The Plains CO_2 Reduction (PCOR) Partnership – developing CO_2 sequestration opportunities for the central interior of North America

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Abstract

The Plains CO_2 Reduction (PCOR) Partnership is one of seven regional partnerships that the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) established to assess carbon sequestration opportunities that exist in the United States and Canada. The PCOR Partnership's efforts support the President's Global Climate Change Initiative (GCCI), which seeks to reduce CO_2 intensity in the United States by 18% by the year 2012. A detailed characterization of the region's major stationary CO_2 sources and potential CO_2 sinks was performed and used to develop a prioritized listing of specific field-based CO_2 sequestration validation projects to be performed. Sequestration capacity estimates for oil and gas fields, saline formations, and coalfields were developed for the PCOR Partnership Region.

Keywords: CO_2, sequestration, enhanced oil recovery

Introduction

The PCOR Partnership includes a diverse group of nearly 50 partners from industry, government, and nongovernment organizations that contribute time, resources, and expertise. The PCOR Partnership's Phase I activities have shown that the central interior of North America has significant potential for CO_2 sequestration. Phase I results have indicated the need to develop practical, market-based strategies for carbon management.

Methodology and Results

The PCOR Partnership covers an area of over 1.3 million square miles in the central interior of North America and includes nine states and three Canadian provinces (see Figure 1). The variable nature of the sources and sinks reflects the geographic and socioeconomic diversity of the region, which contains vast agricultural, energy, forest, and water resources. The central interior of North America is home to oil and gas fields, natural gas-processing plants, refineries, ethanol plants, and coal-fired power plants, which fuel the industrial and domestic needs of cities throughout North America. The rich farmlands, forests, and wetlands of the region offer ample opportunities for terrestrial sequestration. Phase I PCOR Partnership characterization activities confirmed that the region has a tremendous capacity for CO_2 sequestration while maintaining and even enhancing the regional economy.

During Phase I, all of the region's major stationary CO_2 sources were evaluated, and many of the major geologic and terrestrial sinks were identified and characterized. The CO_2 source and sink data

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Figure 1 PCOR Partnership region.

are housed in the PCOR Partnership Decision Support System (DSS), an interactive, Web-based geographic information system (GIS) database designed to facilitate CO_2 sequestration scenario development. The DSS can be used to identify the character and spatial relationships of sources, sinks, and infrastructure. The research team responsible for the development of geologic sequestration scenarios used the DSS to develop a methodology for identifying potential source–sink matches. Figure 2 shows the relationship between geologic sinks and stationary sources in the PCOR Partnership region.

Emissions from the transportation sector made up slightly less than one-fourth of the total CO_2 from major stationary sources. During the Phase I activities, more than 1300 major individual stationary CO_2 sources were identified within the region [1]. In 2000, the PCOR Partnership region generated nearly 911 million tons of anthropogenic CO_2, about 13.1% of the U.S. and Canadian total [2–6]. Table 1 shows that, for the region as a whole, electric utilities contributed a greater share of the emissions than the other stationary sources. Table 2 summarizes the emissions of the largest of these major stationary sources and shows that while about two-thirds of regional CO_2 emissions result from electricity generation, other major point sources are significant and may provide for key emission reduction opportunities, dependent on quality and proximity to sinks.

The PCOR Partnership region has abundant geologic sink opportunities. Under PCOR Partnership Phase I, key reservoir characterization data were gathered for over 1500 oil fields in the oil-producing states and provinces of the region. Three saline aquifer systems that cover large portions of the region were evaluated under Phase I, and several more have been identified for evaluation under Phase II. Coalfields in the region were shown in Phase I to have significant CO_2 storage capacity. Reconnaissance-level CO_2 sequestration capacity estimates for the sinks evaluated to date show that oil fields have the capacity to sequester 30 billion tons, saline formations evaluated have a sequestration capacity of 220 billion tons, and the capacity of coal seams is over 7 billion tons.

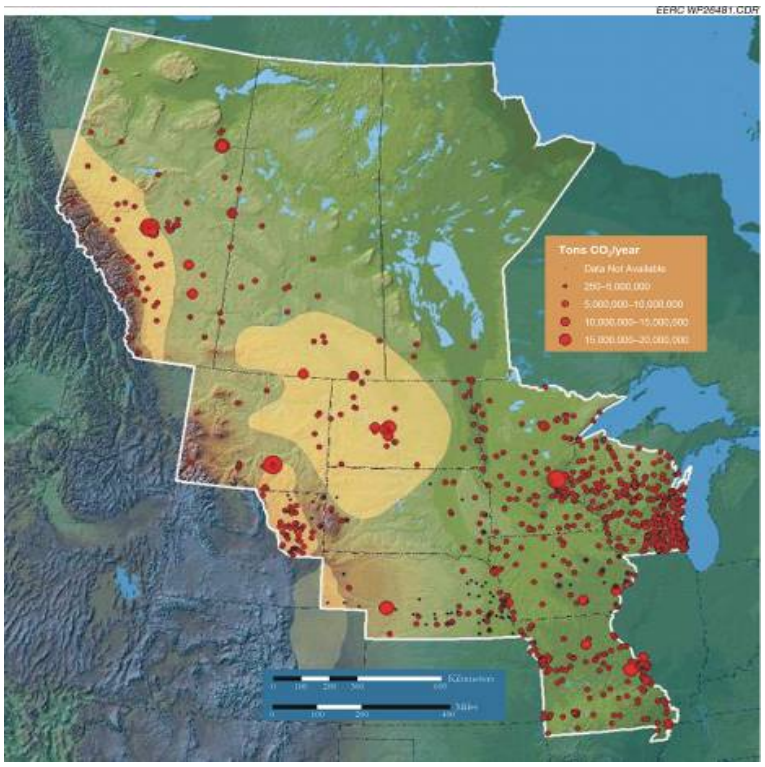

Figure 2 The PCOR Partnership geographic region showing major sinks and stationary sources.

Table 1 CO_2 Emissions in Million Tons of CO_2 for the PCOR Partnership Region During 2000*

Region	Electric Utilities	Other Stationary	Transportation	Total
U.S. PCOR	297.83	188.23	177.89	663.95
Canadian PCOR Partnership	72.84	128.67	45.40	246.91
PCOR Partnership	370.67	316.90	223.29	910.86
Canada Total				631.62
U.S. Total				6305.85

* Jensen, M.D., Steadman, E.N., Harju, J.A. 2005, CO_2 Source Characterization of the PCOR Partnership Region: Plains CO_2 Reduction Partnership Topical Report of the U.S. Department of Energy and multiclients, Grand Forks, North Dakota, Energy & Environmental Research Center p. 7 (June).

Table 2 Summary of Major Stationary CO_2 Sources in the PCOR Partnership Region

Source Type	Quantity	% of All Sources	CO_2 Emissions, million tons/yr	% of All CO_2 Emissions
Electricity Generation	170	12.2	370.67	65.7
Paper and Wood Products	141	10.1	35.40	6.3
Petroleum and Natural Gas Processing	32	2.3	28.94	5.1
Chemical and Fuels Production	43	3.1	24.16	4.3
Ethanol Production	63	4.5	16.43	2.9
Petroleum Refining	21	1.5	16.01	2.8
Cement/Clinker Production	16	1.1	13.94	2.5

The PCOR Partnership region also contains many opportunities for terrestrial sequestration of CO_2. Terrestrial sinks include agricultural lands (e.g., croplands, grasslands, and range lands), forest lands, wetlands, and peat bogs. Forested areas within the PCOR Partnership region total more than 302 million acres [7–10], agricultural lands (both farm- and rangeland) total more than 402 million acres [11,12], the PPR includes 30.9 million acres of wetlands [13,14], and the region contains more than 106 million acres of peat bogs [15,16]. While the amount of carbon that can be sequestered terrestrially is species- or location-dependent, gross estimates of sequestration capacity can be made by applying average sequestration rates [17–21] to the available acreages.

Commercial oil and gas plays are present in five states and all of the provinces of the region, and CO_2-based enhanced oil recovery (EOR) and enhanced coalbed methane (ECBM) are value-added sequestration technologies with the potential for expanded commercial-scale development. Many of the region's oil fields are capable of sequestering CO_2 in commercially significant amounts. EOR is particularly attractive as a near-term opportunity because the geology of the oil- and gas-bearing strata is very well characterized and the cost of developing sequestration infrastructure can be offset by enhanced resource recovery. The lessons learned through EOR and ECBM can eventually be applied to saline aquifers and coal fields of the PCOR Partnership region that, in some cases, extend unbroken over thousands of square miles.

To match a source to a sink, the DSS was used to locate the individual CO_2 sources. Sources having similar physical properties and located in relatively close proximity to each other were consolidated into a single source. A buffer of a desired distance (usually 125 miles) was drawn around the center of the consolidated source, and any viable geologic sinks located within that buffer were identified. The type of sequestration that could be performed in those sinks (e.g., EOR or injection into a saline formation) was determined from the data in the DSS. For each match of geologic sink and consolidated CO_2 source, called a scenario, the types of technologies that might be used to separate and capture the CO_2 for sequestration were identified, if possible. It should be noted that current capture and separation technologies are too expensive under current market conditions for many of the CO_2 streams generated in the PCOR Partnership region, either because the types or quantities of impurities present in the stream would prevent effective separation and capture or because the operating pressures of a particular stream composition are not appropriate for the technology.

Based on the results of Phase I, four field validation tests (see Figure 3) were designed to demonstrate the technical and economic feasibility of the most promising long-term sequestration options in the region. Three geologic field validation tests and one terrestrial test will be conducted over a 4-year time frame during Phase II.

Field Validation Test at Beaver Lodge. CO_2 will be injected into an oil-bearing zone at great depth in the Beaver Lodge oil field in northwestern North Dakota. The activity will be used to determine the efficacy of CO_2 sequestration and the use of CO_2 to produce additional oil from other deep carbonate formations.

Field Validation Test at Zama. Acid gas (approximately 67% CO_2, 33% hydrogen sulfide [H_2S]) from natural gas-processing plants in northern Alberta, Canada, will be injected into an oil-producing zone in an underground pinnacle reef structure. Results will help to determine the best practices to support sequestration in these unique geologic structures as well as further our understanding of the effects of H_2S on tertiary oil recovery and CO_2 sequestration.

Figure 3 PCOR Partnership Phase II sequestration demonstrations.

Field Validation Test of North Dakota Lignite. CO_2 will be injected into unminable lignite seams in southwestern North Dakota. The injected CO_2 is trapped by naturally bonding to the surfaces of the fractured lignite. The injected CO_2 also has the potential to displace methane occupying the coal fractures. This validation test will give valuable information for tailoring practices to the conditions in the region for both CO_2 sequestration and ECBM production.

Terrestrial Validation Test. A managed wetland will be implemented in north-central South Dakota to demonstrate practices that will improve CO_2 update. The results will help to optimize CO_2 storage, monitoring and verification methods, and facilitate the monetization of terrestrial carbon offsets in the region and elsewhere.

Conclusions

Electrical power generation comprises over 60% of the CO_2 emissions from stationary sources in the PCOR Partnership region. Other industries that may be important CO_2 sources for carbon sequestration include refineries, cement manufacturing, and ethanol production facilities. The PCOR Partnership region has abundant opportunities for both geological and terrestrial carbon sequestration. Enhanced resource recovery (EOR and ECBM) are likely the first geologic sequestration projects to be developed due to more favorable economics. Agricultural lands, forestlands, and wetlands have significant potential for terrestrial carbon sequestration.

The PCOR Partnership region will be home to four field validation tests in Phase II. Each field validation test has been designed to gather the data required to monetize carbon credits for the respective activities, and each will result in a series of best practices manuals that can be employed as guides for the large-scale development of CO_2 sequestration in the future.

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