ - 0.54	$ - 23.6
R	$ 1.6	$ 1.6	$ 1.7	$ 2.0	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 2.0
S	$ 8.9	$ 9.0	$ 9.2	$ 11.0	$ -	$ -	$ -	$ -	$ -	$ 0.022	$ 0.025	$ 0.038	$ 11.0
U	$ 2.2	$	$	$ 2.2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2.2
V	$	$ 3.6	$	$ 3.6	$ -	$ -	$ -	$ -	$ -	$ 0.79	$	$ 0.79	$ 4.4
X	$ 7.6	$ - 7.7	$ - 7.9	$ 9.5	$ -	$ -	$ -	$ -	$ -	$ - 0.044	$ - 0.050	$ - 0.077	$ 9.6
Y	$ - 191	$ 194	$ - 199	$ 237	$ -	$ -	$ -	$ -	$ -	$ 0.57	$ - 0.65	$ 1.00	$ 238.5
Z	$ 0.74	$	$	$ 0.74	$ -	$ -	$ -	$ -	$ - 0.14	$	$	$ 0.14	$ 0.88
AA	$ 7.9	$ 8.0	$ 8.2	$ 9.8	$ - 25.7	$ - 26.2	$ - 27.0	$ - 33.7	$	$	$	$	$ 43.4
BB	$ 0.12	$ -	$ - 0.13	$ 0.14	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$	$ 0.14
CC	$ 0.37	$ 0.37	$ 0.38	$ 0.46	$	$	$	$	$ -	$ - 0.022	$ - 0.025	$ - 0.038	$ 0.50
EE	$ 0.86	$ -	$	$ 0.86	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.86
GG	$ 0.74	$ 0.75	$ 0.77	$ 0.92	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.92
TT	$	$ -	$ - 22.1	$ 22.1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 22.1
TOTAL	**$ 1,853**	**$ 1,877**	**$ 1,940**	**$ 2,325**	**$ - 127.7**	**$ - 130.2**	**$ - 134**	**$ - 167.7**	**$ - 0.70**	**$ - 11.2**	**$ - 11.7**	**$ - 20.3**	**$ 2,513**

[a] See Appendix B for detailed summary for each subpart.

Table C-9. Annual Costs (million dollars) for Each Scenario, Based on Actual CEMS Counts[a]

Subpart	Annual Costs (Million Dollars)												
	Scenario 1				Scenario 2				Scenario 3				Total - All Scenarios
	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	
C	$ 901	$ 911	$ 915	$ 950	$ 59.2	$ 61.4	$ 61.7	$ 64.6	$	$ 6.6	$ 6.7	$ 7.1	$ 1,022
E	$	$ 0.21	$	$ 0.21	$	$	$	$	$ -	$	$	$	$ 0.21
F	$ 0.70	$	$	$ 0.70	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.70
G	$ 1.5	$	$ -	$ 1.5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.5
H	$ 2.0	$ 2.0	$ 2.0	$ 2.1	$ -	$ -	$ -	$ -	$ 0.6	$ 2.4	$ 2.4	$ 2.7	$ 4.8
K	$ 0.70	$ -	$ 0.71	$ 0.73	$ -	$ -	$ -	$ -	$	$ -	$ -	$ -	$ 0.73
L	$	$	$	$	$ -	$ -	$ -	$ -	$ -	$	$	$	$
N	$ 7.5	$ 7.6	$ 7.6	$ 7.9	$ -	$ -	$ -	$ -	$ -	$ 0.06	$ 0.06	$ 0.07	$ 8.0
O	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
P	$ 7.0	$ 7.1	$ 7.1	$ 7.4	$ -	$ -	$ -	$ -	$ -	$ 0.06	$ 0.06	$ 0.07	$ 7.5
Q	$ 10.6	$ 10.7	$ 10.8	$ 11.2	$ -	$ -	$ -	$ -	$ -	$ 0.30	$ 0.30	$ 0.32	$ 11.5
R	$ 0.91	$ 0.92	$ 0.93	$ 0.96	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.96
S	$ 5.1	$ 5.1	$ 5.1	$ 5.3	$ -	$ -	$ -	$ -	$ -	$ 0.021	$ 0.021	$ 0.023	$ 5.4
U	$ 1.3	$	$	$ 1.3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.3
V	$	$ 2.1	$	$ 2.1	$ -	$ -	$ -	$ -	$ -	$ 0.76	$	$ 0.76	$ 2.8
X	$ 4.4	$ 4.4	$ 4.4	$ 4.6	$ -	$ -	$ -	$ -	$ -	$ 0.042	$ 0.043	$ 0.046	$ 4.6
Y	$ 109	$ 110	$ 111	$ 115	$ -	$ -	$ -	$ -	$ -	$ 0.55	$ 0.56	$ 0.60	$ 115.6
Z	$ 0.42	$	$	$ 0.42	$ -	$ -	$ -	$ -	$ 0.14	$	$	$ 0.14	$ 0.57
AA	$ 4.5	$ 4.5	$ 4.6	$ 4.7	$ 14.9	$ 15.5	$ 15.5	$ 16.3	$	$	$	$	$ 21.0
BB	$ 0.07	$ -	$ 0.07	$ 0.07	$	$	$	$	$ -	$ -	$ -	$	$ 0.07
CC	$ 0.21	$ 0.21	$ 0.21	$ 0.22	$ -	$ -	$ -	$ -	$ -	$ 0.021	$ 0.021	$ 0.023	$ 0.25
EE	$ 0.49	$ -	$	$ 0.49	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.49
GG	$ 0.42	$ 0.43	$ 0.43	$ 0.44	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.44
TT	$	$ -	$ 12.3	$ 12.3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 12.3
TOTAL	**$ 1,058**	**$ 1,066**	**$ 1,082**	**$ 1,129**	**$ 74.1**	**$ 76.8**	**$ 77.3**	**$ 80.9**	**$ 0.74**	**$ 10.8**	**$ 10.2**	**$ 11.9**	**$ 1,223**

[a] See Appendix B for detailed summary for each subpart.

Table C-10. Capital Costs (million dollars) for Each Scenario, Based on Potential CEMS Counts[a]

Subpart	Capital Costs (Million Dollars)												
	Scenario 1				Scenario 2				Scenario 3				Total - All Scenarios
	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	
C	$ 1,578	$ 1,603	$ 1,640	$ 1,960	$ 111	$ 114	$ 117	$ 146	$	$ 6.8	$ 7.7	$ 11.9	$ 2,118
E	$	$ 0.37	$	$ 0.37	$	$	$	$	$ -	$	$	$	$ 0.4
F	$ 1.2	$	$	$ 1.2	$	$	$	$	$ -	$	$	$	$ 1.2
G	$ 2.7	$	$ -	$ 2.7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2.7
H	$	$ -	$ -	$	$ -	$ -	$ -	$ -	$ 0.56	$ 3.1	$ 3.5	$ 7.0	$ 7.0
K	$ 1.2	$ -	$ 1.3	$ 1.4	$ -	$ -	$ -	$ -	$	$ -	$ -	$ -	$ 1.4
L	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$	$	$	$
N	$ 13.2	$ 13.4	$ 13.7	$ 16.3	$ -	$ -	$ -	$ -	$ -	$ 0.066	$ 0.074	$ 0.11	$ 16.5
O	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$
P	$ 12.3	$ 12.5	$ 12.8	$ 15.3	$ -	$ -	$ -	$ -	$ -	$ 0.066	$ 0.074	$ 0.11	$ 15.4
Q	$ 18.6	$ 18.9	$ 19.3	$ 23.1	$ -	$ -	$ -	$ -	$ -	$ 0.31	$ 0.35	$ 0.54	$ 23.6
R	$ 1.6	$ 1.6	$ 1.7	$ 2.0	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 2.0
S	$	$	$	$	$ -	$ 7.2	$ 7.4	$ 8.4	$ -	$	$	$	$ 8.4
U	$ 2.2	$	$	$ 2.2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2.2
V	$ -	$ 3.6	$ -	$ 3.6	$ -	$	$	$	$ -	$ 0.79	$ -	$ 0.79	$ 4.4
X	$ 7.9	$ 8.0	$ 8.2	$ 9.8	$ -	$ -	$ -	$ -	$ -	$ 0.044	$ 0.050	$ 0.077	$ 9.9
Y	$ 155	$ 158	$ 161	$ 193	$ 18.1	$ 18.5	$ 19.0	$ 23.7	$ 2.08	$ 2.85	$ 3.23	$ 6.48	$ 223.1
Z	$ 0.74	$	$	$ 0.74	$ -	$ -	$ -	$ -	$ 0.14	$	$	$ 0.14	$ 0.88
AA	$ 3.5	$ 3.5	$ 3.6	$ 4.3	$ 29.2	$ 29.8	$ 30.7	$ 38.2	$	$	$	$	$ 42.5
BB	$ 0.12	$ -	$ 0.13	$ 0.14	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$	$ 0.14
CC	$ 0.37	$ 0.37	$ 0.38	$ 0.46	$	$	$	$	$ -	$ 0.022	$ 0.025	$ 0.038	$ 0.50
EE	$ 0.86	$ -	$	$ 0.86	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.86
GG	$ 0.74	$ 0.75	$ 0.77	$ 0.92	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.92
TT	$	$ -	$ 22.1	$ 22.1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 22.1
TOTAL	**$ 1,801**	**$ 1,823**	**$ 1,885**	**$ 2,260**	**$ 158.7**	**$ 169.0**	**$ 174.4**	**$ 216.4**	**$ 2.8**	**$ 14.0**	**$ 15.0**	**$ 27.2**	**$ 2,504**

[a] See Appendix B for detailed summary for each subpart.

Table C-11. Annual Costs (million dollars) for Each Scenario, Based on Potential CEMS Counts[a]

Subpart	Annual Costs (Million Dollars)												
	Scenario 1				Scenario 2				Scenario 3				Total - All Scenarios
	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	CO_2	N_2O	CH_4	Total	
C	$ 901	$ 911	$ 915	$ 950	$ 64.5	$ 66.9	$ 67.3	$ 70.4	$	$ 6.6	$ 6.7	$ 7.1	$ 1,027
E	$	$ 0.21	$	$ 0.21	$	$	$	$	$ -	$	$	$	$ 0.21
F	$ 0.70	$	$	$ 0.70	$ -	$ -	$	$	$ -	$	$	$	$ 0.70
G	$ - 1.5	$	$ -	$ 1.5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.5
H	$	$ -	$ -	$	$ -	$ -	$ -	$ -	$ - 0.6	$ - 3.0	$ - 3.0	$ - 3.4	$ 3.4
K	$ 0.70	$ -	$ - 0.71	$ 0.73	$ -	$ -	$ -	$ -	$	$ -	$ -	$ -	$ 0.73
L	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$	$	$	$
N	$ 7.5	$ - 7.6	$ 7.6	$ 7.9	$ -	$ -	$ -	$ -	$ -	$ - 0.06	$ - 0.06	$ - 0.07	$ 8.0
O	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
P	$ 7.0	$ 7.1	$ 7.1	$ 7.4	$ -	$ -	$ -	$ -	$ -	$ 0.06	$ 0.06	$ 0.07	$ 7.5
Q	$ - 10.6	$ - 10.7	$ - 10.8	$ - 11.2	$ -	$ -	$ -	$ -	$ -	$ - 0.30	$ - 0.30	$ - 0.32	$ - 11.5
R	$ 0.91	$ 0.92	$ 0.93	$ 0.96	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.96
S	$	$	$	$	$ -	$ - 4.2	$ - 4.3	$ - 4.4	$ -	$	$	$	$ 4.4
U	$ 1.3	$	$	$ 1.3	$ -	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.3
V	$ -	$ - 2.1	$ -	$ - 2.1	$ -	$ -	$	$	$ -	$ - 0.76	$ -	$ - 0.76	$ 2.8
X	$ - 4.5	$ - 4.5	$ - 4.6	$ 4.7	$ -	$ -	$ -	$ -	$ -	$ - 0.042	$ - 0.043	$ - 0.046	$ 4.8
Y	$ 89	$ 90	$ 90	$ 94	$ - 10.5	$ - 10.9	$ - 10.9	$ - 11.4	$ - 2.14	$ 2.75	$ 2.79	$ 3.15	$ 108.1
Z	$ 0.42	$	$	$ 0.42	$	$	$	$	$ 0.14	$	$	$ 0.14	$ 0.57
AA	$ 2.0	$ 2.0	$ 2.0	$ 2.1	$ - 16.9	$ - 17.6	$ 17.6	$ 18.5	$	$	$	$	$ 20.6
BB	$ 0.07	$ -	$ - 0.07	$ 0.07	$	$	$ -	$ -	$ -	$ -	$ -	$	$ 0.07
CC	$ 0.21	$ - 0.21	$ 0.21	$ 0.22	$ -	$ -	$ -	$ -	$ -	$ - 0.021	$ - 0.021	$ - 0.023	$ 0.25
EE	$ 0.49	$	$	$ 0.49	$ -	$ -	$ -	$ -	$ -	$	$	$	$ 0.49
GG	$ 0.42	$ 0.43	$ 0.43	$ 0.44	$ -	$ -	$	$	$ -	$	$	$	$ 0.44
TT	$	$ -	$ - 12.3	$ 12.3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 12.3
TOTAL	**$ 1,029**	**$ 1,036**	**$ 1,052**	**$ 1,099**	**$ - 91.9**	**$ - 99.6**	**$ - 100.1**	**$ - 104.7**	**$ - 2.9**	**$ - 13.5**	**$ - 13.0**	**$ - 15.1**	**$ 1,217**

[a] See Appendix B for detailed summary for each subpart.