PCO$_2$R Partnership Plains CO$_2$ Reduction (PCOR) Partnership
Energy & Environmental Research Center (EERC)

REVIEW OF SOURCE ATTRIBUTES

Update 1

Plains CO$_2$ Reduction (PCOR) Partnership Phase III
Task 1 – Deliverable D1

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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 crucial to 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, 2009, and September 30, 2010.

APPROACH

Four 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 2008 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 2009. This search engine can be accessed at camddataandmaps.epa.gov/gdm/index.cfm?fuseaction=emissions.wizard.

- The Nebraska State government Web site “Ethanol Facilities Capacity by State and Plant” was used to update 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 2010. It can be accessed online at www.neo.ne.gov/statshtml/122.htm.

- Petroleum refinery CO_2 emissions were estimated using fuel usage and refinery production data obtained online from the U.S. Energy Information Administration at tonto.eia.doe.gov/dnav/pet/pet_pnp_capfuel_dcu_nus_a.htm and tonto.eia.doe.gov/dnav/pet/pet_pnp_refp2_dc_nus_mbblpd_a.htm, respectively. The necessary emission coefficients are available online at www.eia.doe.gov/oiaf/1605/coefficients.html.

The methodologies used to estimate CO_2 emissions from ethanol plants and petroleum refineries are included in Appendix A.

RESULTS

As of September 15, 2010, the updated PCOR Partnership database contains 966 sources that produce an estimated 594.37 million short tons of CO_2 annually. This compares to the September 2009 values of 927 sources producing an estimated 561.89 million short tons of CO_2 annually.

In 2008, the PCOR Partnership instituted a minimum CO_2 emission rate for sources contained in the database of 15,000 tons/yr. Many sources produced less CO_2 during the past calendar year as a result of efficiency gains and/or changes in production; 19 of these 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 18 sources since October 1, 2010.

Sources that no longer exist or that were found to be duplicate entries in the database were eliminated. There were a total of nine such point sources in the PCOR Partnership database. On the other hand, 67 new facilities were found to be missing from the data set and were added to it.

New Google Earth satellite imagery made location verification possible for some of the areas that had been too out of focus for location verification in the past. The location coordinates for 53 point sources were changed because of the higher resolution of the new Google Earth images.

Of the 966 sources contained in the database, updated emission values were found or estimated from current information for 314 of them. Table 1 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 EERC Foundation) is currently under way. When this process is complete, the new locations, sources, and emissions will be reflected via the online geographic information systems on the PCOR Partnership DSS and U.S. Department of Energy’s national portal.

Table 1. Changes Made to the PCOR Partnership CO_2 Emissions Database Between October 1, 2009, and September 30, 2010

Explanation	Number of Sources Affected
Removed Because the Source Produces Less than 15,000 tons/yr	19
Source Name Was Found to Have Changed	18
Sources That No Longer Exist	5
Location Changes	53
Removed Duplicate Plants	4
New Facilities Added to the Database	67
Updated the Emission Values	314

APPENDIX A

METHODOLOGIES USED TO ESTIMATE CO_2 EMISSIONS FROM THE PLAINS CO_2 REDUCTION PARTNERSHIP REGION'S ETHANOL FACILITIES AND PETROLEUM REFINERIES

METHODOLOGIES USED TO ESTIMATE CO_2 EMISSIONS FROM THE PLAINS CO_2 REDUCTION PARTNERSHIP REGION'S ETHANOL FACILITIES AND PETROLEUM REFINERIES

ESTIMATION OF CO_2 EMISSIONS FROM ETHANOL PRODUCTION FACILITIES

IDENTIFICATION OF ETHANOL PLANT LOCATIONS

Identification of ethanol plants in the Plains CO_2 Reduction (PCOR) Partnership region was accomplished through the use of the Renewable Fuels Association Ethanol Biorefinery Locations Web site (www.ethanolrfa.org/industry/locations). This Web site lists the name of cities in which ethanol plants are located but does not always provide enough direction to effectively use Google Earth (http://earth.google.com) to locate the plant's latitude and longitude to the extent possible. Web searches for the facilities can result in street addresses that can be helpful when locating a plant on Google Earth. At this time, 95 ethanol facilities have been identified in the PCOR Partnership region.

PROCESS EMISSIONS

Ethanol plants produce CO_2 during the fermentation step. The quantity of ethanol produced by a plant was found at the Renewable Fuels Association Ethanol Biorefinery Locations Web site (www.ethanolrfa.org/industry/locations). For every gallon of anhydrous ethanol produced, 6.6 lb of CO_2 is produced (Aulich, personal communication, May 2004). The quantity of CO_2 produced during the fermentation step in the production of the ethanol is:

$$\text{tons } CO_2/\text{yr} = (\text{gal ethanol/yr}) \times (6.6 \text{ lb } CO_2/\text{gal ethanol}) \times (1 \text{ ton}/2000 \text{ lb} \qquad [\text{Eq. 1}]$$

COMBUSTION EMISSIONS

Power for the ethanol facility (primarily for heat) is produced through the combustion of fossil fuels, usually natural gas, although there are a few coal-fired plants in the PCOR Partnership region. The CO_2 emissions produced during the combustion were calculated using the following procedure.

A rule of thumb is that 39,000 Btu of energy is required to produce a gallon of anhydrous ethanol (Duff, personal communication, May 2004). The quantity of fuel used by the plant must be calculated and its heat content defined.

A cubic foot of natural gas has a heat content of roughly 1000 Btu (Energy Information Administration, 2009). The amount of CO_2 produced is calculated using typical combustion calculations. For example:

$$\text{tons } CO_2/\text{yr} = (\text{gal ethanol/yr} \times 39{,}000 \text{ Btu/gal}) \times (1 \text{ ft}^3 \text{ natural gas}/1000 \text{ Btu}) \times$$

$$(1 \text{ lb-mole natural gas}/359 \text{ ft}^3) \times (1 \text{ lb-mole } CO_2/1 \text{ lb-mole natural gas}) \times (44.01 \text{ lb } CO_2/\text{lb-mole } CO_2) \times (1 \text{ ton}/2000 \text{ lb}) \qquad \text{[Eq. 2]}$$

If the coal that is burned at the ethanol plant is described, then the higher heating value for that coal can be used in the calculations. The PCOR Partnership ethanol plants that burn coal did not specify a coal, so an average value of 20.33 million Btu/short ton (Energy Information Administration, 2009) was used. Because the coal type was unknown, the percentage of carbon for the coal was unknown, so CO_2 emissions for coal from each state were utilized (Hong and Slatick, 1994). The combustion calculations for CO_2 produced from coal-fired ethanol plants when the specific coal is not known can be determined as follows:

$$\text{tons } CO_2/\text{yr} = (\text{gal ethanol/yr} \times 39{,}000 \text{ Btu/gal ethanol}) \times (CO_2 \text{ emission factor for coal in lb } CO_2/\text{million Btu}) \times (\text{ton } CO_2/2000 \text{ lb } CO_2) \qquad \text{[Eq. 3]}$$

The total CO_2 emitted by the ethanol plant is the sum of the process- and combustion-produced CO_2.

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ESTIMATION OF CO_2 EMISSIONS FROM PETROLEUM- AND NATURAL GAS-PROCESSING FACILITIES

IDENTIFICATION OF PETROLEUM- AND NATURAL GAS-PROCESSING FACILITIES AND THEIR LOCATIONS

Petroleum- and natural gas-processing facilities in the Plains CO_2 Reduction (PCOR) Partnership region include petroleum refineries, natural gas-processing plants, and petroleum transmission facilities. The facilities were located using the U.S. Environmental Protection Agency (EPA) Technology Transfer Network Ozone Implementation Web site (www.epa.gov/ttn/naaqs/ozone/areas/), the EPA Clean Air Markets Web site (http://camddataandmaps.epa.gov/gdm) and the Environment Canada Web site for Canadian sources (www.ec.gc.ca/pdb/ghg/onlineData/dataSearch_e.cfm). Gas-processing facility data were also gathered from the North Dakota Department of Health, purchased from the *Oil & Gas Journal* Web site, and derived from DeBruin et al. (2004). Where latitude and longitude information was absent in the databases, the street address was used with Google Earth (http://earth. google.com) to locate the plant. Often, the street address or the latitude and longitude are for an office removed from the facility operations. In such instances, these locations are being corrected using Google Earth imagery to the extent possible.

PETROLEUM REFINERY EMISSIONS

The emissions from U.S. petroleum refineries are calculated by multiplying the net production by a CO_2 emission factor. This emission factor can be calculated as follows.

The United States is divided into five Petroleum Administration for Defense Districts, or PADDs. Montana and Wyoming are in PADD 4, while the remaining states in the PCOR Partnership region are in PADD 2. The Energy Information Administration (EIA) keeps statistics for the refinery fuel usage and net production in each PADD (Energy Information Administration, 2009a, b) and provides a table of CO_2 emission factors for various fuels (Energy Information Administration, 2009c). Three fuels used at refineries are not listed on the EIA CO_2 emission factor table: coal, “other petroleum products,” and still gas. The emission factor used for coal is an average of the EIA emission factors for bituminous and subbituminous coals and lignite, the three coal types used in the PCOR Partnership region. The emission factor used for “other petroleum products” is the average of the CO_2 emission factors for all of the petroleum products listed on the EIA table. The CO_2 emission factor for still gas can be calculated by multiplying the Intergovernmental Panel on Climate Change default value of 66.7 tonnes CO_2/TJ (Herold, 2003) by the still gas heat content of 6.0 MMBtu/bbl (Energy Information Administration, 2009d) and the conversion factors of 1055.056 J/Btu and 1.102311 tons/tonne.

The usage of each fuel is multiplied by its corresponding CO_2 emission factor to determine an overall CO_2 emission for an entire PADD. When this value is divided by the PADD’s net production, an overall CO_2 emission factor in units of tons CO_2/barrel produced per calendar day can be calculated for a PADD. A specific refinery’s emissions can be estimated by multiplying the production of the refinery by the CO_2 emission factor for the PADD in which the refinery is located. It should be noted that the fuel usage and net production values are updated annually, requiring that the refinery CO_2 emission calculations be recalculated and updated as well. The most current CO_2 emission factors for PADDs 2 and 4 are 16.11 and 14.46 tons CO_2/bbl per calendar day, respectively.

As an example, for the calculation of an emission factor for a refinery in North Dakota, an emission factor of 16.11 tons CO_2/barrel per calendar day of the major product was used to calculate the total combustion-related emissions as follows:

$$\text{tons } CO_2/\text{yr} = 16.11 \text{ (ton } CO_2/[\text{barrel/day}]) \times \text{refinery production (barrel/day)} \qquad \text{[Eq. 1]}$$

NATURAL GAS-PROCESSING PLANT EMISSIONS

At natural gas-processing facilities, various hydrocarbons and fluids are separated from the natural gas stream to produce pipeline-quality, dry natural gas. (Natural Gas Supply Association, 2009) The oil and condensate are removed first, followed by water removal. The third step is extraction of the natural gas liquids. Finally, sulfur and CO_2 are removed in a sweetening process. The gas-sweetening process requires energy that is often provided by combustion of fuels. The CO_2 emissions associated with that combustion are calculated using a procedure similar to the one described in the section on emissions from electricity-generating facilities.

Additionally, a relatively pure stream of CO_2 is released from the sweetening process. The sweetening process is often performed by scrubbing the natural gas stream with an amine such as monoethanolamine (MEA). The CO_2 is absorbed by the amine while the cleaned gas passes through the scrubber. The CO_2-rich amine solution is heated to recover a stream of wet, very pure CO_2 that could be relatively easily captured and compressed for transportation to a geologic storage site for sequestration. The size of this CO_2 stream was determined using data contained in the Oil & Gas Processing Survey’s Worldwide Gas Processing Survey data set. For facilities employing amine scrubbers, it was assumed that the raw natural gas contained 4% by volume CO_2 (Metz et al., 2005) and that 75% of the CO_2 contained in this stream was captured. This approach matches that taken by other Regional Carbon Sequestration Partnerships in their data sets (National Energy Technology Laboratory, 2008).

$$\begin{aligned}\text{tons } CO_2/\text{yr} = {} & \text{(scf NG)} \times \text{(1 lb-mole NG/379 scf)} \times (\text{1 lb-mole } CO_2/\text{lb-mole NG}) \\ & \times (44.01 \text{ lb } CO_2/\text{lb-mole } CO_2)/(2000 \text{ lb/ton}) \qquad \text{[Eq. 2]}\end{aligned}$$

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