# Case Studies for Regional Characterization Using a Geographic Information System

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## Overview

This poster presents two case studies of the application of a Geographic Information System (GIS) for the regional characterization of $CO_2$ capture and storage (CCS) potentials. The geographic areas studied are California and eastern Texas. In each case, we evaluated the large concentrated $CO_2$ sources and the storage capacity of geologic formations. Then, we applied our transportation cost model to construct the aggregate transportation cost layer for each region. Finally, we applied our least-cost source-sink matching model to build a CSS network in the study region that minimizes the cumulative $CO_2$ transport and injection cost of the system.

## Large Stationary $CO_2$ Sources

**Table 1 $CO_2$ Flow Rate by Plant Types, California**

| Plant Type | Number of Plants | 25-year $CO_2$ Flow (Mt) |
|---|---|---|
| Power Plant | 18 | 1,754 |
| Cement and Lime Plant | 6 | 135 |
| Refinery | 7 | 255 |
| All sources | 31 | 2,144 |

**Table 2 $CO_2$ Flow Rate by Plant Types, eastern Texas**

| Plant Type | Number of Plants | 25-year $CO_2$ Flow (Mt) |
|---|---|---|
| Power Plant | 98 | 7,904 |
| Ammonia | 1 | 6 |
| Cement | 8 | 166 |
| Gas Processing | 8 | 82 |
| Refinery | 15 | 771 |
| All sources | 130 | 8,929 |

❖ The $CO_2$ emissions were estimated assuming an operation capacity of 80% for power plants and full production capacity for non-power stationary $CO_2$ sources. The capture efficiency was assumed to be 90% for non-pure $CO_2$ sources and 100% for pure $CO_2$ sources.

❖ We restricted $CO_2$ sources to power plants with design capacity greater than 100 MWe and non-power $CO_2$ sources with the 25-year emissions over 20 Mt in California or 5 Mt in eastern Texas.

## Capacity of Geologic Formations

**Potential Sink List and Capacity: California**

**Oil fields with EOR potential** 3.2 Gt
**Non-EOR sinks**
- Non-EOR oil fields 0.2 Gt
- Gas fields 1.4 Gt
- Saline aquifers not available

**Potential Sink List and Capacity: eastern Texas**

**Oil fields with EOR potential** 1.2 Gt
**Non-EOR sinks**
- Gas fields 1.7 Gt
- Saline aquifers 196 Gt

❖ The screening criteria: (1) Depth > 800 m; (2) Storage capacity greater than 20 Mt in California or storage capacity greater than 5 Mt in eastern Texas

## $CO_2$ Pipeline Transportation Cost

➢ Pipelines are considered the most economical means of transporting large quantities of $CO_2$ from the sources to the corresponding sinks.

➢ The pipeline construction costs vary considerably according to local terrains, number of crossings (waterway, railway, highway), and the traversing of populated places, wetlands, and national or state parks.

➢ In order to account for such obstacles, the locations and characteristics of these obstacles were loaded into the GIS database and were used to construct a single aggregate transportation obstacle layer (cost surface).

➢ The transportation cost layer was used to determine the least cost pipeline path for connecting each source and sink.

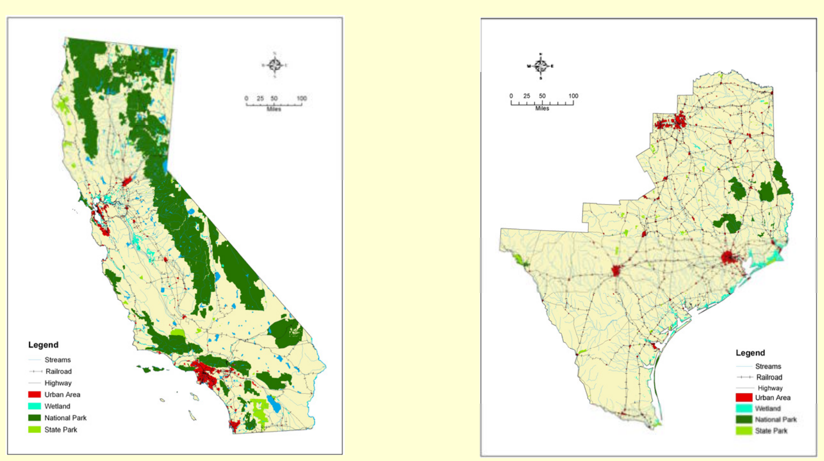


Figure 1 Terrain Maps in California and Eastern Texas

## Least-Cost Path Source-Sink Matching Algorithm

➢ The least-cost source-sink matching methodology approximates the optimal source-sink allocation among a set of $CO_2$ sources and $CO_2$ sinks within the study region.

➢ The method links each $CO_2$ source to a least-cost geological sink based on sum of the transportation cost and the injection cost subject to the sink's storage capacity constraint.

➢ The linking analysis is conducted in two stages. An iterative algorithm presented in the right flow chart is applied in each stage.

➢ In the first stage, the candidate sink set includes only EOR sites where storage projects that transport $CO_2$ to site can earn EOR credits.

➢ If there are sources that remain unmatched or are matched with transportation costs greater than the EOR credits, a second stage analysis will be conducted to link them to non-EOR sinks.

**Table 3 Estimated Relative Construction Cost Factor**

| Construction Condition | | Cost Factor |
|---|---|---|
| Base Case | | 1 |
| Slope | | |
| | 10-20% | 0.1 |
| | 20-30% | 0.4 |
| | >30% | 0.8 |
| Protected Area | | |
| | Populated Area | 15 |
| | Wetland | 15 |
| | National Park | 30 |
| | State Park | 15 |
| Crossing | | |
| | Waterway Crossing | 10 |
| | Railroad Crossing | 3 |
| | Highway Crossing | 3 |

Note: The relative weights are calculated as the ratios of the additional construction costs to cross those obstacles and the base case construction cost for an 8 inch pipeline.

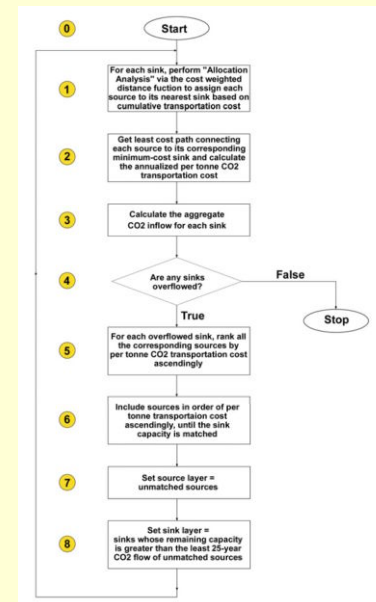


Figure 2 Least-Cost Source-Sink Matching Iterative Algorithm

## Matching Sources to EOR Sinks

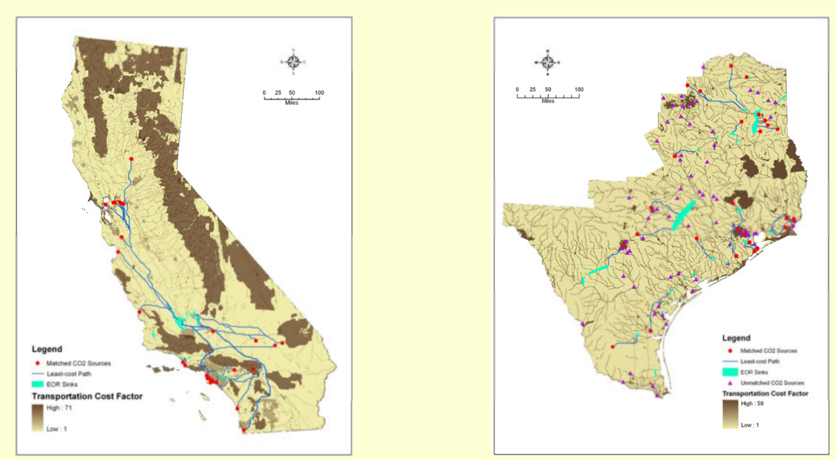


Figure 3 $CO_2$ Sources Matching to Oil Fields with EOR Potential in California and Eastern Texas

## Matching Sources to EOR Sinks (Continued)

**California** **Eastern Texas**

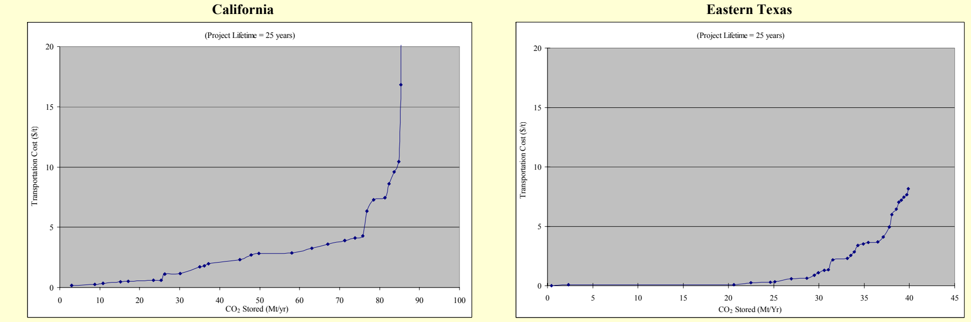


Figure 4 Marginal Transportation Cost in Oil Fields with EOR Potential

**California**

❖ All of the 31 $CO_2$ sources can be connected to their corresponding EOR sinks in the first stage.

❖ Four sources had transportation costs to the closest EOR site greater than the EOR credit value (\$16/t $CO_2$). These sources would be considered in the second stage matching.

**Eastern Texas**

❖ Twenty nine sources were matched to EOR sinks, 101 sources remained unmatched in the first stage.

❖ All the transportation costs for matched sources were below the EOR credit value, suggesting that none of the matched sources would enter the Second stage matching.

## Matching Sources to Non-EOR Sinks

**California**

❖ A new round of source-sink matching was applied for the four sources with transportation cost over EOR credit from the first stage.

❖ A final check was run to conduce a full-cost comparison to decide whether they should be matched to EOR or non-EOR sinks.

❖ Except for the source with transportation to EOR site of \$16.8/t $CO_2$ that remained to be connected to its EOR destination, the other three sources were reassigned to saline aquifers instead because of the lower full cost.

**Eastern Texas**

❖ The second stage source-sink matching was run for the 101 unmatched $CO_2$ sources to link them to non-EOR sinks.

❖ All of the 101 sources were linked to gas fields or saline aquifers.

## Marginal Abatement Cost Curves

➢ $CO_2$ sources linked to EOR sinks: full sequestration cost = capture cost + transport cost – EOR credit

➢ $CO_2$ sources linked to non-EOR sinks: full sequestration cost = capture cost + transport cost + injection cost

**California** **Eastern Texas**

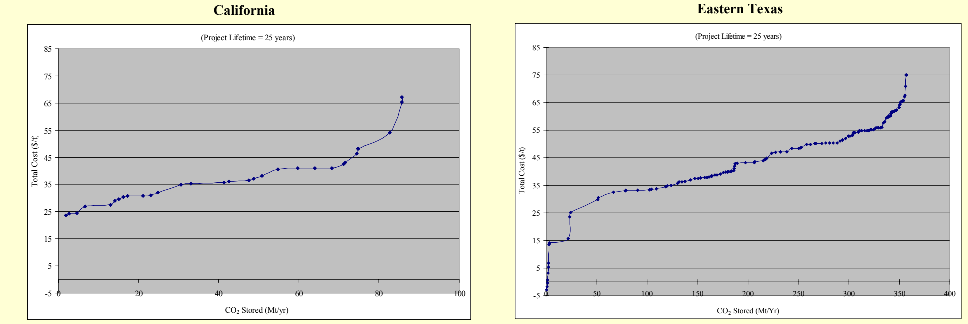


Figure 5 Marginal Abatement Cost Curves

**California**

❖ The marginal costs of sequestering 20, 40, or 80 Mt of $CO_2$ per year would be \$31/t $CO_2$, \$35/t $CO_2$, or \$50/t $CO_2$, respectively.

**Eastern Texas**

❖ The marginal costs of sequestering 20, 100, or 200 Mt of $CO_2$ per year would be \$16/t $CO_2$, \$33/t $CO_2$, or \$43/t $CO_2$, respectively.

❖ Sequestration costs could be negative for certain ammonia and gas processing plants that have low transportation costs since their capture costs would be less than the assumed EOR credit.