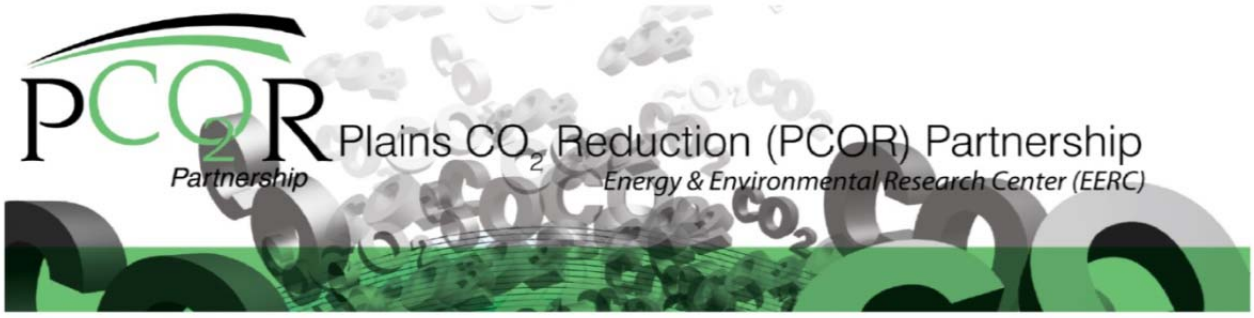

REVIEW OF SOURCE ATTRIBUTES

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 1 – Deliverable D1

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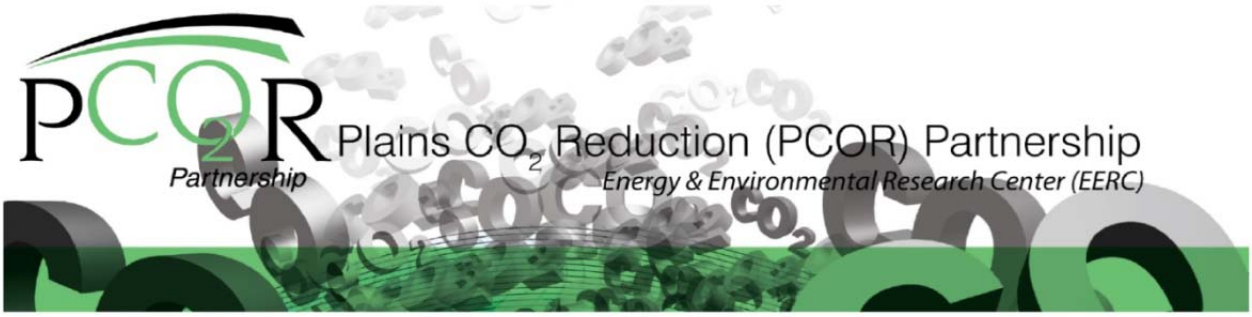
NOMENCLATURE

β	heat content of the fuel used
θ_{fuel}	CO_2 emissions factor based on heat input rate
M_{CO_2}	total CO_2 emissions
Bscfd	billions of standard cubic feet per day
Btu	British thermal units
CO_2	carbon dioxide
DSS	Decision Support System
EIA	U.S. Energy information Administration
EPA	U.S. Environmental Protection Agency
F_t	fuel usage rate
MMBtu	millions of Btus
MMscf	millions of standard cubic feet
MMscfd	millions of standard cubic feet per day
NO_x	nitrogen oxides
PCOR Partnership	Plains CO_2 Reduction Partnership
scf	standard cubic feet
scfd	standard cubic feet per day
SO_2	sulfur dioxide
tons	short tons; equivalent to 2000 lb_m
yr	year



REVIEW OF SOURCE ATTRIBUTES

INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership maintains a database of significant regional point sources of carbon dioxide (CO_2). The database is a key in the development of CO_2 capture–transportation–sequestration scenarios that have the potential to reduce greenhouse gas emissions in the PCOR Partnership region. To maintain a reasonably current status, the data set undergoes an annual review during which new or missing sources are identified and added, CO_2 emission rates are updated, and facility locations are verified. This report summarizes the data review that took place between October 1, 2010, and September 30, 2011.

APPROACH

Five primary data sets were used to update the PCOR Partnership CO_2 emissions database:

- The Environment Canada Reported Facility Greenhouse Gas Data, an online greenhouse gas search engine, provides the annual emissions of CO_2, CH_4, N_2O, and other greenhouse gases for point sources from all sectors. The Canadian point sources in the PCOR Partnership database were updated using 2009 data (the most current data). The search engine can be accessed at www.ec.gc.ca/pdb/ghg/onlineData/dataSearch_e.cfm.

- The U.S. Environmental Protection Agency (EPA) Clean Air Markets Data and Maps online emissions search engine provides CO_2, SO_2, and NO_x emission data for electric utilities and larger industrial heat/power plants. The PCOR Partnership database was updated using facility data from 2010. This search engine can be accessed at camddataandmaps.epa.gov/gdm/.

- The Nebraska State government Web site "Ethanol Facilities Capacity by State and Plant" was used to update the U.S. portion of the PCOR Partnership region's ethanol production values (The PCOR Partnership estimates ethanol facility emissions based on the quantity of ethanol produced at the plant). The Web site states that the information contained on it was current as of June 2011. It can be accessed online at www.neo.ne.gov/statshtml/122.htm.

- The EPA 2010 e-GRID contains annual emissions of CO_2, SO_2, and NO_x by electric utilities as well as industrial and municipal heat/power plants. Although dated 2010, the data are from 2007. The data set was used to update information about power plants that are not large enough to be included in the EPA Clean Air Markets Data and Maps searchable database. The e-GRID spreadsheets can be accessed at www.epa.gov/cleanenergy/egrid/index.htm.

- The Oil and Gas Journal's Worldwide Gas Processing 2011 data set was purchased. This data set included data for natural gas-processing and transmission sites that are located within the PCOR Partnership region. The purchased data set did not specifically include CO_2 emissions; the gas throughput was used to estimate the CO_2 emissions by the methodology described in *CO_2 Point Source Emission Estimation Methodologies Summary* (Regional Carbon Sequestration Partnerships' Capture and Transportation Working Group, 2008). The methodology was also discussed in the 2009 version of the PCOR Partnership review of source attributes report. Actual CO_2 emissions values were found for many of the facilities by searching the Environment Canada Facility Greenhouse Gas Reporting Search Data Web site (Environment Canada, 2011).

The Oil and Gas Journal data set does not identify which sources are natural gas-processing plants and which are natural gas transmission sites (e.g., compressor stations along the pipeline routes). Efforts have been made to visually determine which type of site a given entry in the data set might be through Google Earth satellite imagery. Occasionally, the images were not clear enough to allow a definitive identification of site type. To be sure that no gas-processing plants have been overlooked, the natural gas transmission sites within the PCOR Partnership have been treated as gas-processing plants during the estimation of their CO_2 emissions. This practice probably overestimates the CO_2 emissions because the only source of CO_2 from a compression station is from the combustion of fuel by the compressor(s). Therefore, all sources that could not be identified as gas-processing plants using Google Earth imagery were assumed to be compressor stations. The CO_2 emissions from these compressor stations were calculated using a second gas-processing plant formula taken from the Capture and Transportation Working Group emission estimation methodology document (Regional Carbon Sequestration Partnerships' Capture and Transportation Working Group, 2008). This calculation, given in Equation 1, determines the amount of CO_2 produced by the combustion of fuel.

$$M_{CO_2} = \beta F_t \theta_{fuel} \qquad \text{[Eq. 1]}$$

where M_{CO_2} = total CO_2 emissions in short tons per year
β = heat content of the fuel used (Btu/scf)
F_t = fuel usage rate (scf/year)
θ_{fuel} = CO_2 emissions factor based on heat input rate in short tons CO_2/MMBtu

It was assumed that the compressors would run on natural gas. The heat content, β, of natural gas is 1020 Btu/scf.

Calculation of the fuel usage rate required knowing the power needed to compress the gas throughput for a given site. The U.S. Energy Information Administration (EIA) has gathered

information on the relationship between installed horsepower and gas throughput for compressors on the interstate pipeline network (U.S. Energy Information Administration, 2007). A "best-fit" line through these data indicates that, for compressor stations with a capacity of 1000 Bscfd or less, the horsepower required is roughly 20.6 times the gas throughput in MMscf. The fuel usage rate can then be calculated as follows:

$$F_t = x\ \text{MMscfd} \times \frac{20.6\ \text{hp}}{\text{MMscfd}} \times \frac{8500\ \text{Btu}}{\text{hp hr}} \times \frac{\text{scf}}{1020\ \text{Btu}} \times \frac{8760\ \text{hr}}{\text{yr}} \quad \text{[Eq. 2]}$$

The fuel emissions factor, θ_{fuel}, is 116.87 lb/MMBtu.

Plugging all of these factors into the equation gives the annual CO_2 emissions for a compressor station. For example, for a compressor station with a throughput of 36 MMcfd:

$$M_{CO_2} = \frac{1020\ \text{MMBtu}}{\text{MMscf}} \times 36\ \text{MMscfd} \times \frac{20.6\ \text{hp}}{\text{MMscfd}} \times \frac{8500\ \text{Btu}}{\text{hp hr}} \times \frac{\text{scf}}{1020\ \text{Btu}} \times \frac{8760\ \text{hr}}{\text{yr}} \times \frac{\text{MMscf}}{1\times10^6\ \text{scf}} \times \frac{116.87\ \text{lb}}{\text{MMBtu}} \times \frac{\text{short ton}}{2000\ \text{lb}} = 3227\ \text{short tons}\ CO_2/\text{yr} \quad \text{[Eq. 3]}$$

The end result of the calculations was that the majority of the natural gas transmission stations in Canada did not meet the PCOR Partnership data set minimum emission rate of 15,000 short tons CO_2/yr and were dropped from the data set. However, the Environment Canada greenhouse gas data search engine provides CO_2 emission measurements for the pipeline systems in the Canadian provinces that were incorporated into the PCOR Partnership data set, meaning that the data set most likely includes the emissions from all of the compressor stations.

RESULTS

As of September 15, 2011, the updated PCOR Partnership database contains 906 sources that produce an estimated 606.45 million short tons of CO_2 annually. This compares to the September 2009 values of 966 sources producing an estimated 594.37 million short tons of CO_2 each year. The breakdown of the CO_2 emissions by broad source category is presented in Table 1.

In 2008, the PCOR Partnership instituted a minimum CO_2 emission rate for sources contained in the database of 15,000 short tons/yr. Many sources produced less CO_2 during the past calendar year as a result of efficiency gains, changes in production or, in the case of the natural gas transmission stations, because the emissions estimation methodology changed. A total of 88 sources were removed because they no longer produced the minimum amount of CO_2 required for inclusion in the PCOR Partnership database.

Occasionally, the name of a source is found to have changed in an emissions data set. The PCOR Partnership database was modified to reflect the name change of 62 sources since October 1, 2010.

Table 1. Summary of CO_2 Point Sources Found Within the PCOR Partnership Region as of September 15, 2011

Broad Category	Number of Point Sources	Emissions, millions of short tons/yr	Percentage of Total Number of Sources	Percentage of Emissions
Agricultural and Agriculture-related Processing	54	5.04	6.0	0.8
Electricity Generation	189	379.98	20.9	62.7
Chemical and Fuel Production	36	18.66	4.0	3.1
Ethanol Manufacture	129	50.11	14.2	8.3
Cement/Clinker Production	24	16.53	2.6	2.7
Industrial	39	16.28	4.3	2.7
Small-Scale Heat and Power	40	2.70	4.4	0.4
Manufacturing	87	9.90	9.6	1.6
Petroleum- and Natural Gas-Related	223	87.26	24.6	14.4
Paper and Wood Products	74	19.09	8.2	3.1
Waste Processing	11	0.90	1.2	0.2
Total	906	606.45	100.0	100.0

Sources that no longer exist or that were found to be duplicate entries in the database were eliminated. There were a total of 20 such point sources in the PCOR Partnership database. On the other hand, 48 new facilities were found to be missing from the data set and were added to it.

The location coordinates for 24 point sources were changed either because of the higher resolution of the newer Google Earth images or because additional information allowed a more precise location to be determined.

Of the 906 sources contained in the database, updated information was found for 593 of them. Table 2 summarizes the changes made to the PCOR Partnership CO_2 emissions database as a result of the data update.

The process of moving this latest data set to the PCOR Partnership Decision Support System (DSS, ©2007–2011 EERC Foundation) is currently under way. When the process is complete, the updated emissions data will be reflected via the online geographic information systems on the PCOR Partnership DSS and U.S. Department of Energy's national portal.

Table 2. Changes Made to the PCOR Partnership CO_2 Emissions Database Between October 1, 2010, and September 30, 2011

Explanation	Number of Sources Affected
Removed Because the Source Produces Less than 15,000 short tons/yr	88
Source Name Was Found to Have Changed	62
Sources That No Longer Exist	4
Location Changes	24
Removed Duplicate Plants	16
New Facilities Added to the Database	48
Updated Entry Information	593

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