Comparative Economic Analysis of Capture, Transport, and Storage from a CO_2 Source Perspective in the Central U.S.

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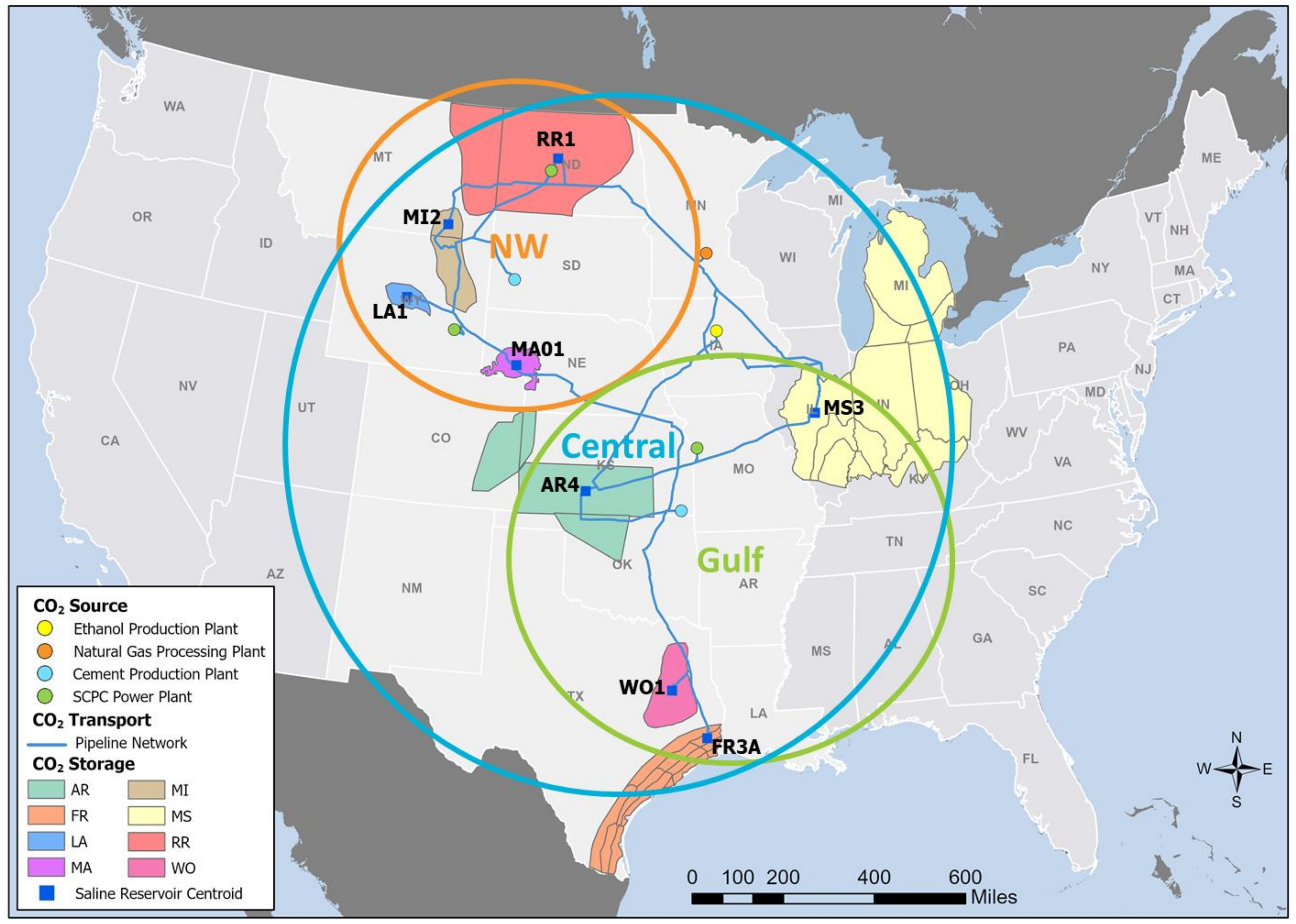
ABSTRACT

Carbon capture and storage (CCS) is considered a promising strategy to significantly reduce carbon emissions in the United States. While many CCS studies have been performed, few provide an integrated economic analysis for each component of the CCS value chain (i.e., capture, transport, and storage) or consider the geographic or geological impacts of a region. The Central United States is home to several types of CO_2 generating sources that would likely require tailored approaches to CO_2 management, and many states in this region have or are moving toward favorable regulatory requirements for CO_2 storage operations.

For this analysis, the Central United States was divided into three regional impact areas and used NETL-developed models and resources to estimate overall CCS costs. Each regional area included a specifically designed CCS network that connected different source types at hypothetical source locations with geologic storage reservoirs through either a dedicated pipeline or trunkline network, resulting in the evaluation of more than 100 integrated source-to-sink matching scenarios. The results highlight the significance of the location and type of the CO_2 source, capture rate of a CO_2 source, and quality of the saline storage reservoir on overall costs.

Regional Impact Areas Evaluated



▲ Impact areas enable exploration of the challenges and advantages of different areas within a region from the perspective of a CO_2 source. Each regional impact area has a specifically designed CCS network.

CO_2 CAPTURE + CO_2 TRANSPORT + CO_2 STORAGE

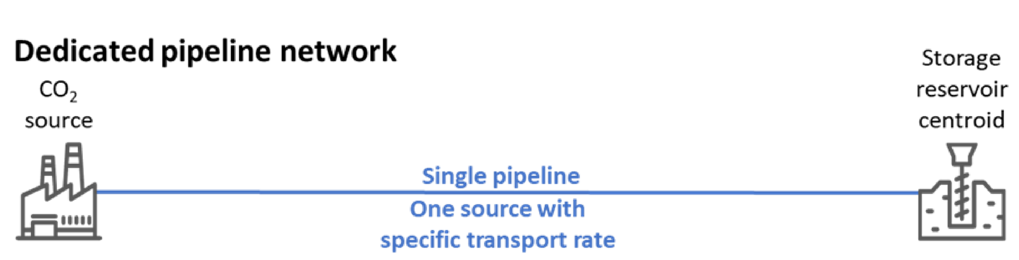
CO_2 CAPTURE

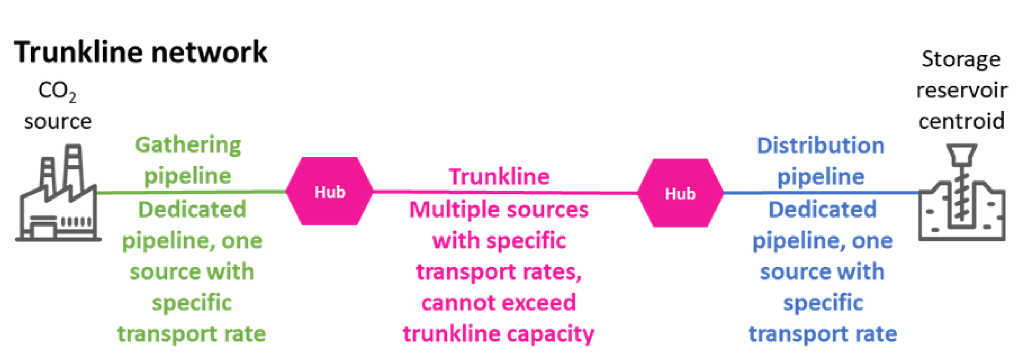
- Four CO_2 source types
- Seven hypothetical source locations
  - Iowa (ethanol)
  - Minnesota (natural gas processing plant [NGPP])
  - Wyoming, North Dakota, and Missouri (supercritical pulverized coal [SCPC] electric power plant)
  - South Dakota and Kansas (cement plant)
- Capture costs associated with Greenfield sites

CO_2 Source Type	CO_2 Captured at 85% Capacity Factor (million tonnes/yr)	Capture Costs (2018\$/tonne)
NGPP	0.55	20.92
Ethanol Production Plant	0.12	35.22
SCPC Electric Power Plant	4.33	65.50
Cement Production Plant	0.97	106.48

CO_2 TRANSPORT

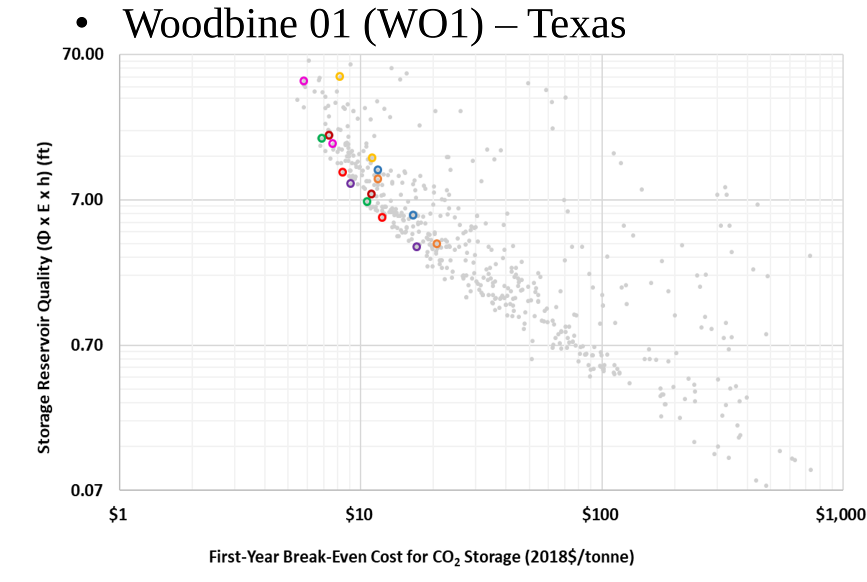
- Two Transportation networks
  - Dedicated pipeline
  - Trunkline
- Trunkline network uses gathering and distribution pipelines of 30 miles each.
- Pipeline networks follow existing natural gas pipeline rights-of-way.





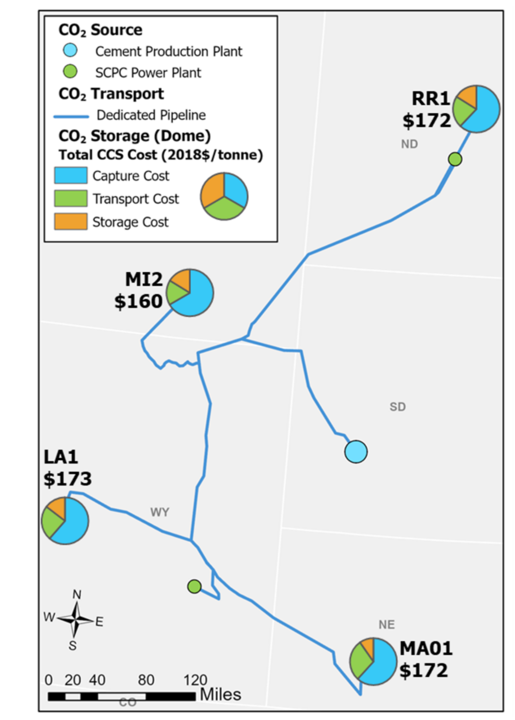
CO_2 STORAGE

- Regional storage reservoirs were screened and selected based on lowest cost and/or best reservoir quality options.
- Eight storage reservoirs
  - Arbuckle 4 (AR4) – Kansas
  - Frio 3A (FR3A) – Texas
  - Lance 1 (LA1) – Wyoming
  - Maha 01 (MA01) – Nebraska
  - Minnelusa 2 (MI2) – Montana
  - Mt. Simon 3 (MS3) – Illinois
  - Red River 1 (RR1) – North Dakota
  - Woodbine 01 (WO1) – Texas

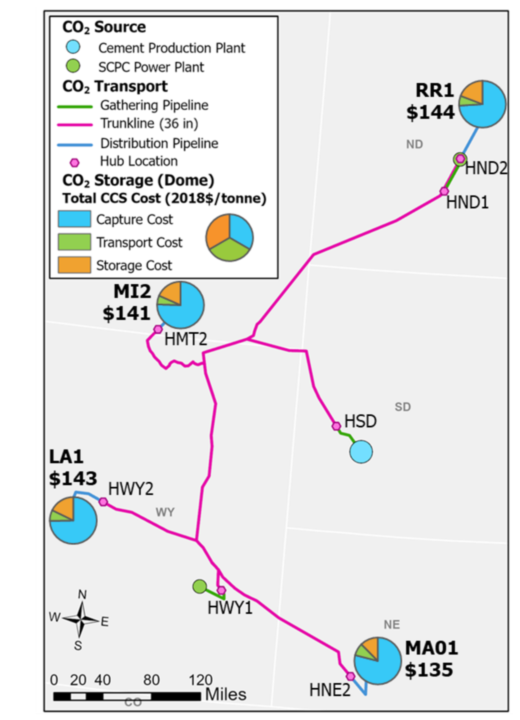


RESULTS and CONCLUSIONS

CCS Cost Analysis for the Cement Plant in South Dakota



Dedicated Pipeline Network

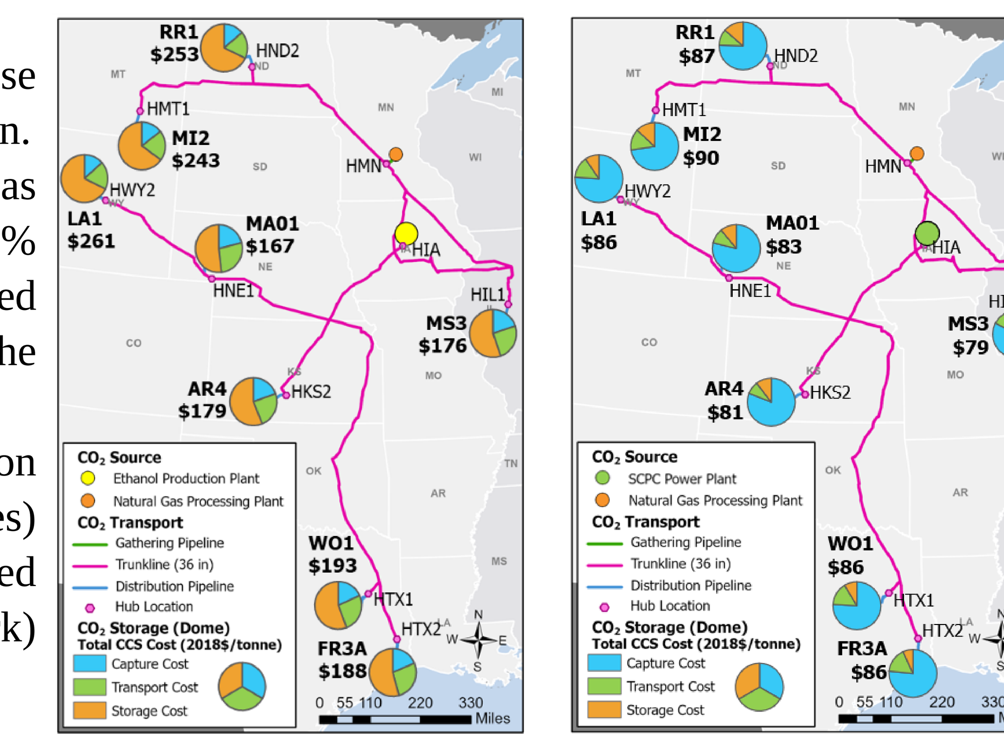


Trunkline Network

- Capture is the highest CCS cost component in the dedicated pipeline network followed by transport and storage; transport and storage switch in the trunkline network.
- The closest storage reservoir (Minnelusa 2 [MI2]) is the lowest cost CCS option in the dedicated pipeline network.
- The furthest storage reservoir (Maha 01 [MA01]) becomes the lowest cost CCS option in the trunkline network.

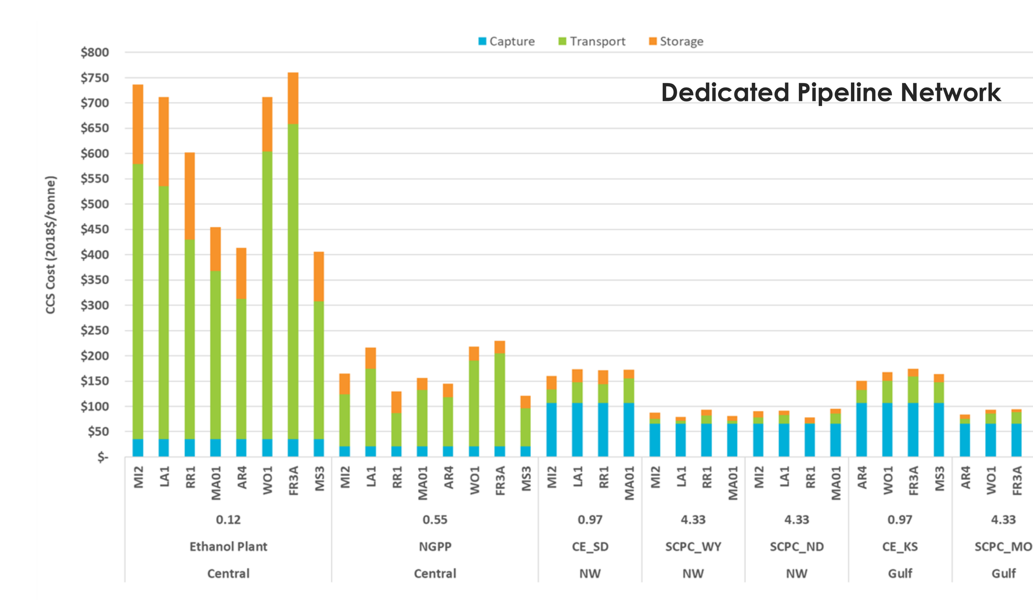
Economies of Scale

- A high capture rate helps decrease CCS costs across the CCS value chain.
- An SCPC plant at the same location as the ethanol plant can save up to 83% on CCS unit costs in the dedicated pipeline network and 58% in the trunkline network.
- An Ethanol hub capturing 4.33 million tonnes/yr collectively (~36 sources) can save up to 86% (dedicated network) and 67% (trunkline network) on CCS unit costs.



Central Impact Area – Ethanol plant (left) and SCPC plant (right) - Trunkline

Cost Comparison Across Regional Impact Areas



- The SCPC plant has the lowest CCS unit costs followed by the cement plant, NGPP, and ethanol plant in the dedicated pipeline network.
- Storing CO_2 in the closest storage reservoir resulted in the lowest CCS unit costs in five of seven networks for the dedicated pipeline and three of seven for the trunkline pipeline.
- The average CCS cost savings with a trunkline is 26%. An ethanol plant has the highest cost savings at 64%, and an SCPC plant has the lowest with an average cost savings of 8%.

RESOURCES

- FECM/NETL CO_2 Transport Cost Model (CO2_T_COM)
- FECM/NETL CO_2 Saline Storage Cost Model (CO2_S_COM)
- Cost of Capturing CO_2 from Industrial Sources (2014) – 2022 version now available
- Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity (Revision 4, 2019) – 2022 version now available

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