An assessment of potential CO_2 Sources throughout the Illinois Basin
Subtask 5.1 – CO_2 Source Assessment
Topical Report

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CARBONSAFE ILLINOIS EAST SUB-BASIN

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Executive Summary

Large-scale anthropogenic CO_2 sources (>100,000 tonnes/year) were catalogued and assessed for the Illinois East Sub-Basin project area. The portfolio of sources is quite diverse, and contains not only fossil-based power generation facilities but also ethanol, chemical, and refinery facilities. Over 60% of the facilities are relatively new (i.e. post year 2000 construction) hence increasing the likelihood that retrofitting the facility with a carbon capture plant is feasible. Two of the facilities have indicated interest in being "early adopters" should the CarbonSAFE project eventually transition to a build and operate phase: the Prairie State Generating Company's electricity generation facility near Marissa, Illinois, and Quasar Syngas, LLC's Wabash ammonia/direct-reduced iron plant, currently in development north of Terre Haute, Indiana.

Summary

Large-scale anthropogenic CO_2 sources (>100,000 tonnes/year) from the Illinois East Sub-Basin project area are listed in Table 1, and highlighted in Figure 1. The data on total amount of CO_2 emission per year for each facility were collected from the US EPA and Midwest Geological Sequestration Consortium databases. The web site of each facility was visited to confirm the location and operational status of the facility. The publicly available data such as the latest Air Permit for each facility were scanned to get more details about the respective facility and a spreadsheet was prepared listing all the details. The US EPA Acid Rain Program database was also searched to obtain emissions details of the facilities.

The portfolio of sources is quite diverse, i.e. contains not only fossil-based power generation facilities but also ethanol, chemical, and refinery facilities. This is a major strength since market diversity reduces future project risk due to market variations– i.e. downturns in one market (e.g. refineries and oil prices) might cause delays in deployment of carbon capture and storage (CCS) due to limited capital available for investment in CCS. It is also significant that over 60% of the facilities are relatively new (i.e. post year 2000 construction) hence increasing the likelihood that retrofitting the facility with a carbon capture plant is feasible. Nearly 20% of the portfolio are ethanol facilities. Power generation accounts for half of the facilities with 90% of the power generating facilities being coal-based. Many of the power generating facilities could more than likely utilize capture technologies either deployed or under development by the DOE/NETL.

Two of the facilities contacted have indicated interest in being "early adopters" should the CarbonSAFE project eventually transition to a build and operate phase.

Prairie State Generating Company has expressed interest in participating in CarbonSAFE Illinois, and assessing CCS options relating to their 1,600-megawatt (MW) Energy Campus east of Marissa, Illinois. This modern coal-fired electricity generation facility has been online since 2012, and its supercritical design and state-of-the-art emissions control technologies (including nitrogen oxide and mercury controls, sulfur dioxide scrubbers, and wet and dry electrostatic precipitators) result in low NO_x, SO_x, and particulate matter. The company is committed to reducing its CO_2 emissions, and is looking toward CarbonSAFE researchers to assist in locating the best site (or multiple sites) for storing the plant's annual CO_2 emissions exceeding 10 million tonnes.

Table 1: Large-scale anthropogenic CO_2 sources (>100,000 tonnes/year) considered in the CarbonSAFE Illinois – East Sub-Basin project area.

ID	Facility	Class	City	County	CO_2 Tonne	MW	Fuel	Company	Yr. of Build	Upgrade	Comment
1	Gibson Power Plant	Power Plant	Owensville	Gibson (IN)	13,350,951	3,145	Coal	Duke Energy	1971-1982		
2	Prairie State Generating Station	Power Plant	Marissa	Washington	10,495,061	1,600	Coal	Cooperative	2012		Only plant in Illinois with supercritical boilers. Interested in CCS due to 45Q tax credits. CarbonSAFE visited facility for discussions. Expected early adopter.
3	Petersburg Power Plant	Power Plant	Petersburg	Pike (IN)	9,249,149	1,720	Coal/ Fuel Oil	Indianapolis Power & Light Company	1967-1986	1996-2004	Added FGD, SCR, low NOx burner -1996-2004
4	Merom Power Plant	Power Plant	Sullivan	Sullivan (IN)	5,082,733	1,070	Coal	Hoosier Energy	1976		
5	Cayuga Power Plant	Power Plant	Cayuga	Vermillion (IN)	5,045,932	1,104	Coal	Duke Energy	1967-1972	1993	Added Low NOx burner
6	Newton Power Plant	Power Plant	Newton	Jasper	4,794,893	615	Coal	Dynegy	1972-1975		One boiler retired in 2016
7	Edwardsport Power Plant	Power Plant	Edwardsport	Knox (IN)	2,653,783	618	Coal/ IGCC	Duke Energy	2013		Original unit built in 1918, retired in 2011
8	AB Brown Generating Station	Power Plant	Mt. Vernon	Posey (IN)	2,642,472	650	Coal/NG	Vectren	1979-2002		
9	Southern Illinois Power Coop	Power Plant	Marion	Williamson	2,323,167	433	Coal/NG	Cooperative	1963-1978	2003	
10	Marathon Petroleum	Refinery	Robinson	Crawford	1,697,277		Gas/Liquid		1906		
11	Sugar Creek Generating station	Power Plant	W. Terre Haute	Vigo (IN)	1,291,233	535	NG	Northern Indiana Public Service Company	2002-2003		
12	Lone Star Industries Inc.	Cement	Greencastle	Putnam (IN)	1,107,214		Coal/ Petcoke/Others	Buzzi Unicem USA	Kiln - 1966	2000	
13	SABIC Innovative Plastics, LLC	Petrochemicals	Mt. Vernon	Posey (IN)	661,148		NG	SABIC (Saudi Basic Industries Corpn)	1979-1996	2014	5 boilers. 2 coal boilers converted to NG in 2014
14	Countrymark Refining & Logistic	Refinery	Mt. Vernon	Posey (IN)	205,147		Refinery Fuel Gas		1950	2016	
15	Grain Processing Corpn	Ethanol	Washington	Daviess (IN)	209,246		NG/Biogas	Kent Corporation	2000	2015	Fermenter, dryer, boiler
16	Rain Cii Carbon LLC	Chemical	Robinson	Crawford	156,198		Greencoke		1998		Kiln. Calcined Pet Coke
17	Abengoa Biorefinery of Indiana	Ethanol	Mt. Vernon	Posey (IN)	151,574		NG	Green Plains, Inc.	2007		Fermenter, dryer, boiler
18	Eli Lilly & Co.	Chemical	Clinton	Vermillion (IN)	133,261		Coal/NG		1970-1976		
19	Valero Renewable Fuels	Ethanol	Mt. Vernon	Posey (IN)	139,838		NG		2008		Fermenter, dryer, boiler
20	POET Biorefinery - Cloverdale	Ethanol	Cloverdale	Putnam (IN)	132,877		NG		2008		Fermenter, dryer, boiler
21	Quasar Syngas, LLC - Wabash (in development)	Ammonia/Iron	W. Terre Haute	Vigo (IN)	1,570,000		Coal/ Petcoke				IGCC plant conversion in development, company interest in participation; Wabash CarbonSAFE feasibility proposal developed and submitted Feb. 2018 to DOE. Expected early adopter.
				Total CO_2 Tonnes, Annual	63,093,154						

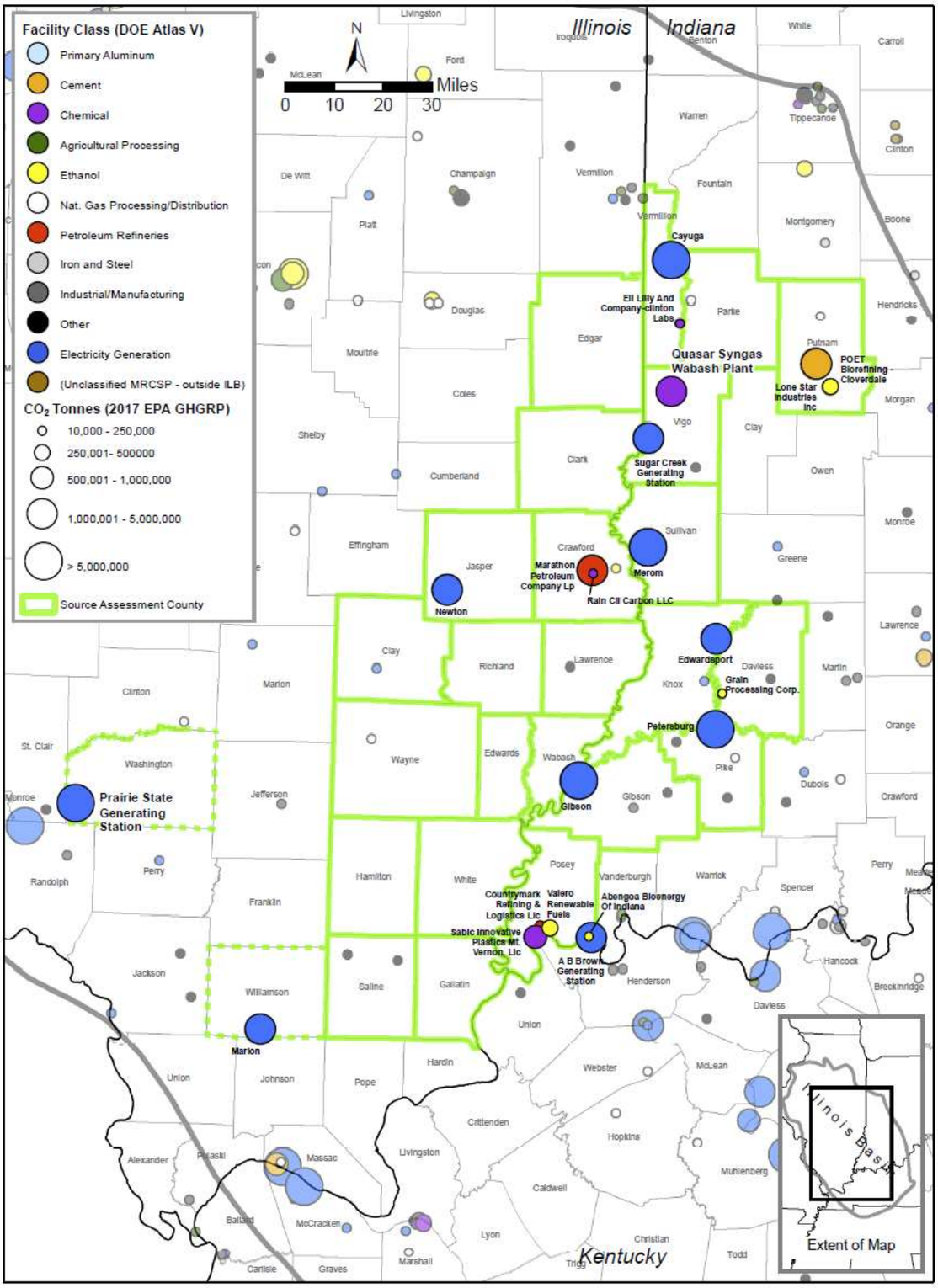

Figure 1: Locations and relative annual CO_2 emissions of regional anthropogenic CO_2 sources. Plants considered in the CarbonSAFE Illinois – East Sub-Basin project area (CO_2 emissions greater than 100,000 tonnes/year) are shown bolded, with plant names labeled.

Additionally, the CarbonSAFE Illinois – East Sub-Basin project has support and active participation from Quasar Syngas LLC (QSG) to conduct the technical feasibility for storage of CO_2 produced through their ammonia/Direct Reduced Iron (DRI) project, currently in development, at the Wabash Integrated Gasification Combined Cycle (IGCC) Plant north of Terre Haute, Indiana. The Wabash IGCC plant has a reliable operating and performance history, and environmental permits are already in place.

Quasar Syngas LLC (QSG) acquired the Wabash IGCC plant in 2016 to repurpose the facility for production of ammonia and Direct Reduced Iron (DRI) for the domestic market. The project has an approximate total cost of $400 million and a 36-month construction timeline beginning July 2018. Petcoke will be converted to syngas and then hydrogen that is used to produce ammonia and DRI. The syngas will be purified using the Rectisol process that results in a very pure CO_2 stream (Figure 2) that can be readily compressed and transported for storage, CO_2 EOR, or other use.

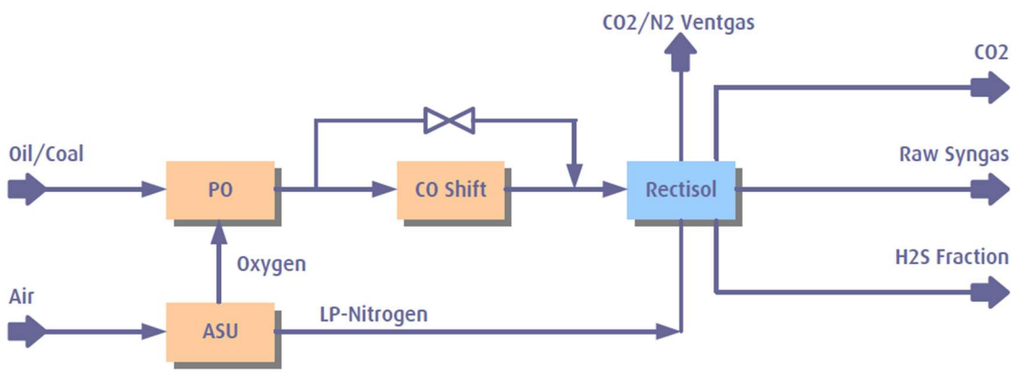

Figure 2: Overview of process involving Rectisol that will be used by QSG to collect CO_2 from the syngas stream. The Rectisol process results in a pure stream of CO_2 that can be compressed and transported at relatively low incremental cost to the overall project.

QSG has conducted initial engineering to repurpose the facility to produce hydrogen from synthetic gas to feed new process units to produce 1,500 tonnes ammonia and 1,750 tonnes DRI daily. QSG's Acid Gas Recovery system (Figure 3) will use the Rectisol process to remove acid gases (H_2S and CO_2) from the syngas stream. The Rectisol process uses methanol, a physical solvent, that does not rely on chemical reactions to separate the acid gases as do amine-based systems. Rectisol is often used to treat syngas as it is an effective method to remove contaminants such as ammonia, mercury and other trace components commonly found in these gases.

In the Rectisol process, cold methanol absorbs the acid gases at relatively high pressure, and then the pressure is reduced to release the acid gases for recovery. The cold methanol solvent process has advantages as it is flexible for separation of various components and can remove more of the acid gases than many competing processes. At the QSG facility using a standard application of the Rectisol process to the syngas stream based on Pre-FEED studies, approximately 65% of the CO_2 will be separated at a flow rate of about 120 tonnes/hour (nominally 1 MT/year). This separated CO_2 will be greater than 95% pure and will be delivered at about 2 bar. QSG will add a vacuum flash step within the desorption loop to increase the separation to 95% CO_2, or 179 tonnes/hour (nominally 1.57 MT/year), at a similar purity and lower pressure. At full and continuous operation the QSG facility will deliver almost 1.6MT CO_2/year for storage or EOR use.

Figure 3. Aerial view of the QSG facility with various components of the syngas to ammonia process. The Acid Gas Recovery system is associated with the Sulfur Recovery location.

A distinct advantage of the QSG Wabash plant is that the source of CO_2 is being developed as part of the business strategy to provide ammonia and DRI to the American Midwest primarily as a fertilizer and feedstock for agriculture and electric arc furnaces, respectively. The facility will provide low-cost ammonia alternative for regional farming cooperatives. The CO_2 must be removed from the syngas for process reasons. The facility can accept coal, or petcoke from several refineries in the region, as feedstock. The ammonia and DRI sales will be aided by onsite railcar access and a nearby ammonia pipeline. 77% of the 20.7 million tons of annual US ammonia sales are in the Midwest and this project will displace more expensive, imported ammonia that currently dominates the domestic market. The reliability of the existing gasification infrastructure, simplicity of the design modifications for CO_2 separation, and experience of the operations and management team are all advantages to this proposed carbon management project