TECHNICAL SUPPORT DOCUMENT FOR CO_2 SUPPLY: PROPOSED RULE FOR MANDATORY REPORTING OF GREENHOUSE GASES

CONTENTS

1. Source Description

Preliminary estimates indicate that the amount of CO_2 captured from industrial processes and natural sites and used for enhanced oil recovery (EOR) is approximately 39 $MMTCO_2e$. An additional 1.6 $MMTCO_2e$ is estimated to be captured for non-EOR applications (EPA 2008). Inclusion of CO_2 suppliers in a mandatory GHG reporting program would allow for the tracking of the total supply of CO_2 being used in the economy, whether it is for EOR, or any number of emissive end uses, such as beverage manufacturing. The successful implementation of any future policies or programs for geologic sequestration will rely on knowing the total potential CO_2 that has been supplied to the economy.

There are potentially three different entities that might be the point of reporting for CO_2 supply: CO_2 capture facilities, natural CO_2 production wells, and transport systems (e.g., CO_2 pipelines). This technical support document attempts to address issues associated with incorporating CO_2 supply in a mandatory reporting system. This document focuses on reporting of CO_2 supply. Although not the focus of this document, some options for quantifying fugitive emissions at capture and production sites are also discussed.

a. Overview

Processes to which CO_2 capture could be applied include fossil fuel-fired electric power plants, natural gas processing plants, cement kilns, iron and steel mills, ammonia manufacturing plants, petroleum refineries, petrochemical plants, hydrogen production plants, and other combustion and industrial process sources. Carbon dioxide is also produced commercially for use in EOR from natural underground CO_2 reservoirs, and produced commercially for use in industrial gas applications (e.g., food production, chemical manufacturing).

Carbon dioxide is currently being produced and captured in the United States for the purposes of CO_2-based Enhanced Oil Recovery (EOR). EOR involves injecting CO_2 into injection wells at well fields for the purposes of increasing crude oil production. Some of the injected CO_2 is recovered with and separated from the produced oil and then recompressed and reinjected into the well field. The CO_2 being used in EOR is primarily produced from naturally-occurring underground CO_2 reservoirs, but is also captured from natural gas processing plants and ammonia plants. There are approximately 80 operating EOR sites in the United States that are injecting CO_2. However, there are no operating CO_2 storage sites in the U.S.[1]

Pipelines could also be considered a point of reporting for CO_2 supply. Transport systems carry CO_2 captured at industrial facilities and CO_2 production well facilities and transport it to an end user (e.g., industrial facilities or EOR operations). Based on data from the Department of Transportation's Office of Pipeline Safety, there were approximately

[1] Appendix A is a *Summary of Carbon Capture, Injection, and Storage Research and Demonstration Projects* developed by the National Energy Technology Laboratory.

3,740 miles of CO_2 transport pipelines operating in the United States in 2006, operated by approximately 27 separate business entities (some of which are subsidiaries of parent companies). Pipelines operated by five of these business entities were inactive in 2006, with no CO_2 being transported.[2]

b. Definition of Source Category

For CO_2 supply, monitoring and reporting procedures depend on the type and purpose of facility operations. The monitoring and reporting procedures differ by the following three source categories:

- CO_2 Capture Sites
- CO_2 Production Well Sites
- Transport Systems

Each of these source categories is described below.

CO_2 Capture Sites

Capture of CO_2 can occur at industrial facilities (e.g., ammonia production plants, natural gas processing plants) and combustion source facilities (e.g., electric power or steam production). The source category for CO_2 capture is defined as production process units that capture a carbon dioxide stream for purposes of supplying carbon dioxide for commercial applications.

In most cases, identification of the CO_2 capture facility and the facility from which the CO_2 is captured is straightforward. Individual CO_2 capture facilities are typically associated with industrial or combustion sites (e.g., stationary source electric power production, cement production, ammonia production). The installations from which the CO_2 is being captured are readily identifiable as a facility, and given their generally larger size (e.g., cement production.), would likely already be included in a reporting program However, note that the CO_2 capture process is a separate and distinct source category from the process from which the CO_2 is captured, even if owned and operated by the same facility, and could therefore be subject to different reporting thresholds.

Also, commercial industrial gas suppliers may establish CO_2 capture and processing plants adjacent to an industrial or combustion facility that generates CO_2 (e.g., an ammonia plant) and in this case the facility generating the CO_2 and the facility capturing the CO_2 may be two separate and distinct legal entities and also two separate and distinct reporting facilities. In either case, the CO_2 capture process may be a potential facility subject to reporting for the purposes of reporting CO_2 supply.

CO_2 Production Well Sites

[2] Department of Transportation's Office of Pipeline Hazardous Liquid Annuals Data Report. http://ops.dot.gov/stats/DT98.htm

The source category for CO_2 production is defined as carbon dioxide production wells that drill in the earth to extract a carbon dioxide stream from a geologic formation or group of formations which contain deposits of carbon dioxide. The production of CO_2 from natural CO_2 formations is categorized separately from "CO_2 capture," because of the different methods associated with producing and quantifying CO_2 at these facilities. Production of CO_2 from natural formations involves extracting a CO_2 stream from the natural formation using CO_2 production wells and subsequent processing of the CO_2.

For the purposes of defining a "facility" a CO_2 production well means any hole drilled in the earth from which a carbon dioxide stream is extracted. A CO_2 production well facility could then be defined as one or more carbon dioxide production wells that are located on one or more contiguous or adjacent properties, which are under the control of the same person (or persons under common control). Under this definition, carbon dioxide production wells located on different oil and gas leases, mineral fee tracts, lease tracts, subsurface or surface unit areas, surface fee tracts, surface lease tracts, or separate surface sites, whether or not connected by a road, waterway, power line, or pipeline, would be considered part of the same CO_2 production well facility.

Transport Systems

Transport systems carry CO_2 captured at industrial and combustion facilities and CO_2 production well facilities and transport it to an end user (e.g., industrial facilities or EOR operations). Transport systems include CO_2 pipelines and associated surface equipment (e.g., compressors, pumps, valves, flanges). At this time, the majority of CO_2 transported for commercial use (e.g., to EOR operations) is transported by pipeline.

Pipelines could be considered for inclusion in a mandatory reporting program for the purposes of reporting CO_2 supply. The primary challenge with including transport systems in a reporting program would be defining a facility. One option considered for defining the facility is a contiguous pipeline owned and operated by a single business entity. Another option for reporting of CO_2 supply from a pipeline might be to require corporate-level reporting. This would avoid having to explicitly define a facility, while still ensuring that all CO_2 transported, including fugitive emissions from transport, would be reported.

For purposes of this background document, transport facilities were not considered the most likely candidates for reporting due to the difficulty in defining a facility and potentially complex resource ownership issues with pipelines. One disadvantage of exempting transport systems from reporting would be that data would not be available on the amount of CO_2 actually transported in the CO_2 pipeline system. These data would potentially be useful for quality assurance purposes. For example, discrepancies between the total amount of CO_2 reported captured and the total amount of CO_2 reported injected and stored could not be as easily resolved in the absence of data from CO_2 transport systems.

c. Total Emissions

The U.S. GHG Inventory includes a discussion of the amount of CO_2 captured or produced for EOR and injected at the approximately 80 operating EOR sites in the United States.[3] The discussion in the U.S. GHG Inventory identifies the amount of CO_2 produced annually from natural CO_2 sources for injection for EOR and the amount of CO_2 captured from natural gas processing plants and ammonia plants for injection for EOR. Preliminary estimates indicate that the amount of CO_2 captured from industrial process and natural sites and used for EOR is, 39.0 $MMTCO_2e$. According to the U.S. GHG Inventory, an additional 1.6 $MMTCO_2e$ is captured and used for non-EOR applications, for example chemical manufacturing and food production. Further research conducted in support of this rulemaking identified four additional combustion process facilities (coal-fired electric power plants) that are capturing CO_2. Data for these facilities indicates that an additional approximately 511,600 $mtCO_2e$ per year are being captured for use as food-grade CO_2 (three plants) and for production of soda ash (one plant.)[4]

A total of 31.4 $MMTCO_2e$ were produced from natural CO_2 sources in 2006 and a total of 7.0 $MMTCO_2e$ were captured from natural gas processing plants and ammonia plants in 2006, for injection for EOR. Of the 7.0 $MMTCO_2e$, 6.3 MMTCO2e is from gas processing and 0.7 $MMTCO_2e$ was captured from one ammonia plant in 2006 (a second ammonia plant commenced capturing CO_2 in 2007). Time series data for CO_2 production and capture for injection for EOR are included in Table 1. Table 1 is reproduced from Table 3-45 of the 1990-2006 U.S. Inventory. Time series data for CO_2 capture for food-grade and industrial-grade CO_2 (used for chemical production) are included in Table 2. The facilities in Table 2 include those facilities listed in Table 4-41 of the 1990-2006 Inventory, as well as the additional facilities identified during this effort.

Table 1: Potential Emissions from CO_2 Capture (1,000$mtCO_2e$)

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006
Acid Gas Removal Plants	**4,832**	**3,672**	**2,264**	**2,894**	**2,943**	**2,993**	**3,719**	**5,992**	**6,997**
Naturally Occurring CO_2	**20,811**	**22,547**	**23,149**	**23,442**	**22,967**	**24,395**	**27,002**	**28,192**	**31,359**
Ammonia Production Plants	**0**	**676**	**676**	**676**	**676**	**676**	**676**	**676**	**676**

[3] U.S. Inventory 1990-2006: *Box 3-3: Carbon Dioxide Transport, Injection, and Geological Storage*
[4] http://www.co2captureandstorage.info/cont_northamerica.php

Total	**25,651**	**26,904**	**26,098**	**27,020**	**26,595**	**28,073**	**31,405**	**34,868**	**39,041**

Table 2: CO_2 Capture for non-EOR Applications (1,000mtCO_2e)

Year	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
CO_2 Captured	**1,768**	**1,890**	**1,933**	**1,341**	**1,501**	**1,823**	**1,710**	**1,833**	**2,091**

d. Types of Emissions to be Reported

In a mandatory reporting system where industrial facilities and CO_2 production well facilities are reporting the amount of CO_2 that they supply to the market, the amount of CO_2 reported could be equal to the total amount of CO_2 captured or extracted, or the amount of CO_2 transferred offsite, depending upon the available data. Reporting on the amount captured or extracted would be the most accurate estimate of total CO_2 supply, because it would account for total CO_2 prior to any onsite purification, processing, and compression of the gas. The amount of CO_2 available for sale (i.e., for transfer offsite to commercial customers) would be the total captured or extracted, less any fugitive emissions resulting from these processes. Note that it is assumed that the entire amount of the captured or extracted CO_2 that is transferred off site is assumed to be emitted to the atmosphere from downstream systems in which the CO_2 is used.

Fugitive CO_2 emissions from capture or production of CO_2 include both unintentional and intentional releases. Fugitive emissions may arise from leakage of CO_2 from surface equipment such as flanges, valves, and flow meters. Emissions could also arise from compressor seal vents, CO_2 dehydrator vents, and other equipment in which produced or captured CO_2 is handled or processed.

Stationary combustion emissions (CO_2, CH_4 and N_2O) associated with CO_2 supply would be related to fossil fuel-fired engines and turbines used to operate pumps, compressors, and other equipment, and also related to fossil fuel-fired combustion systems to provide process heat and/or electricity, including, for example, energy needed to heat amines used to separate CO_2 from gas streams. GHG emissions from combustion sources are discussed in the Stationary Combustion Technical Support Document (EPA-HQ-OAR-2008-0508-004) and are not discussed further here.

There may be specific types of operations in which the produced CO_2 would also have a CH_4 component (but this is considered to be unlikely). However, any non-CO_2 emissions are expected to be low so they are not considered further here.

2. Options for Reporting Threshold

a. Overview of Options Considered

The options for reporting threshold for CO_2 supply are summarized in Table 3, and expanded upon in the sections below.

Table 3. Summary of Options Considered

Source	Description of Option
Production	
Option 1	All CO_2 production well facilities could be required to report the amount of CO_2 extracted and the amount of CO_2 transferred off site.
Option 2	A reporting threshold could be set based on the amount of CO_2 produced. CO_2 production well facilities that produce less than the threshold amount of CO_2 annually would not be required to report
Capture	
Option 1	All CO_2 capture facilities could be required to report all CO_2 captured and the amount of CO_2 transferred off site.
Option 2	Set a reporting threshold for CO_2 capture facilities. CO_2 capture facilities that capture less than the threshold amount of CO_2 annually would not be required to report.

There were multiple options considered for including CO_2 supply into a threshold analysis, including:

- Should EPA set a reporting threshold for CO_2 capture and CO_2 production well facilities based on the amount of CO_2 supply, or should EPA require that all CO_2 capture and CO_2 production well facilities report?

- Should CO_2 capture and CO_2 production well facilities be required to separately report the amount of CO_2 supply and the onsite fugitive GHG emissions, or should CO_2 capture and CO_2 production well facilities be required to only report the amount of CO_2 supply? Because this document focuses exclusively on the supply of CO_2 to the economy, and not fugitive emissions from the entire chain of carbon dioxide capture, transport, injection and storage, fugitive emissions were not explicitly addressed in the above options. Note, however, that if the total CO_2 extracted is reported, this would implicitly include any subsequent fugitive emissions from operations downstream of extraction.

- An issue not explicitly addressed in this document, but which is relevant for facilities where CO_2 is captured, is whether the emissions reporting threshold for the facility should assume that no carbon capture occurs, or whether the reporting threshold for the facility should be based on the net emissions from the facility [i.e., should the facility threshold determination be based on gross GHG emissions or net GHG emissions?][5].

[5] Note that the facility from which the carbon is captured (e.g., an ammonia plant) may be a different legal entity, and a separate facility, than the facility that is capturing the CO_2 (e.g., a commercial industrial gas supplier.)

Allowing a facility from which CO_2 is being captured to incorporate the CO_2 capture into the facility emissions reporting threshold analysis suggests that that CO_2 is never emitted to the atmosphere. However, in order to know whether this CO_2 is ultimately emitted, the facility from which the carbon is being captured (e.g., a utility) would have to know the end use of the CO_2 (i.e., whether it is used for emissive or non-emissive purposes). Due to the fact that the use of a facility's net emissions to determine emissions reporting threshold applicability is not transparent, the fact that net emissions at the facility could change significantly on a year to year basis depending on the capture operations, and the fact that facilities may not know the end use application of the CO_2, this is likely not a favorable approach.

b. CO_2 Production Well Facilities

Option 1 (Production)

Under Option 1, all facilities producing CO_2 from natural CO_2 formations for the purposes of injection (e.g., EOR), for storage, or for other purposes would pass the threshold and report the amount of CO_2 extracted and the amount transferred offsite. It is estimated that CO_2 produced from each CO_2 production well facility is significantly greater than any commonly considered threshold level (Table 4). CO_2 production from an individual CO_2 production well facility ranged from about 883,000 $mtCO_2e$ annually to over 18 $MMTCO_2e$ annually.

Table 4. Threshold Analysis Based on Quantity of CO_2 Extracted at CO_2 Production Well Facilities

Source Category	Threshold Level ($mtCO_2e$)	Total Production ($mtCO_2e$)	Number of Facilities	$mtCO_2e$/ yr over Threshold	Percent of Emissions over Threshold	Number of Facilities over Threshold	Percent of Facilities over Threshold
Extraction from Natural CO_2 Formations	1,000	31,358,853	4	31,358,853	100%	4	100%
	10,000	31,358,853	4	31,358,853	100%	4	100%
	25,000	31,358,853	4	31,358,853	100%	4	100%
	100,000	31,358,853	4	31,358,853	100%	4	100%

Option 2 (CO_2 Production Well Facilities)

Under Option 2, EPA could set a reporting threshold based on the amount of CO_2 extracted or transferred offsite annually. Based on Table 4 above, all CO_2 production well facilities would extract significantly more CO_2 than any of the considered thresholds. Therefore, there would be no difference between establishing a threshold level, and indicating that all CO_2 producers must report. Note that both Option 1 and Option 2 define a "CO_2 production well facility" at the "dome" level (i.e., Jackson Dome, Bravo Dome, McElmo Dome, and Sheep Mountain Dome are each considered a facility)

and does not consider the distribution of individual CO_2 production wells at each of these locations. There are a number of options for defining the reporter, and the definition of "facility" could be based on the specific distribution of CO_2 production wells from which the reporter would have to report the amount of CO_2 extracted.

For example, Denbury Resources reported that the company operates (as of 2004) 15 CO_2 production wells at three separate locations in northern Rankin County Mississippi, near Jackson, producing approximately 4.8 $MMTCO_2$ per year. [6] These three locations are referred to as the Goshen Springs Field, the Picah Field, and the Holly Bush Creek Field. Information is not available as to how many CO_2 production wells Denbury Resources is operating at each location, however, EPA could define the entire Jackson Dome as a single "CO_2 production well facility" or define each of the three field locations as a "facility" for the purposes of reporting.

c. CO_2 Capture Facilities

Option 1 (CO_2 Capture Facilities)

Under Option 1, all facilities conducting capture of CO_2 could be required to report the amount of CO_2 captured and transferred, regardless of the amount of CO_2 captured.

A primary rationale for requiring all CO_2 capture to be reported is to ensure equity among CO_2 capture sites, as well as to provide the necessary data to evaluate future policies and programs related to the full chain of carbon dioxide capture, transport, injection and storage. Complete reporting of CO_2 capture would be a strong quality control check when assessing the total amount of CO_2 injected and stored.

Option 2 (CO_2 Capture Facilities)

Under Option 2, EPA could set a reporting threshold based on the amount of CO_2 captured annually. There are currently nine CO_2 capture operations operating in the U.S. for which data are available concerning the amount of CO_2 being captured. As shown in Table 5, based on available information, each of these CO_2 capture facilities is capturing more than 25,000 $mtCO_2e$ annually. If a threshold were established at 100,000 $mtCO_2e$ captured, four facilities would fall under the reporting threshold and would not be required to report the quantity of CO_2 captured. The number of potential new [future] CO_2 capture facilities has not been estimated.

[6] http://findarticles.com/p/articles/mi_qa5277/is_200405/ai_n24278763 Carbon dioxide an often overlooked natural resource, The Mississippi Business Journal, May 03, 2004 by McNeill, George

Table 5. Threshold Analysis Based on Quantity of CO_2 Captured

Source Category	Threshold Level ($mtCO_2e$)	Total Capture ($mtCO_2e$)	Number of Facilities	Metric tons CO_2e/ yr over Threshold	Percent of Emissions over Threshold	Number of Entities over Threshold	Percent of Facilities over Threshold
Capture at Industrial Process and Stationary Combustion Facilities	1,000	8,186,881	9	8,186,881	100%	9	100%
	10,000	8,186,881	9	8,186,881	100%	9	100%
	25,000	8,186,881	9	8,186,881	100%	9	100%
	100,000	8,038,478	5	8,038,478	98%	5	56%

3. Monitoring Methods Considered

This section presents the monitoring methods for CO_2 production well facilities and CO_2 capture facilities. One method was proposed for monitoring the total quantity of CO_2 supplied. An additional method was also initially considered which would enable the measurement of fugitive emissions in addition to CO_2 supply.

(i) CO_2 Production Well Facilities

Direct Measurement of CO_2 Supply and Fugitive CO_2 Emissions

For direct measurement of the CO_2 supply and also measurement of the fugitive CO_2 emissions from the CO_2 production process, the flow rate of CO_2 produced from the CO_2 production wells and the composition of the CO_2 produced from the CO_2 production wells would be monitored at the points of extraction (i.e., at the CO_2 production wells). The flow rate and composition of the CO_2 produced and transferred to an offsite CO_2 transport system would also be directly monitored. The difference between the flow measurement of CO_2 at the point of extraction and the flow measurement of CO_2 at the point of transfer would be the fugitive CO_2 emissions from the CO_2 production process, including all equipment located between the point of capture and the point of transfer (e.g., valves, flanges, compressor vents.) In addition, leak detection monitoring (e.g., infrared detection) would need to be applied to estimate the fugitive CO_2 emissions from any CO_2 production process equipment that is located upstream of the point where the amount of CO_2 extracted is measured (e.g., the CO_2 production well heads would generally be upstream of the point at which the amount of CO_2 extracted from the wells is measured.) The fugitive emissions from upstream equipment would be added to the difference between the amount extracted and the amount transferred to obtain the total fugitive emissions from the CO_2 production process.

In addition to measuring the volume of the CO_2 stream captured, it would be necessary to determine the CO_2 composition of the CO_2 stream sold. As the CO_2 stream is not necessarily 100% pure CO_2, quarterly samples would be required to determine the CO_2 content of the stream. Alternatively, an assumption could be made about the CO_2 content

of the sold gas, based on the end user of the gas. For example, food grade CO_2 is usually required to be of a known quality, similar to pipeline quality gas.

Direct Measurement of CO_2 Supply (Only)

For direct measurement of the CO_2 supply without any measurement of the fugitive CO_2 emissions from the CO_2 production process, the flow rate of the CO_2 stream produced from the CO_2 production wells and the composition of the CO_2 stream produced from the CO_2 production wells would be monitored either at the points of extraction (i.e., at the CO_2 production wells) or at the point at which the produced CO_2 is transferred to an offsite CO_2 transport system, or both.

The value of the CO_2 flow measured at the point of extraction would be somewhat different than the value of the CO_2 measured at the point of transfer. The value measured at the point of extraction would be the total amount of CO_2 extracted including any [downstream] fugitive emissions from the CO_2 production process. The value measured at the point of transfer would be the total amount of CO_2 extracted less any [upstream] fugitive emissions from the CO_2 production process. The principal advantage of measuring the CO_2 supply at the point of transfer rather than at the point of extraction is that CO_2 production well facilities are likely already measuring the amount of CO_2 transferred using existing equipment, but may not already be directly measuring the amount of CO_2 extracted at the CO_2 production wells. There may be an additional cost for installation of monitoring equipment to directly measure the amount of CO_2 extracted.

Similar to the discussion for "Direct Measurement of CO_2 Supply and Fugitive CO_2 Emissions" above, gas composition would also have to be quantified.

(ii) CO_2 Capture Facilities

Direct Measurement of CO_2 Supply and Fugitive CO_2 Emissions

For CO_2 capture facilities, the monitoring approach for monitoring both the CO_2 supply and fugitive CO_2 emissions would be to monitor the amount of CO_2 going into the carbon capture process, monitor the amount of (un-captured) CO_2 going out of the capture process, and monitor the amount of CO_2 that is actually captured by the CO_2 capture process. Alternatively, one could subtract the CO_2 captured by the capture process from the CO_2 input to the capture process to estimate "fugitive" emissions from the carbon capture process itself, i.e., the amount of CO_2 actually emitted from valves, flanges, etc.. This method also directly monitors the amount of CO_2 captured, i.e., the CO_2 supply.

As above, gas composition would have to be quantified in a similar manner to quantify the total potential CO_2 supplied.

Direct Measurement of CO_2 Supply (Only)

If the only parameter of interest is the CO_2 supply, then the amount of CO_2 could be monitored either at the point where the captured CO_2 exits the capture system or at the point where the captured CO_2 is transferred offsite. As described for CO_2 production, above, the value measured at the point of capture would be the total amount of CO_2 captured including any [downstream] fugitive emissions from the CO_2 capture process (e.g., CO_2 compressors, dehydrators, and other downstream equipment). The value measured at the point of transfer would be the total amount of CO_2 extracted less any [upstream] fugitive emissions from the CO_2 capture process. The principal advantage of measuring the CO_2 supply at the point of transfer rather than at the point of capture is that CO_2 capture sites are likely already measuring the amount of CO_2 transferred using existing equipment, but may not already be directly measuring the amount of CO_2 captured. There may be an additional cost for installation of monitoring equipment to directly measure the amount of CO_2 captured rather than the amount transferred.

As above, gas composition would have to be quantified in a similar manner to quantify the total potential CO_2 supplied.

Additional alternative monitoring methods for monitoring fugitive CO_2 emissions from CO_2 capture facilities and CO_2 production well facilities are include in Attachment 1. These methods could be applied as alternatives to direct measurement of CO_2 inlet and outlet flow rates using continuous emissions monitors (CEMS). The alternative methods listed in Attachment 1 may involve lower capital and operating costs than direct measurement using CEMS.

4. Procedures for Estimating Missing Data

a. CO_2 Production Facilities and CO_2 Capture Facilities

Monitoring of CO_2 Supply from Production Facilities

Monitoring of CO_2 supply for CO_2 production well facilities is based on direct measurement using CEMS. Procedures for management of missing data are established under Part 75 (Acid Rain Program.) These procedures would be applicable to direct measurement using CEMS for CO_2 production facilities.

Part 75 Procedures for Estimating Missing CEMS Data

Procedures for management of missing data are described in Part 75.35(a), (b), and (d). In general, missing data from operation of the CEMS may be replaced with substitute data to determine the CO_2 flow rates or CO_2 emissions during the period in which CEMS data are missing.

Under Part 75.35(a), the owner or operator of a unit with a CO_2 CEMS for determining CO_2 mass emissions in accordance with Part 75.10 (or an O_2 monitor that is used to determine CO_2 concentration in accordance with appendix F to this part) shall substitute for missing CO_2 pollutant concentration data using the procedures of paragraphs (b) and

(d) of this section. Subpart (b) covers operation of the system during the first 720 quality-assured operation hours for the CEMS. Subpart (d) covers operation of the system after the first 720 quality-assured operating hours are completed.

Under Part 75.35(b), during the first 720 quality assured monitor operating hours following initial certification at a particular unit or stack location (i.e., the date and time at which quality assured data begins to be recorded by a CEMS at that location), or (when implementing these procedures for a previously certified CO_2 monitoring system) during the 720 quality assured monitor operating hours preceding implementation of the standard missing data procedures in paragraph (d) of this section, the owner or operator shall provide substitute CO_2 pollutant concentration data or substitute CO_2 data for heat input determination, as applicable, according to the procedures in Part 75.31(b).

Under Part 75.35(d), upon completion of 720 quality assured monitor operating hours using the initial missing data procedures of Part 75.31(b), the owner or operator shall provide substitute data for CO_2 concentration or substitute CO_2 data for heat input determination, as applicable, in accordance with the procedures in Part 75.33(b) except that the term " CO_2 concentration" shall apply rather than "SO_2 concentration," the term "CO_2 pollutant concentration monitor" or "CO_2 diluent monitor" shall apply rather than "SO_2 pollutant concentration monitor," and the term "maximum potential CO_2 concentration, as defined in section 2.1.3.1 of appendix A to this part" shall apply, rather than "maximum potential SO_2 concentration."

Monitoring of CO_2 Supply from Capture Facilities

One option for "missing data" for CO_2 capture facilities is that it could be assumed that the facility did not capture any CO_2 during the reporting period for which CEMS data for the amount of CO_2 captured are missing. If the amount of CO_2 captured is not reported, 100 percent of the CO_2 emissions from the industrial process source or stationary combustion source would be assumed to be emitted to the atmosphere and zero percent of the CO_2 emissions would be assumed to be captured.

Another option for estimating missing data for CO_2 capture is that alternative data could be used, using the procedures described above under Part 75. For example, the amount of CO_2 captured would be metered at the capture facility fenceline, i.e., at the point where the CO_2 is transferred from the capture site to the offsite transport system. If the amount of CO_2 transferred offsite from the capture process was metered, but the amount of CO_2 emitted from the capture process was not measured, the amount of CO_2 emitted could be estimated from the expected total amount generated by the industrial or stationary combustion source (e.g., using historical data) and the amount transferred offsite.

Missing CEMS data for the amount of CO_2 entering the capture process could be estimated using CO_2 (liquid) flow rate data (the amount of CO_2 captured) and a "capture process efficiency" factor developed from prior month or prior year CEMS data (e.g., using the historical CEMS data it can be estimated, over time, what percentage of the CO_2 input to the capture process was actually captured).

5. QA/QC and Data Verification Requirements

a. General QA/QC Requirements

Facilities could conduct quality assurance and quality control (QA/QC) of production data, emissions measurements, flow measurements, carbon contents, and emission estimates reported. Facilities could be encouraged to prepare an in-depth QA/QC plan which would include checks on production data, carbon content data, and calculations performed to estimate GHG emissions. Examples of specific QA/QC procedures to include in a QA/QC plan for carbon dioxide capture and production are:

CO_2 Production Well Facilities and CO_2 Capture Facilities using CEMS

For CO_2 production well facilities and CO_2 capture facilities using CEMS to measure CO_2 inlet and outlet flow rates and fugitive CO_2 emissions, the equipment could be tested for accuracy and calibrated as necessary by a certified third party vendor. These procedures could be required to be consistent in stringency and data reporting and documentation adequacy with the QA/QC procedures for CEMS described in Part 75 of the Acid Rain Program.

CO_2 Production Well Facilities and CO_2 Capture Facilities Measuring CO_2 Supply Only

For CO_2 production well and CO_2 capture facilities using CEMS to measure CO_2 flow rates (CO_2 supply) but not fugitive CO_2 emissions, equipment could be required to be tested for accuracy and calibrated as necessary by a certified third party vendor. Mass flow meter calibrations could be required to be NIST traceable. Methods to measure the composition of the carbon dioxide captured, transferred, or extracted could be required to conform to applicable chemical analytical standards. For example, CO_2 used as a Generally Recognized As Safe (GRAS) direct human food ingredient must be analyzed for composition in accordance with U.S. Food and Drug Administration food-grade specifications for carbon dioxide (see 21 CFR 184.1250.) Carbon dioxide used in supercritical applications must be analyzed for composition in accordance with ASTM standard E-1745-95 (2005).

b. Equipment Maintenance

For units using flow meters to measure the amount of CO_2 captured or produced, flow meters could be required to be calibrated on a scheduled basis in accordance with equipment manufacturer specifications and standards. Flow meter calibration is generally conducted at least annually. A written record of procedures needed to maintain the flow meters in proper operating condition and a schedule for those procedures could be part of the QA/QC plan for the capture or production unit.

An equipment maintenance plan could be developed as part of the QA/QC plan. Elements of a maintenance plan for equipment could include the following:

- Conduct regular maintenance and calibration of equipment, including flow meters:

    - Keep a written record of procedures needed to maintain the monitoring system in proper operating condition and a schedule for those procedures.
    - Keep a record of all testing, maintenance, or repair activities performed on any monitoring system or component in a location and format suitable for inspection. A maintenance log may be used for this purpose. The following records could be maintained: date, time, and description of any testing, adjustment, repair, replacement, or preventive maintenance action performed on any monitoring system and records of any corrective actions associated with a monitor's outage period. Additionally, any adjustment that recharacterizes a system's ability to record and report emissions data could be required to be recorded (e.g., changing of flow monitor or moisture monitoring system polynomial coefficients, K factors or mathematical algorithms, changing of temperature and pressure coefficients and dilution ratio settings), and a written explanation of the procedures used to make the adjustment(s) could be kept.

c. Data Management

Data management procedures could be included in the QA/QC Plan. Elements of the data management procedures plan could be as follows:

- Assess the representativeness of carbon content data (e.g., for composition of CO_2 supplied to an injection site) by comparing the values received from the supplier to laboratory analysis;

- Check for temporal consistency in production data, carbon content data, and CO_2 emission and CO_2 flow estimates. If outliers exist, determine whether they can be explained by changes in the facility's operations, etc?
    - A monitoring error is probable if differences between annual data cannot be explained by:
        - Changes in activity levels;
        - Changes concerning input or output materials; or
        - Changes concerning the emitting process (e.g. process improvements).

- Determine the "reasonableness" of the emission estimate by comparing it to previous year's estimates and relative to national emission estimate for the industry:
    - Comparison of CO_2 delivered to or consumed by specific sources with purchasing or sales data and data on stock changes;
    - Comparison of CO_2 delivery or consumption totals with purchasing data and data on stock changes;

- Comparison of emission factors for specific equipment operations (e.g., CO_2 compressors) to national or international reference emission factors of comparable operations; and
- Comparison of measured and calculated emissions.

- Maintain data documentation, including comprehensive documentation of data received through personal communication:
  - Check that changes in data or methodology are documented.

d. Calculation Checks

Calculation checks could be performed for all reported calculations. Elements of calculation checks could include:

- Perform calculation checks by reproducing a representative sample of emissions calculations or building in automated checks such as computational checks for calculations;
- Check whether emission units, parameters, and conversion factors are appropriately labeled;
- Check if units are properly labeled and correctly carried through from beginning to end of calculations;
- Check that conversion factors are correct;
- Check the data processing steps (e.g., equations) in the spreadsheets;
- Check that spreadsheet input data and calculated data are clearly differentiated;
- Check a representative sample of calculations, by hand or electronically;
- Check some calculations with abbreviated calculations (i.e., back of the envelope checks);
- Check the aggregation of data across source categories, business units, etc.; and/or
- When methods or data have changed, check consistency of time series inputs and calculations

e. Data Verification

As part of the data verification requirements, the owner or operator could be required to submit a detailed explanation of how company records of measurements are used to quantify all sources of carbon input and output within a certain time period after receipt of a written request from EPA or from the applicable State or local air pollution control agency.

6. Data to Be Reported

a. Direct Measurement of CO_2 Supply for CO_2 production well and CO_2 capture Facilities

For direct measurement of CO_2 supply and fugitive emissions for CO_2 production well and CO_2 capture facilities, the primary monitoring method discussed is based on direct measurement of the gaseous and liquid CO_2 flows. The difference between the inlet and outlet CO_2 flows could be used to estimate the fugitive CO_2 emissions from the capture process. CO_2 capture facilities and CO_2 production well facilities could be required to report the CO_2 emissions and the measured CO_2 flows and measured CO_2 concentrations used to estimate the fugitive CO_2 emissions and CO_2 supply.

For measurement of CO_2 supply for CO_2 capture facilities and CO_2 production well facilities without measurement of fugitive CO_2 emissions, the primary monitoring methods discussed are based on direct measurement of the amount of CO_2 captured or extracted, or the amount of CO_2 transferred from the CO_2 production well or CO_2 capture facility to another facility. These facilities could be required to report the measured CO_2 flows and measured CO_2 concentrations used to estimate the CO_2 supply.

b. Additional Data for Verification

At a given production well or capture facility, if extraction/capture and the amount of CO_2 transferred offsite are reported, this provides one method of data verification. The difference between extraction/capture and offsite transfers could indicate if one of the pieces of data reported could be in error.

If the entire carbon extraction/capture, transport, injection and storage chain were included in a reporting program, additional data for verification could include data from CO_2 pipeline operators concerning the amount of CO_2 they are receiving from CO_2 production well facilities and CO_2 capture facilities and transporting to injection sites and storage sites. Under the various options, capture sites could report how much CO_2 they are transferring to the pipeline operators and injection sites and storage sites would report how much CO_2 they are receiving from pipeline operators. In the event that these reported values don't correspond, EPA may not be able to resolve this issue if there are no data from CO_2 pipeline operators to use for verification.

c. Additional data to be retained onsite (recordkeeping).

Facilities could be required to retain data concerning monitoring of CO_2 flows onsite for a period of at least five years from the reporting year. EPA could use such data to conduct trend analyses and potentially to develop process or activity-specific emission factors for carbon extraction or capture.

7. ATTACHMENTS

Attachment 1 summarizes alternative monitoring methods for CO_2 capture facilities and CO_2 production well facilities. These methods are potential elements of site-specific monitoring plans for monitoring fugitive CO_2 emissions that represent potential alternatives to direct measurement using CEMS. Schematic diagrams illustrating the alternative monitoring points for carbon capture and production are included as Attachment 2.

a. Attachment 1: Monitoring Methods for CO_2 Capture Facilities

1.1.1 Chemical Solvent (Amine) Absorption Unit

Process vent emissions

Solvent absorber tower vent flow rate:	Vent gas flow meter
Solvent absorber tower vent CO_2:	Continuous monitoring of CO_2 vent gas concentration
Captured CO_2 from regeneration unit:	Direct measurement of CO_2 flow rate using flow meter
Captured CO_2 from regeneration unit:	Continuous monitoring of captured CO_2 concentration or periodic sampling and analysis of captured CO_2 concentration

Fugitive CO_2 Emissions

Valves, flanges, flow meters:	Infrared Detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection

1.1.2 Gas Separation Membrane

Process Vent Emissions

Inflow flue gas flow rate:	Flue gas flow meter
Inflow flue gas CO_2 concentration:	Continuous monitoring of flue gas CO_2 concentration
Low pressure CO_2 outflow:	Direct measurement of CO_2 flow rate using flow meter
Low pressure CO_2 outflow:	Continuous monitoring of captured CO_2 concentration or periodic sampling and analysis of captured CO_2 concentration

Fugitive CO_2 Emissions

Valves, flanges, flow meters:	Infrared Detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection

1.1.3 Physical Absorption Unit

Process Vent Emissions

Exhaust/synthesis gas absorber tower vent:	Vent gas flow meter
Exhaust/synthesis gas absorber tower vent:	Continuous monitoring of vent gas CO_2 concentration
Captured CO_2 from regeneration unit:	Direct measurement of CO_2 flow rate using flow meter
Captured CO_2 from regeneration unit:	Continuous monitoring of captured CO_2 concentration or periodic sampling and analysis of captured CO_2 concentration

Fugitive CO_2 Emissions

Valves, flanges, flow meters:	Infrared Detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection

1.1.4 Hydrate-based Separation Unit (R&D stage)

Process Vent Emissions

Input Synthesis gas flow rate:	Direct measurement of synthesis gas flow rate using flow meter
Input Synthesis gas composition:	Continuous monitoring of synthesis gas CO_2 concentration
CO_2 product gas outflow rate:	Direct measurement of CO_2 flow rate using flow meter
CO_2 product gas outflow concentration:	Continuous monitoring of CO_2 outflow concentration or periodic sampling and analysis of CO_2 outflow concentration

Fugitive CO_2 Emissions

Valves, flanges, flow meters:	Infrared Detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection

1.2 CO_2 Production from Natural CO_2 Formations

Production of CO_2 from natural formations involves fugitive CO_2 emissions from CO_2 production wells (wellheads) and fugitive and vent emissions of CO_2 from associated piping systems (e.g., valves and flanges,) dehydration, and compression systems.

1.2.1 CO_2 Production Wells (and associated piping)

Fugitive emissions of CO_2 from CO_2 Production Wells

Monitoring Methods

Production Rate of CO_2:	Measurement of CO_2 flow from production wells at on-site metering stations
Composition of Produced CO_2:	Periodic measurement of composition of the CO_2 produced by CO_2 production wells ***(note that the "CO_2" produced by the CO_2 production wells will not be 100 percent carbon dioxide)***
Valves and Flanges:	Infrared Detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection
System Blowdown Venting:	Volume of blowdown vent gas (estimated from piping system volume and pressure); composition of vent gas (based on periodic sampling and analysis of CO_2 produced from the CO_2 production wells)
Casing/annulus pressure testing:	Volume of pressure test vent gas (flow meter) and composition of vent gas (based on periodic sampling and analysis of CO_2 from pressure testing the wells)
Production wellhead leakage:	Infrared detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection

1.2.2 CO_2 Dehydration System

The CO_2 Production Well Facility is assumed to have a CO_2 dehydration system to dehydrate the CO_2 produced by the CO_2 production wells.

Fugitive and vent emissions of CO_2 from CO_2 dehydration system

Monitoring Methods

Dehydrator Flash Tank Vent:	Vent gas flow rate (flow meter) and composition (CEMS or periodic vent gas sampling and analysis)
Valves and Flanges:	Infrared Detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection

Combustion emissions of CO_2 from CO_2 dehydration system

Monitoring Methods

Dehydrator Pump Engine Exhaust:	Fuel consumption (flow meter) and fuel composition (periodic sampling and analysis)

1.2.3 CO_2 Compression System

The CO_2 Production Well Facility is assumed to have a CO_2 compression system to compress the CO_2 for delivery to the CO_2 pipeline.

Fugitive and vent emissions of CO_2 from CO_2 compression system

Monitoring Methods

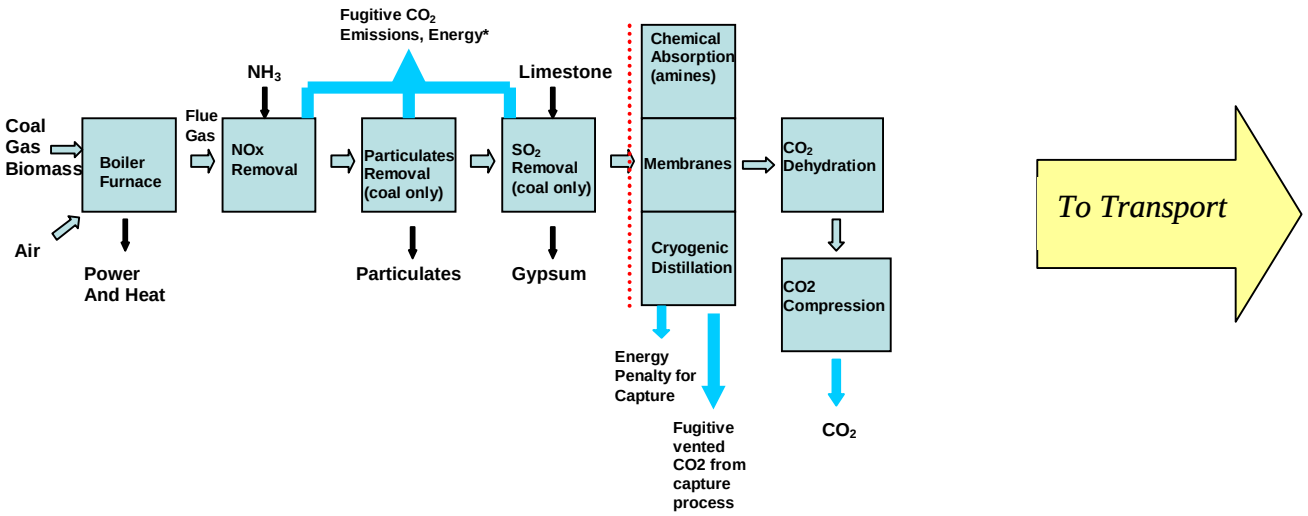
Compressor Seals Exhaust Vent:	Infrared detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection
Compressor Seals Exhaust Vent	Open ended line measurement: vent gas flow rate (flow meter) and composition (CEMS or periodic vent gas sampling and analysis)
Pressure Relief Valves:	Estimated from number of pressure relief incidents and periodic sampling analysis of composition of CO_2 delivered to the compressor *[or]*
Pressure Relief Valves:	Infrared detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection
Open Ended Lines:	Infrared detection (Infrared Gas Analyzers - IRGA) or other atmospheric detection
Compressor Intercooler Leaks:	Estimated from pressure drop across intercooler and periodic sampling and analysis of CO_2 delivered to the intercooler.
System Blowdown Emissions:	Volume of blowdown vent gas (estimated from compressor cylinder volume, suction/discharge

cylinder volumes, volume of piping between valves) and composition of blowdown vent gas (based on periodic sampling and analysis of CO_2 delivered to the compressor)

b. Attachment 2: Monitoring Points for Capture

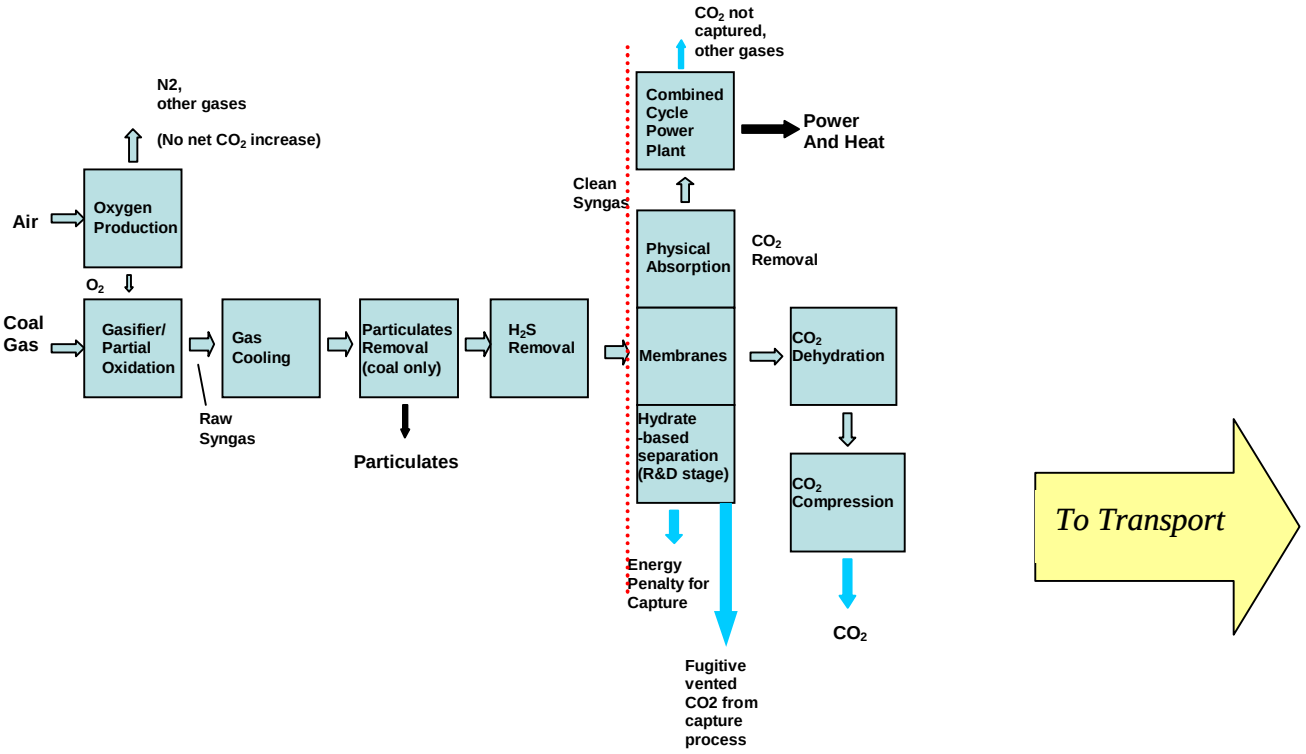
Post-Combustion Carbon Capture
Coal Power Plant, NGCC Power Plant

= CCS inventory boundary

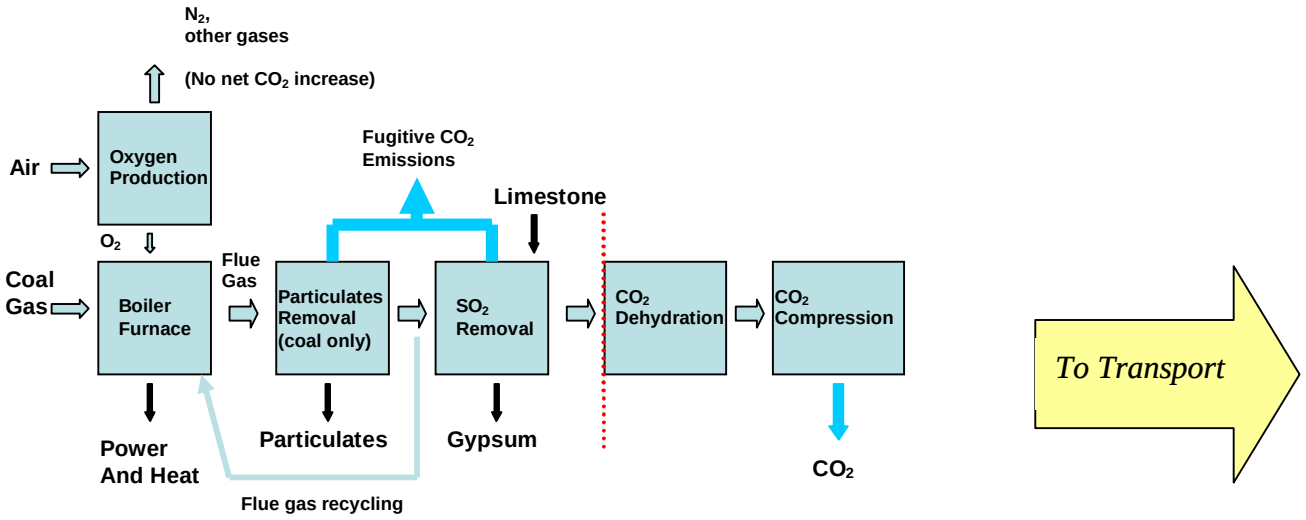


Pre-Combustion Carbon Capture

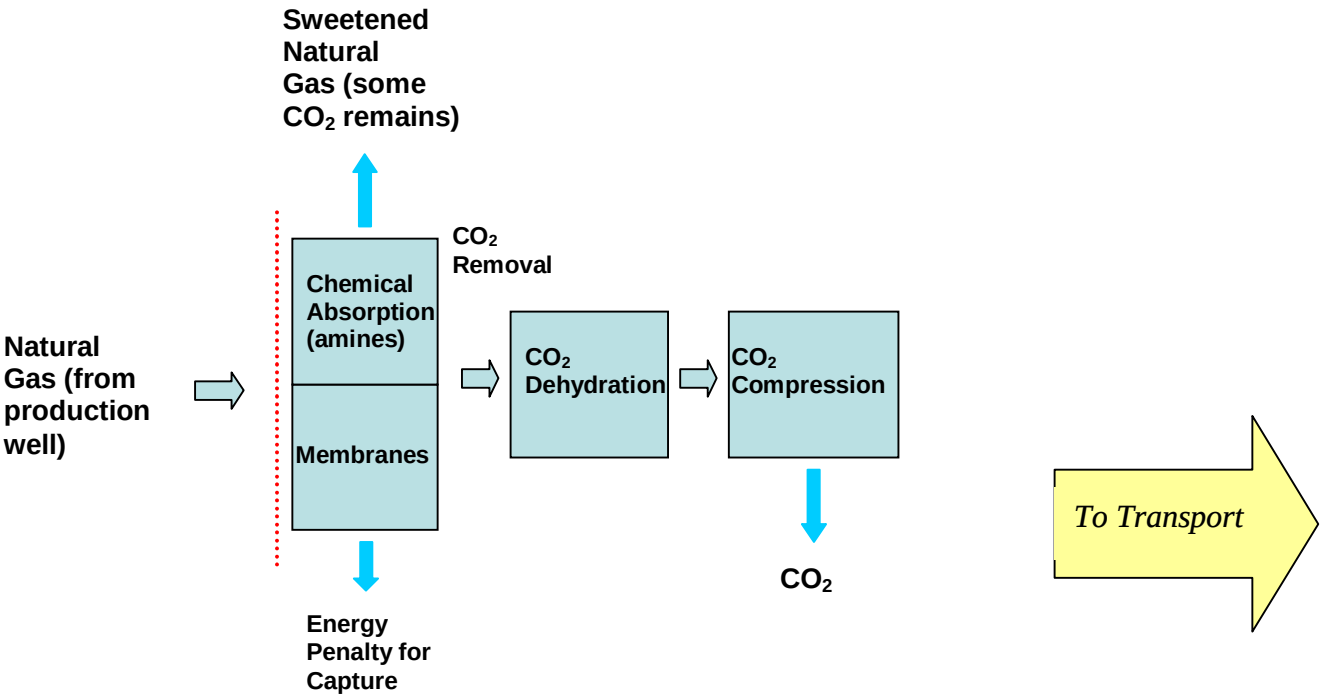
Coal Gasification Plant, IGCC Plant



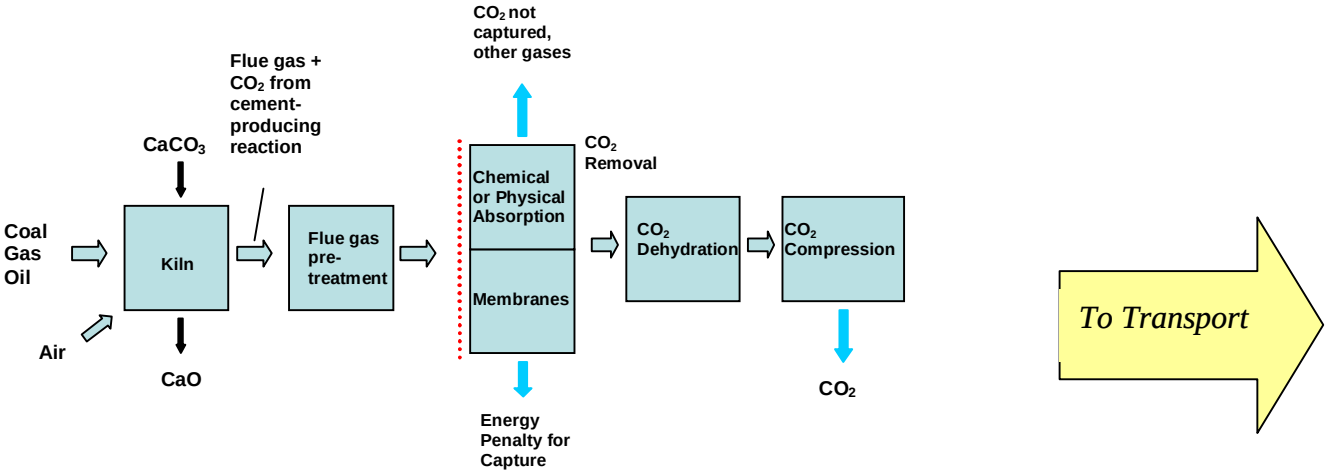
Oxy Combustion Carbon Capture



Natural Gas Production and Processing



Cement Plant Carbon Capture



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