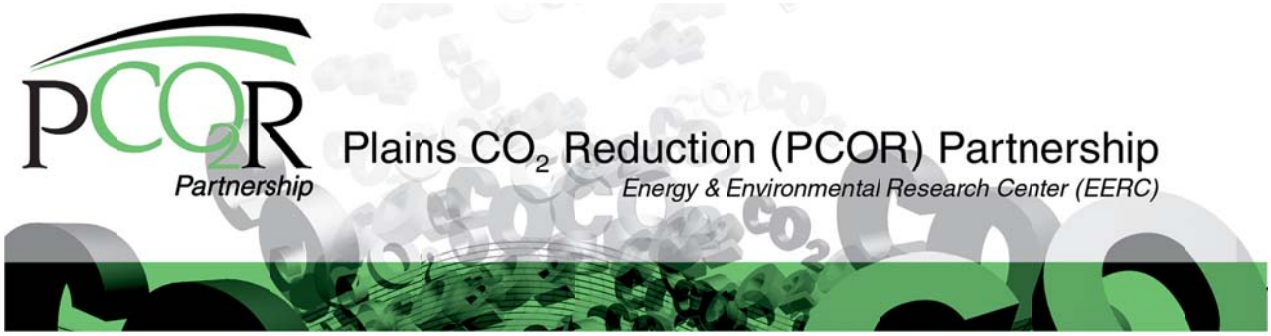

REVIEW OF SOURCE ATTRIBUTES

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

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NOMENCLATURE AND ABBREVIATIONS

Btu	British thermal unit
CH_4	methane
CO_2	carbon dioxide
CO_2eq	CO_2-equivalent
DOE	U.S. Department of Energy
DSS	Decision Support System
EPA	U.S. Environmental Protection Agency
gal	gallon
HFC-23	fluoroform
lb	pounds mass
NATCARB	National Carbon Sequestration Database and Geographic Information System
N_2O	nitrous oxide
NO_x	nitrogen oxides
PCOR	Plains CO_2 Reduction
PFC-116	hexafluoroethane
PFC-14	tetrafluoromethane
SO_2	sulfur dioxide

REVIEW OF SOURCE ATTRIBUTES

INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership maintains a database of significant regional point sources of CO_2. The database is a key in the development of CO_2 capture–transportation–storage 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, 2012, and August 22, 2013.

APPROACH

Actual emission measurements are used whenever possible, but measured data are not always available for each of the sources. In cases where measured data are unavailable, emissions are estimated using the methodologies developed for the U.S. Department of Energy (DOE) National Energy Technology Laboratory by the DOE Regional Carbon Sequestration Partnerships Capture and Transportation Working Group (Capture and Transportation Working Group of the DOE Regional Carbon Sequestration Partnerships, 2010). Web searches are used to acquire updated information regarding fuel type, heat content, and usage rate and/or product slate and quantities; these values are used to estimate CO_2 emission rates.

Four primary data sets were used to update the PCOR Partnership CO_2 emission database:

- The Environment Canada Reported Facility Greenhouse Gas Data (Environment Canada, 2013a), 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 2011 data (the most current data). The search engine can be accessed at www.ec.gc.ca/pdb/ghg/onlineData/data Search_e.cfm.

- Emission data for criteria pollutants such as SO_2 and NO_x can be found at the online Environment Canada National Pollutant Release Inventory Online Data Search engine (Environment Canada, 2013b). The Canadian point sources in the PCOR Partnership database were updated using 2011 data (the most current data). The search engine can be accessed at www.ec.gc.ca/pdb/websol/querysite/query_e.cfm.

- The U.S. Environmental Protection Agency (EPA) Air Markets Program Data online emission search engine (U.S. Environmental Protection Agency, 2013a) 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 2012. This search engine can be accessed at http://ampd.epa.gov/ampd/QueryToolie.html.

- EPA's Greenhouse Gas Reporting Program Data for Calendar Year 2011 (U.S. Environmental Protection Agency, 2013b). The searchable site contains CO_2, N_2O, CH_4, PFC-14, PFC-116, and HFC-23 emission data reported from large facilities in nine industry groups: power plants, landfills, metal manufacturing, mineral production, petroleum refineries, pulp and paper manufacturing, chemical manufacturing, government and commercial facilities, and other industrial facilities. The Greenhouse Gas Reporting Program Data can be accessed at http://ghgdata.epa.gov/ghgp/main.do.

The emission data obtained from the EPA Greenhouse Gas Reporting Program are relatively easily incorporated into the PCOR Partnership data set with the exception of the ethanol plants. The PCOR Partnership tracks combustion- and process-related CO_2 emissions separately for potential carbon utilization purposes. The EPA site breaks down the emissions as either combustion-related or biogenic CO_2, which is CO_2 that is formed by combustion of a biomass source. Because the EPA Web site only includes values for CO_2 formed during combustion, a methodology was developed to estimate the CO_2 formed during the fermentation step of ethanol production. This methodology is based on one developed by the DOE Regional Carbon Sequestration Partnerships Capture and Transportation Working Group (U.S. Department of Energy Regional Carbon Sequestration Partnerships Capture and Transportation Working Group, 2008). Knowing that 1 gal of ethanol requires 39,000 Btu of energy and produces 6.6 lb of CO_2 during the fermentation step, the fermentation CO_2 was estimated from the combustion-related CO_2 values using the following three-step approach.

The first step consists of determining the amount of combustion-related CO_2 resulting from the production of 1 gal of ethanol for each of the specific fuel(s) used by the ethanol plant. The fuels and CO_2 produced by each is provided on the searchable EPA Web site for each CO_2 source. Fuel CO_2 emission factors for a variety of fuels can be obtained online from the EPA (U.S. Environmental Protection Agency, 2013c).

$$\left(\frac{39{,}000\ Btu}{gal\ ethanol}\right) \times \left(\frac{Fuel\ CO_2\ Emission\ Factor}{10^6\ Btu}\right) = \frac{lb\ combustion\ CO_2}{gal\ ethanol} \qquad \text{[Eq. 1]}$$

During the second step, the resulting quantity of CO_2 produced per gal of ethanol during combustion is then ratioed against the amount of CO_2 produced during the fermentation step (i.e., 6.6 lb), resulting in a multiplier that can be used to estimate the fermentation CO_2 when the combustion CO_2 is known.

$$\left(\frac{\frac{6.6\ lb\ fermentation\ CO_2}{gal\ ethanol}}{\frac{lb\ combustion\ CO_2}{gal\ ethanol}}\right) = multiplier\ for\ combustion\ CO_2\ emission \qquad \text{[Eq. 2]}$$

Finally, the tons of CO_2 produced by the combustion of each fuel are multiplied by each fuel's multiplier value and summed to arrive at the CO_2 produced during fermentation. The total CO_2 for the stationary point source would then be the sum of the combustion CO_2 (from the EPA Web site) and the fermentation CO_2 (estimated using this methodology). The following example illustrates this approach to estimating fermentation CO_2 for a source burning subbituminous coal and natural gas. For natural gas:

$$\left(\frac{39{,}000\ Btu}{gal}\right) \times \frac{117.08\ lb\ CO_2}{10^6\ Btu} = 4.566\ lb\ CO_2 \qquad \text{[Eq. 3]}$$

$$\frac{6.6\ lb\ CO_2}{4.566\ lb\ CO_2} = 1.45 \qquad \text{[Eq. 4]}$$

For subbituminous coal:

$$\left(\frac{39{,}000\ Btu}{gal}\right) \times \frac{212.7\ lb\ CO_2}{10^6\ Btu} = 8.295\ lb\ CO_2 \qquad \text{[Eq. 5]}$$

$$\frac{6.6\ lb\ CO_2}{8.295\ lb\ CO_2} = 0.796 \approx 0.8 \qquad \text{[Eq. 6]}$$

If the CO_2 produced during natural gas combustion totals 100,000 short tons CO_2 and the CO_2 produced during subbituminous coal combustion totals 200,000 short tons CO_2, then the CO_2 produced during fermentation would total:

$$(100{,}000\ tons \times 1.45) + (200{,}000\ tons \times 0.8) = (145{,}000 + 160{,}000)\ tons = 305{,}000\ tons \qquad \text{[Eq. 7]}$$

The total CO_2 emission for the source would be 100,000 + 200,000 + 305,000 = 605,000 tons.

This approach is probably reasonably accurate as long as the source does not emit combustion CO_2 that is related to another process (such as cogeneration) at the facility. Obviously, if the CO_2 is partly produced by another process, the portion that is not ethanol-related would inflate the estimated fermentation CO_2 quantity.

The EPA searchable database presents a second challenge in that it is difficult to determine the total CO_2 emissions as opposed to the total CO_2-equivalent (CO_2eq) emissions for some of the source types. One example of this is sugar-processing facilities with their inherent lime production. This is not true for all source types.

A final note about the use of the EPA database: the power plants are listed as producing CO_2 from both "stationary combustion" and "electricity generation." These values must be summed to produce the total CO_2 emissions at such sites.

RESULTS

As of August 22, 2013, the updated PCOR Partnership database contains 895 sources that produce an estimated 563 million short tons of CO_2 annually. This compares to the 2012 values of 1033 sources producing an estimated 620 million short tons of CO_2 each year. The breakdown of the CO_2 emissions by broad source category is presented in Table 1.

The PCOR Partnership does not include sources in the database having CO_2 emission rates less than 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, etc. During this update, 10 sources were removed from the database 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 emission data set. The PCOR Partnership database was modified to reflect the name changes of 131 sources since October 1, 2012.

Sources that no longer exist or that were found to be duplicate entries in the database were eliminated. There were a total of 26 such point sources in the PCOR Partnership database.

The PCOR Partnership database included many sources for which the most recent information was at least 10 years old. A concerted effort was made to verify their continued existence and update their CO_2 emission rate. A few of the sources were found to have changed

Table 1. Summary of CO_2 Point Sources Found Within the PCOR Partnership Region as of August 22, 2013

Category	Count	Total CO_2	% of Sources	% of Emissions
Agricultural and Agriculture-Related Processing	66	8,717,441	7.4	1.5
Electricity Generation	189	352,431,336	21.0	62.6
Chemical and Fuel Production	38	18,143,773	4.2	3.2
Ethanol Manufacture	126	49,312,385	14.1	8.8
Cement/Clinker Production	21	17,035,393	2.3	3.0
Industrial	47	10,471,068	5.3	1.9
Small-Scale Heat and Power	34	3,900,955	3.8	0.7
Manufacturing	44	3,586,897	4.9	0.6
Petroleum- and Natural Gas-Related	264	88,516,534	29.5	15.7
Paper and Wood Products	46	9,520,368	5.1	1.7
Waste Processing	20	1,173,562	2.2	0.2
Total	**895**	**562,809,712**	**100.0**	**100.0**

names several times and were found to have been duplicated in the spreadsheet, but many sources could not be found, even through significant Web searching. As a result of this exercise, 138 sources were removed from the PCOR Partnership CO_2 emission database.

On the other hand, 36 new facilities were found to be missing from the data set and were therefore added to it. Figure 1 shows the locations of the new facilities.

The location coordinates for 16 point sources were changed because additional information allowed a more precise location to be determined.

Of the 895 sources now contained in the database, updated CO_2 emission information was found for 487 of them. Table 2 summarizes the changes made to the PCOR Partnership CO_2 emission database as a result of the data update.

In addition to updating the CO_2 emissions for the large point sources in the PCOR Partnership region, efforts were made to ensure that the name, location, and emission data are consistent for the sources that are shared by both the PCOR Partnership and the Big Sky Partnership. When the data are next uploaded to NATCARB (National Carbon Sequestration Database and Geographic Information System), the sources that are common to both the PCOR Partnership and the Big Sky Partnership will be identical.

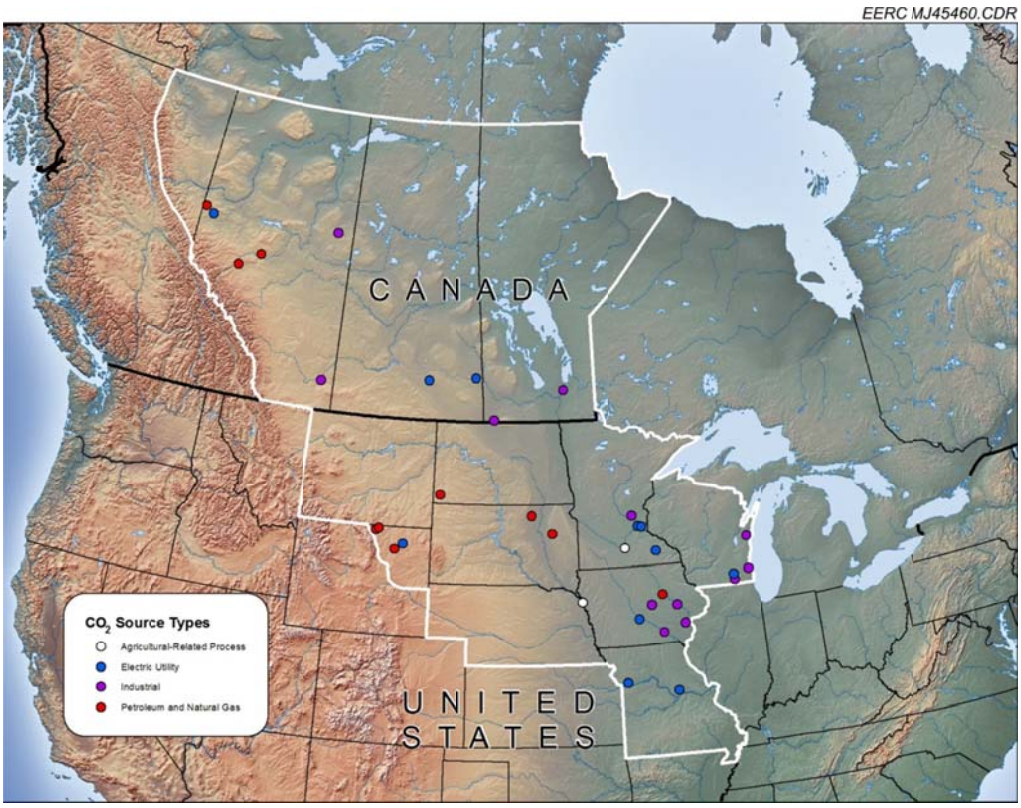

Figure 1. Location of the new facilities identified during this database update.

Table 2. Changes Made to the PCOR Partnership CO_2 Emission Database Between October 1, 2012, and July 31, 2013

Explanation	Number of Sources Affected
Removed Because the Source Now Produces Less Than 15,000 short tons/yr	10
Source Name Was Found to Have Changed	131
Sources That No Longer Exist	8
Sources That Were Removed Because They Have Not Appeared in Any Data Sets in the Last 10 years	138
Location Changes	16
Removed Duplicate Plants	18
New Facilities Added to the Database	36
Updated CO_2 Emission Information on Existing Sources	487

When available, the CO_2eq emissions due to N_2O and CH_4 were incorporated into the PCOR Partnership database. This information was found for 801 of the 895 sources and is summarized in Table 3. Because of the higher intensity of the N_2O and the CH_4, 576 million short tons of CO_2eq emissions were emitted by 89% of the sources in the PCOR Partnership region.

The process of moving this latest data set to the PCOR Partnership Decision Support System (DSS) is currently under way. When the process is complete, the updated emission data will be reflected in the online geographic information systems on the PCOR Partnership DSS and DOE's national portal.

Table 3. CO_2eq Emissions for Stationary Sources in the PCOR Partnership Region for 2011

Category	Count	Total CO_2eq	% of Sources	% of Emissions
Agricultural and Agriculture-Related Processing	66	9,763,921	8.2	1.7
Electricity Generation	167	354,649,137	20.8	61.6
Chemical and Fuel Production	34	19,503,984	4.2	3.4
Ethanol Manufacture	118	54,085,149	14.7	8.6
Cement/Clinker Production	21	17,076,571	2.6	3.0
Industrial	47	10,972,221	5.9	1.9
Small-Scale Heat and Power	32	3,944,734	4.0	0.7
Manufacturing	43	3,622,182	5.4	0.6
Petroleum- and Natural Gas-Related	209	93,843,091	26.1	16.3
Paper and Wood Products	44	10,093,892	5.5	1.7
Waste Processing	20	2,666,231	2.5	0.5
Total	**801**	**575,914,029**	**100.0**	**100.0**

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