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Source/Sink Matching for U.S. Ethanol Plants and Candidate Deep Geologic Carbon Dioxide Storage Formations

RT Dahowski
JJ Dooley

September 2008

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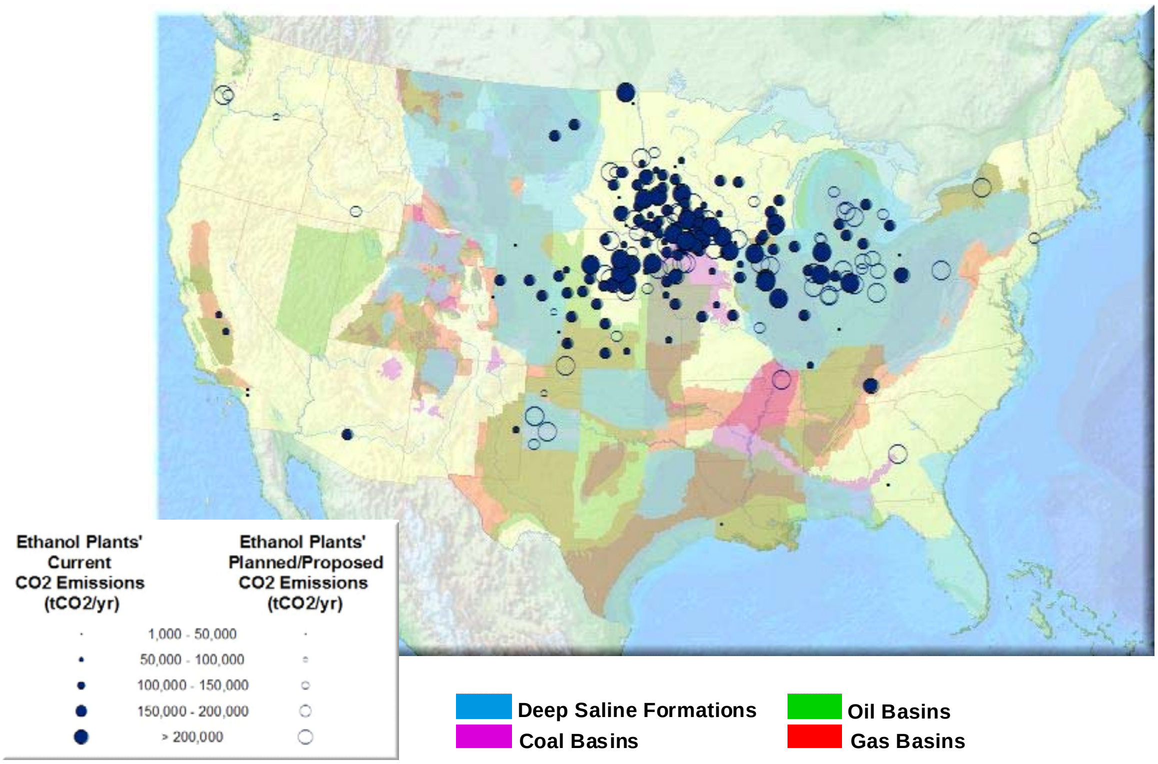
ABSTRACT: This report presents data on the 140 existing and 74 planned ethanol production facilities and their proximity to candidate deep geologic storage formations. Half of the existing ethanol plants and 64% of the planned units sit directly atop a candidate geologic storage reservoir, while 70% of the existing and 97% of the planned units are within 100 miles of at least one candidate deep geologic storage reservoir. As a percent of the total CO_2 emissions from these facilities, 92% of the emissions from exiting units and 97% of the emissions from planned units are generated within 100 miles of at least one potential CO_2 storage reservoir.

KEY WORDS: ethanol production, carbon dioxide capture and storage; climate change, United States.

Figure 1 shows current and announced ethanol production facilities in the United States as well as candidate deep geologic CO_2 storage reservoirs.[1] As can be seen from Figure 1, while many ethanol facilities sit directly atop a potential storage formation, a significant percentage do not. This brief paper will examine the proximity of U.S. ethanol production facilities to candidate storage reservoirs, as well as the implications of this analysis for the potential deployment of carbon dioxide capture and storage (CCS) technologies within the U.S. ethanol industry.

Figure 1: Candidate Deep Geologic CO_2 Storage Reservoirs and Current and Planned Ethanol Production Facilities



[1] A description of the United States' massive and geographically dispersed theoretical geologic CO_2 storage capacity can be found in RT Dahowski, JJ Dooley, CL Davidson, S Bachu, and N Gupta. 2005. *Building the Cost Curves for CO_2 Storage: North America.* Technical Report 2005/3. IEA Greenhouse Gas R&D Programme.

Overview of U.S. Ethanol Plants

Table 1 presents an overview of the existing and planned U.S. ethanol production infrastructure using the most recently available data.

Table 1: Overview of Existing and Planned Ethanol Production Facilities

	Existing Facilities	Planned Facilities	Total
Number of Facilities	140	74	214
Total Emissions, $MtCO_2/yr$	19.3	15.1	34.4

Ethanol plants are seen as potential early adopters of CCS systems as the cost of capturing CO_2 from these facilities is believed to be quite low. The fermentation process involved in producing ethanol results in a very pure stream of CO_2 that is typically vented to the atmosphere. If there were a policy in place that created a disincentive for venting CO_2 to the atmosphere, the CO_2 stream from these ethanol plants would only need to be dehydrated (to prevent corrosion in CO_2 pipelines) and compressed to typical pipeline pressures. The cost of capture (including dehydration and compression) from these facilities could be in the range of \$6-12/tonCO_2, which is far lower than the potential costs to capture and prepare pipeline-ready CO_2 from even the most modern coal fired power plants.[2] For this reason, industrial facilities such as ethanol plants that produce high purity CO_2 streams are often seen as early opportunities for CCS deployment.

Source Sink Matching Transporting CO_2 from Ethanol Facilities

While the cost of capturing CO_2 from ethanol plants is considered to be quite low, the captured CO_2 still needs to be delivered to a suitable deep geologic storage reservoir, injected into that reservoir, and monitored for safety and efficacy. The cost of transport (which for the U.S. and many other parts of the world will almost surely be by dedicated CO_2 pipelines)[3] is likely to be another significant cost element, particularly on a per-ton basis given the relatively low-volume CO_2 streams produced by ethanol facilities.[4]

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[2] JJ Dooley, CL Davidson, RT Dahowski, MA Wise, N Gupta, SH Kim, EL Malone, "Carbon Dioxide Capture and Geologic Storage: A Key Component of a Global Energy Technology Strategy to Address Climate Change." Joint Global Change Research Institute, Battelle Pacific Northwest Division. May 2006. PNWD-3602. College Park, MD.

[3] *IPCC Special Report on Carbon Dioxide Capture and Storage.* 2005. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [B Metz, O Davidson, H de Conick, M Loos, and L Meyer] Cambridge University Press, Cambridge, United Kingdom, 442 pp.

[4] Joel Sminchak, Robert Dahowski, James Dooley, Casie Davidson, and Neeraj Gupta. *Developing a Better Understanding of the Cost of CO_2 Transport and Storage: Moving Beyond a Fixed Storage Cost Assumption.* Presented at the Sixth Annual Conference on Carbon Capture and Sequestration. Pittsburgh. May 9, 2007. Joint Global Change Research Institute. Battelle. PNWD-SA-7806.

Source Sink Matching for Existing Ethanol Production Facilities

Table 2 presents summary information on the existing ethanol facilities and their proximity to candidate deep geologic CO_2 storage formations. As shown in Table 2, 50% of the existing ethanol plants (which cumulatively account for 46% of the CO_2 produced from all existing ethanol plants) sit directly atop a candidate deep geologic CO_2 storage formation. If the search radius is expanded to 50 miles, 85 existing ethanol plants (61%) could reach a candidate CO_2 storage reservoir. If the search radius is extended to 100 miles, 110 existing facilities accounting for 92% of the cumulative CO_2 from these existing ethanol plants could likely reach at least one deep geologic CO_2 storage formation.

Table 2: Existing Ethanol Facilities and their Distance to Candidate Deep Geologic CO_2 Storage Reservoirs

	Number of Facilities	% of Facilities	Total Emissions, $MtCO_2/yr$	% Of Emissions
0 miles	70	50%	19.3	46%
50 miles	85	61%	9.0	76%
100 miles	110	79%	14.8	92%
Total	140	100%	19.3	100%

Source Sink Matching for Planned Ethanol Production Facilities

Table 3 presents summary information on the planned ethanol facilities and their proximity to candidate deep geologic CO_2 storage formations. As can be seen from Table 3, 64% of the planned plants (62% of the planned units CO_2 emissions), appear to sit atop a candidate deep geologic CO_2 storage formation. If pipeline lengths of up to 50 miles are considered, then slightly more than 80% of the facilities and a similar percentage of their CO_2 emissions should be able to reach a candidate CO_2 storage reservoir. If the search radius is extended to 100 miles, virtually all of the facilities and their associated emissions (97% by both measures) should be able to reach a candidate deep geologic CO_2 storage reservoir.

Table 3: Existing Ethanol Facilities and their Distance to Candidate Deep Geologic CO_2 Storage Reservoirs

	Number of Facilities	% of Facilities	Total Emissions, $MtCO_2/yr$	% Of Emissions
0 miles	47	64%	9.4	62%
50 miles	60	81%	12.5	83%
100 miles	72	97%	14.7	97%
Total	74	100%	15.1	100%

The following figures illustrate the findings for both the existing and planned ethanol facilities. Figure 2 shows the distance from each current and planned ethanol production facility to the nearest candidate CO_2 storage formation. Figure 3 shows the cumulative estimated CO_2 emissions from these same sets (and order) of plants. Figure 4 shows a preliminary estimate of cumulative CO_2 pipeline requirements, assuming individual pipelines from each plant to nearest storage reservoir, with a 17% routing factor and 10 mile adder to locate a suitable injection location .

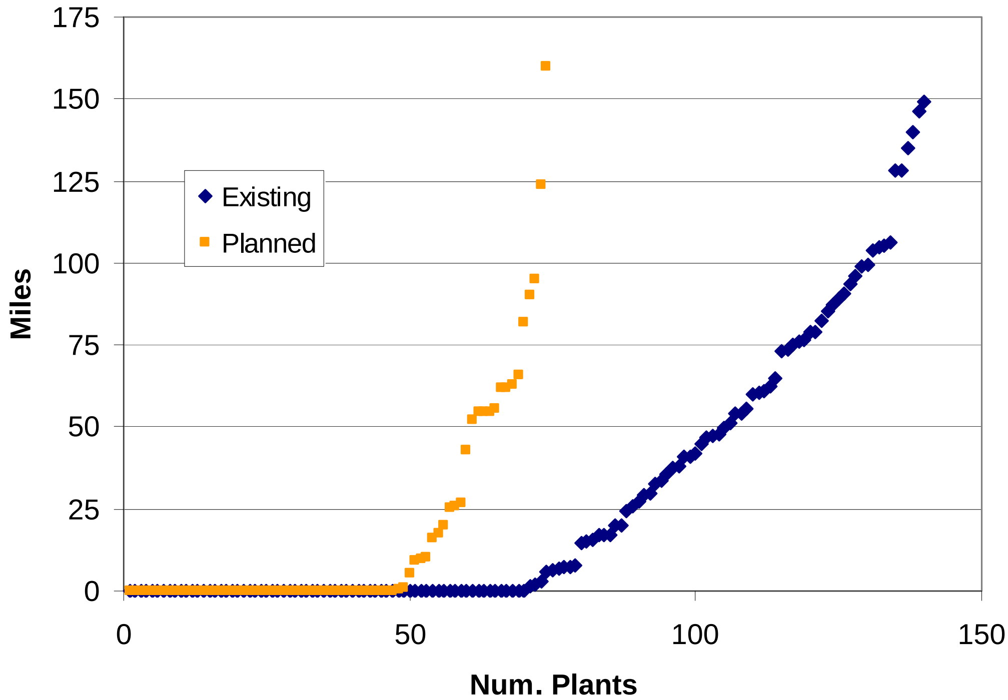

Figure 2: Distance in Miles to Nearest Candidate Deep Geologic CO_2 Storage Formation for Both Existing and Current Ethanol Plants

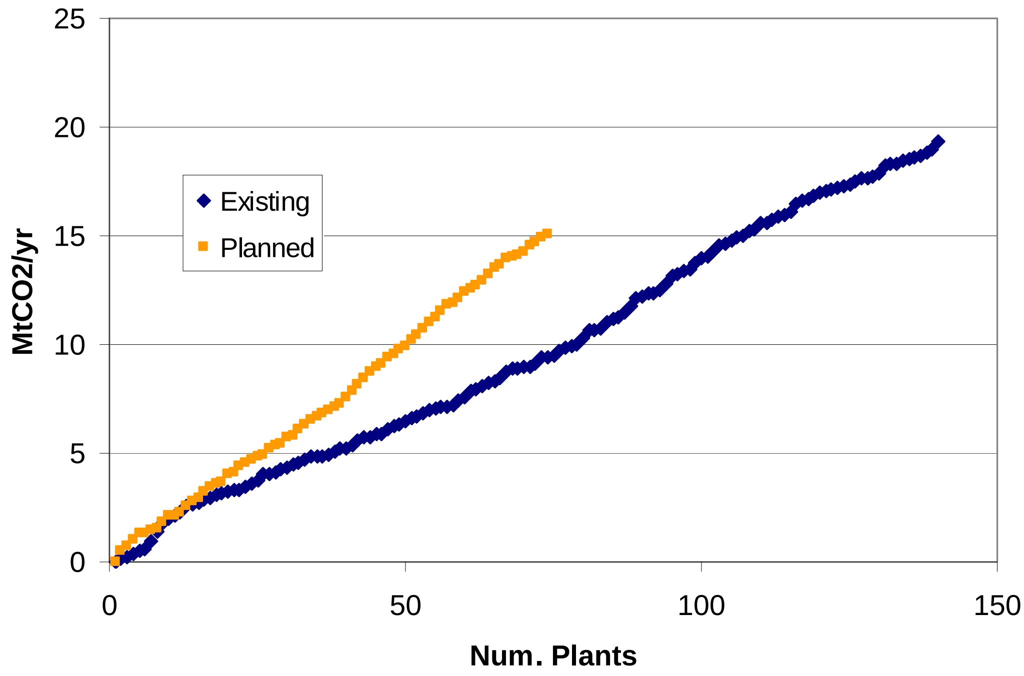

Figure 3: Cumulative Estimated CO_2 Emissions for the Set of Existing and Planned Ethanol Production Facilities Shown in Figure 2.

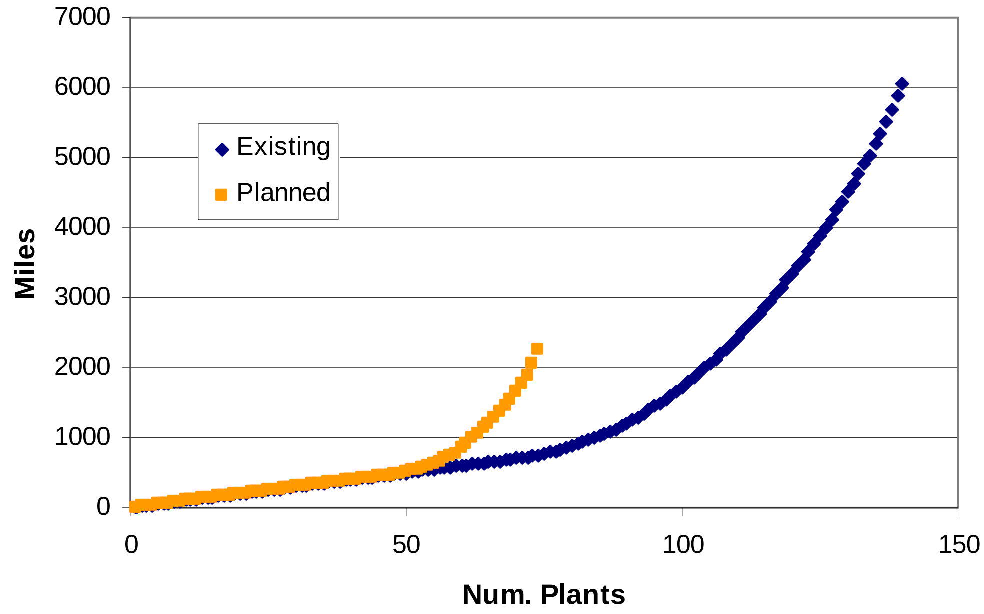

Figure 4: Estimated Cumulative CO_2 Pipeline Infrastructure for the Set of Existing and Planned Ethanol Production Facilities Shown in Figure 2.