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Gigaton CO_2 Transport: A National Scale Perspective

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How is CO_2 Transported?

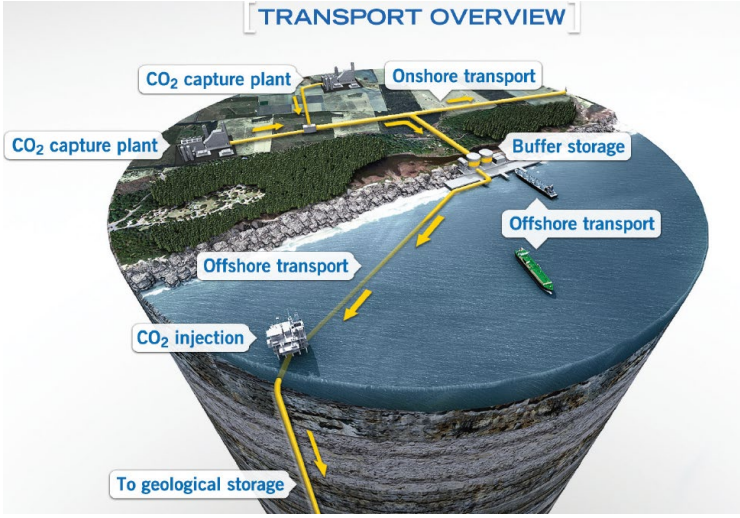
Safely and reliably transporting carbon dioxide (CO_2) from where it is captured to a storage site is an important stage in the carbon capture, utilization, and storage (CCUS) process.

Pipelines are – and are likely to continue to be – the most common method of transporting the very large quantities of CO_2 involved in CCS.

Ship transportation can be an alternative option for many regions of the world. Shipment of CO_2 already takes place on a small scale in Europe and Asia.

Transport of CO_2 by truck and rail is possible for small quantities. Trucks are used at some project sites, moving the CO_2 from where it is captured to a nearby storage location.

- Northern Lights Project (Norway); Acorn CCS Project (UK); Quest CCS Project (Canada); various EOR projects



Source: Global CCS Institute

Existing CO_2 Pipelines in the U.S.

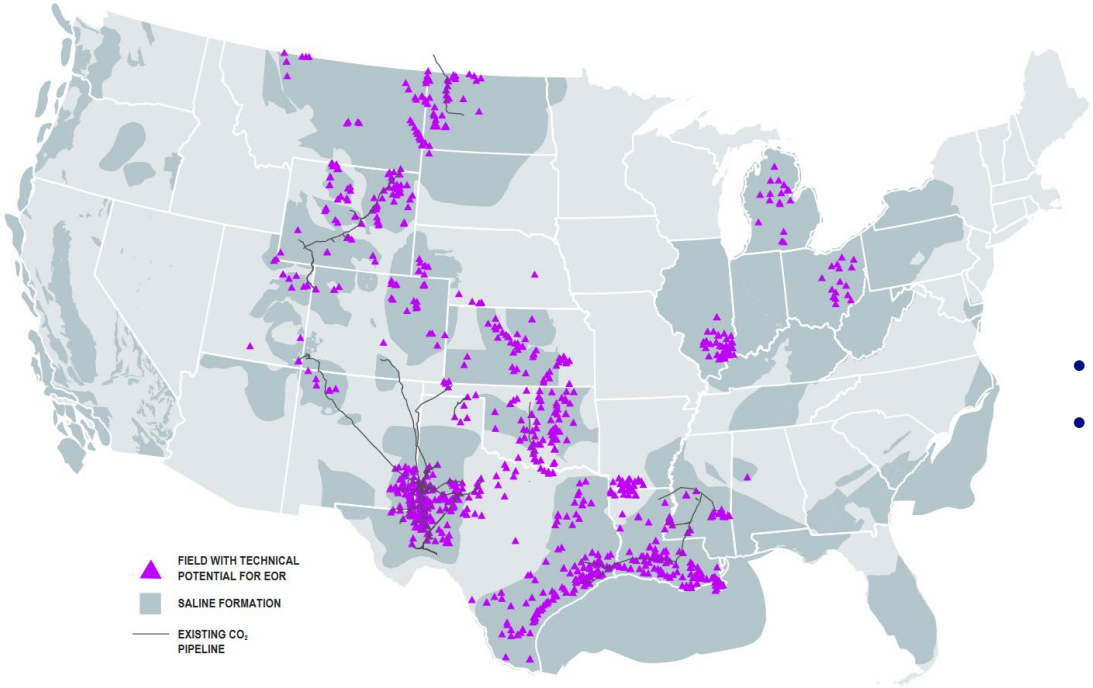
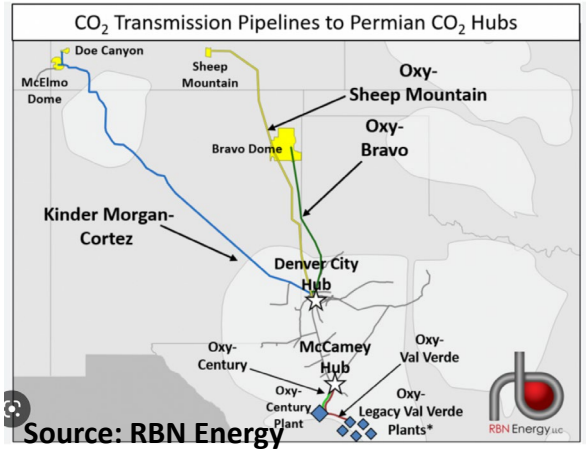
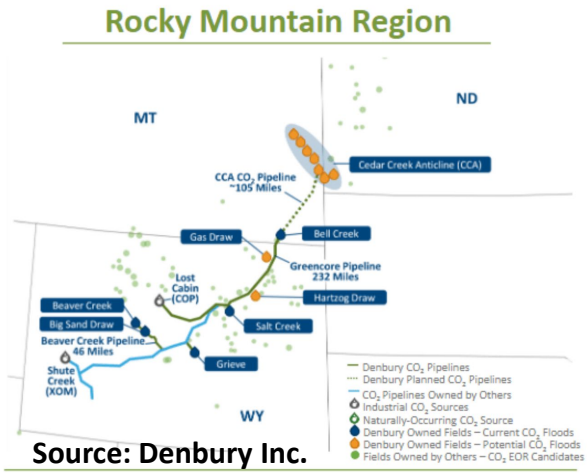


Figure authored by GPI based on data from ARI and NATCARB.

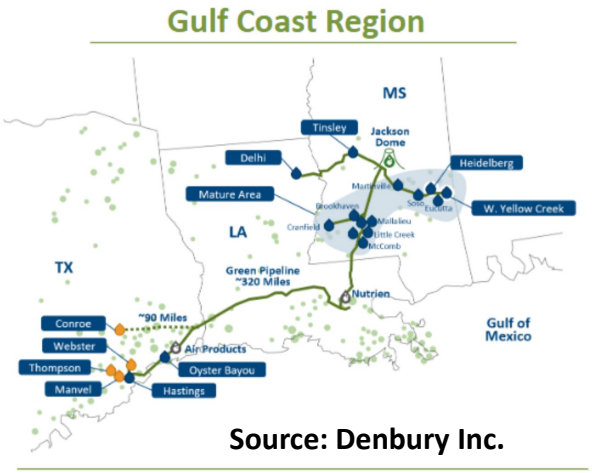
- Approximately 5,500 miles
- Primarily linking natural CO_2 sources to aging oil fields for EOR



Source: RBN Energy



Source: Denbury Inc.



Source: Denbury Inc.

How many miles of new pipeline will need to be built to achieve net-zero emissions by 2050?

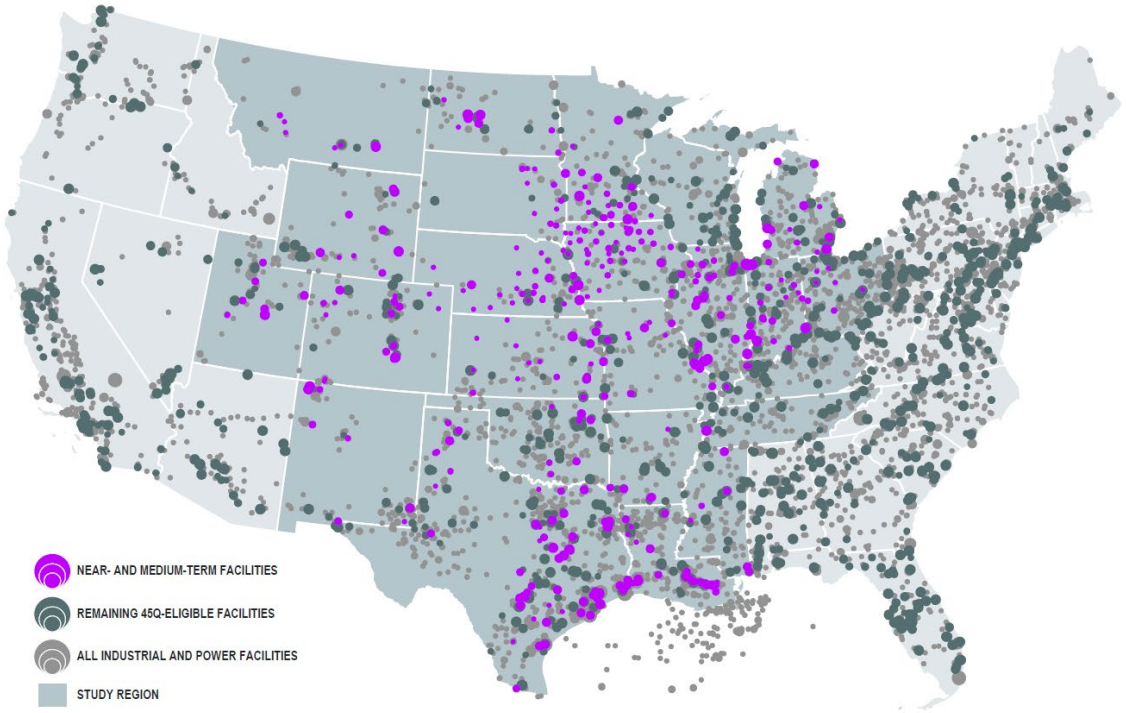
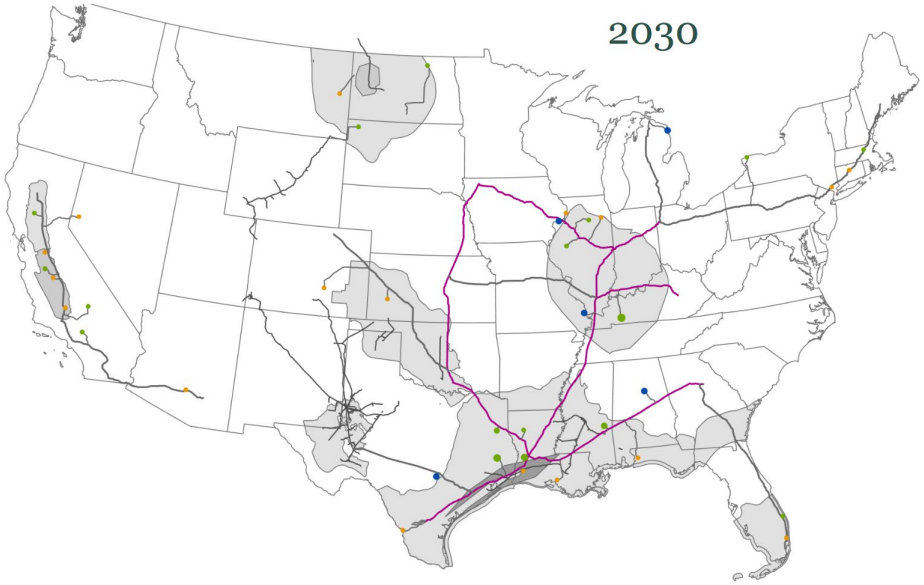


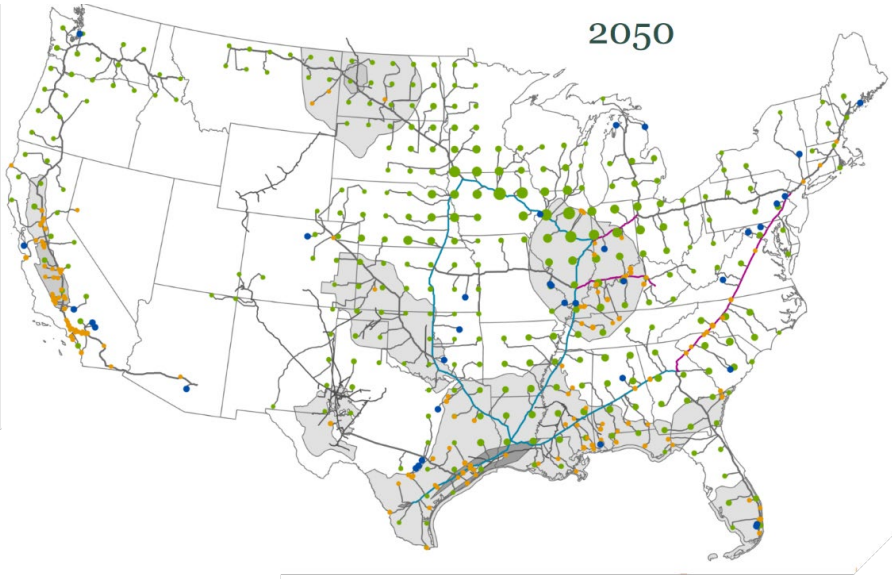
Figure authored by GPI based on data from EPA FLIGHT 2018.

Net-Zero America: Potential Pathways, Infrastructure, and Impacts - Larson et al., 2021

PRINCETON UNIVERSITY

andlinger center for energy+the environment





- 65 million tCO_2/year – 11,806 miles pipelines in total

- 929 million tCO_2/year – 65,865 miles pipelines in total
  - 13,049 miles trunk lines; 52,816 miles spur lines

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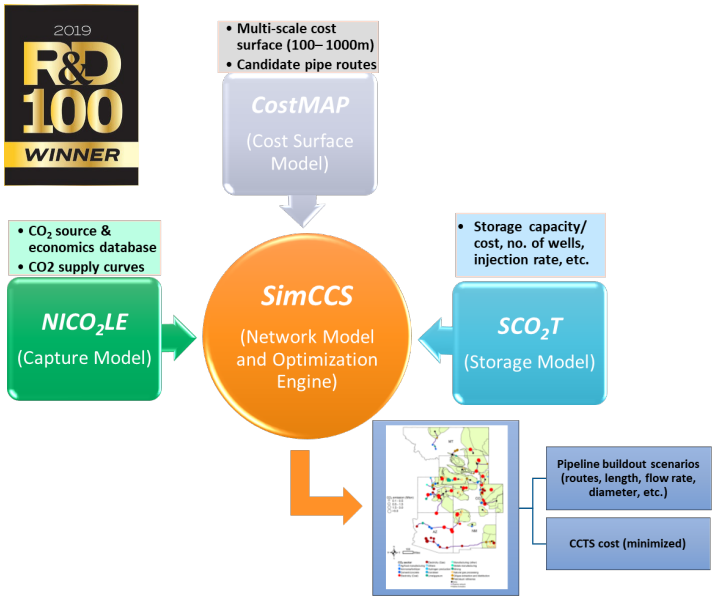
National Scale CCS Pipeline Network Modeling by LANL

- **Objective**: Use *SimCCS* platform to understand potential national scale CCS infrastructure deployment scenarios
- In coordination with DOE-FECM
- In collaboration with OnLocation Inc.

U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

OnLocation 40 YEARS
A KEYLOGIC COMPANY

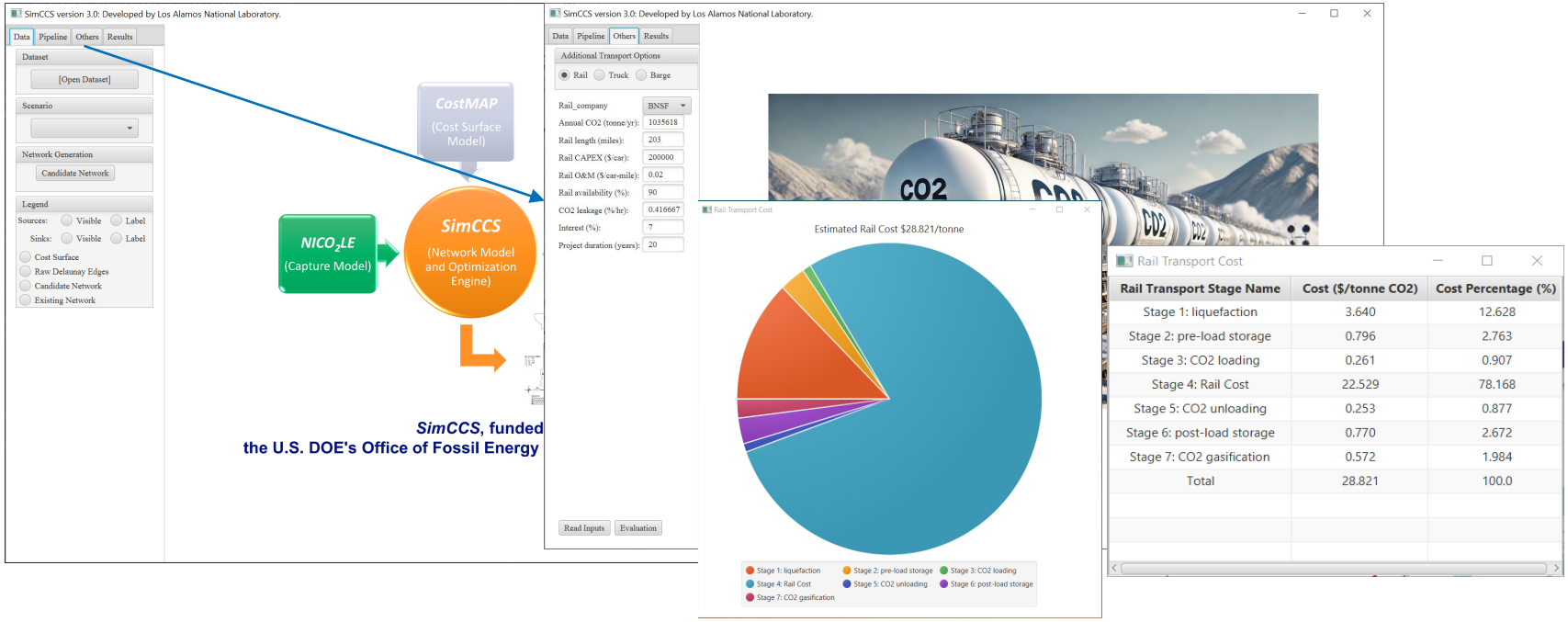
SimCCS: Determines Costs and Optimized Transport Routing by Integrating Factors Across the CCS Value Chain



Publicly available @ https://simccs.lanl.gov/

- ***$NICO_2LE$***
  - Understand commercial-scale capture opportunities
  - Geodatabase: Source locations, CO_2 streams, & capture costs
- ***SCO_2T***
  - Rapidly calculate realistic injection and storage costs
- ***CostMAP***
  - Identify likely corridors
  - Develop candidate pipeline routes for *SimCCS* optimization engine
- ***SimCCS***
  - Determine optimal regional/national network of CO_2 sources, CO_2 sinks, and CO_2 transport pipeline that meet desired CCS goals

User Interface, Inputs & Outputs



Inputs

- Locations of CO_2 sources and sinks, capture amounts & costs, storage resources & costs

Outputs

- Pipeline: Optimal transport network, pipeline lengths, diameters, flow rates, costs, etc.
- Rail/Truck: CAPEX, OPEX, FINEX at different stages

Unified SimCCS Platform including multi-modal transport modeling and transport risk assessment capabilities will be released in winter 2024

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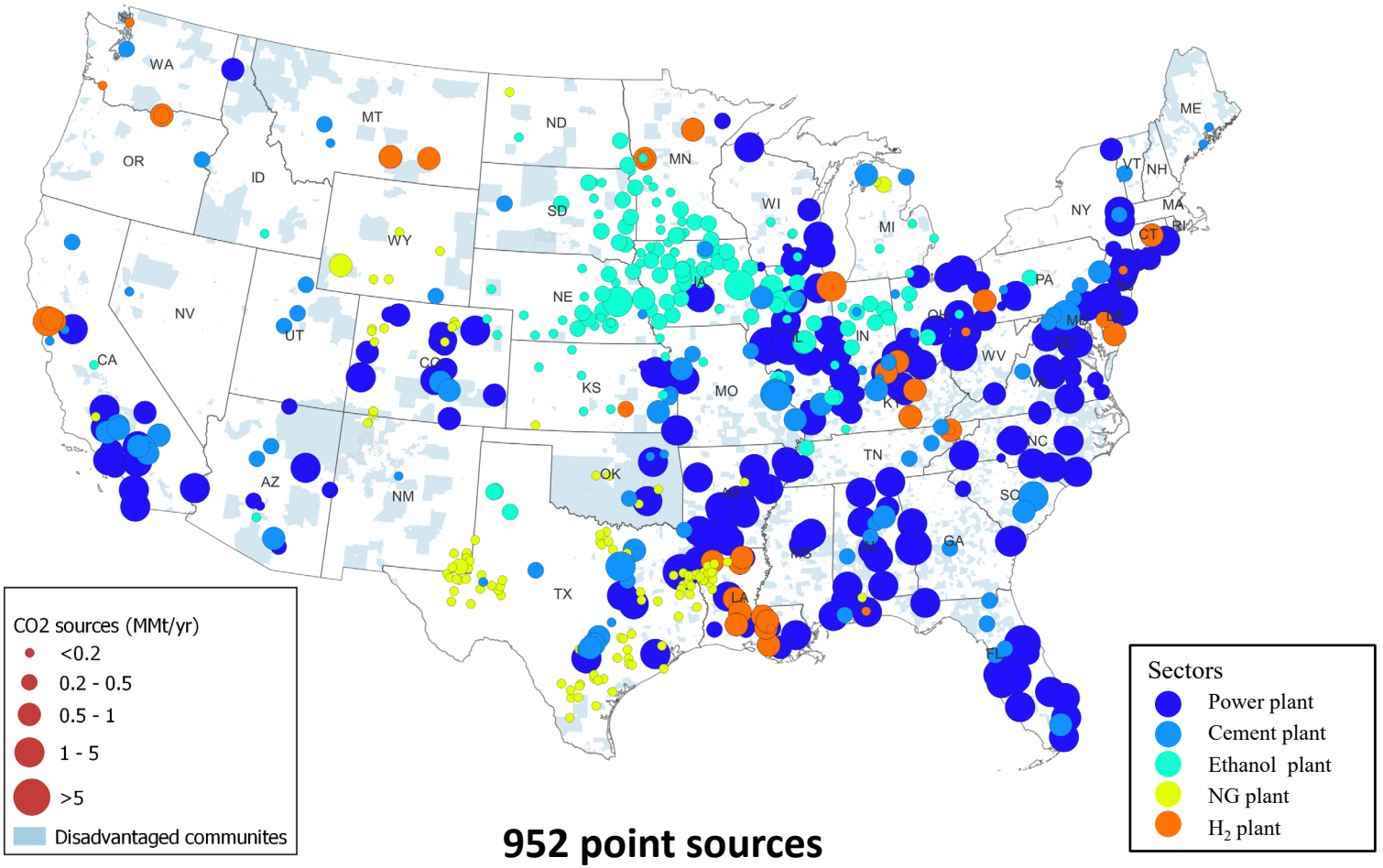
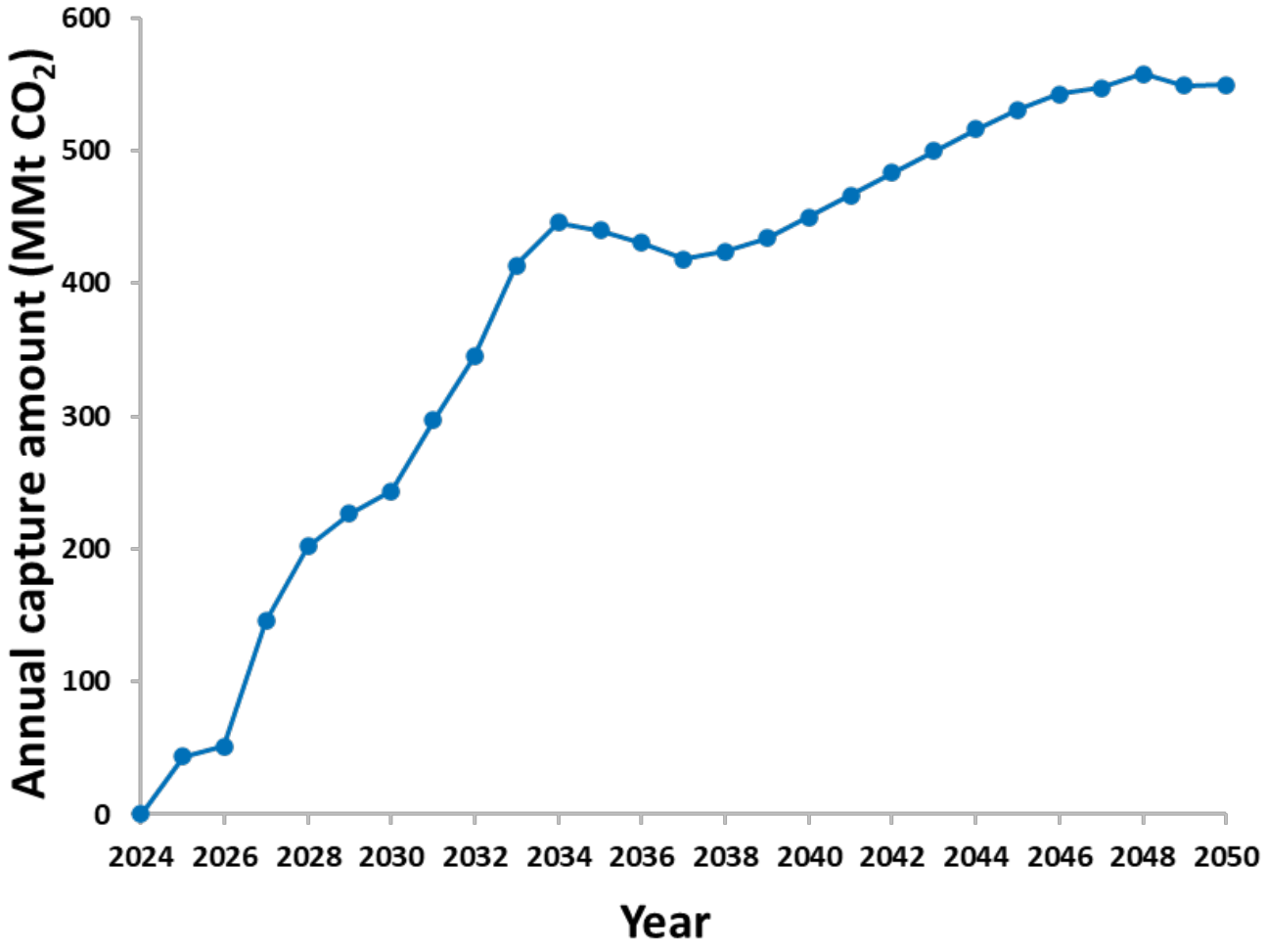
Net-zero IRA case (data from OnLocation)



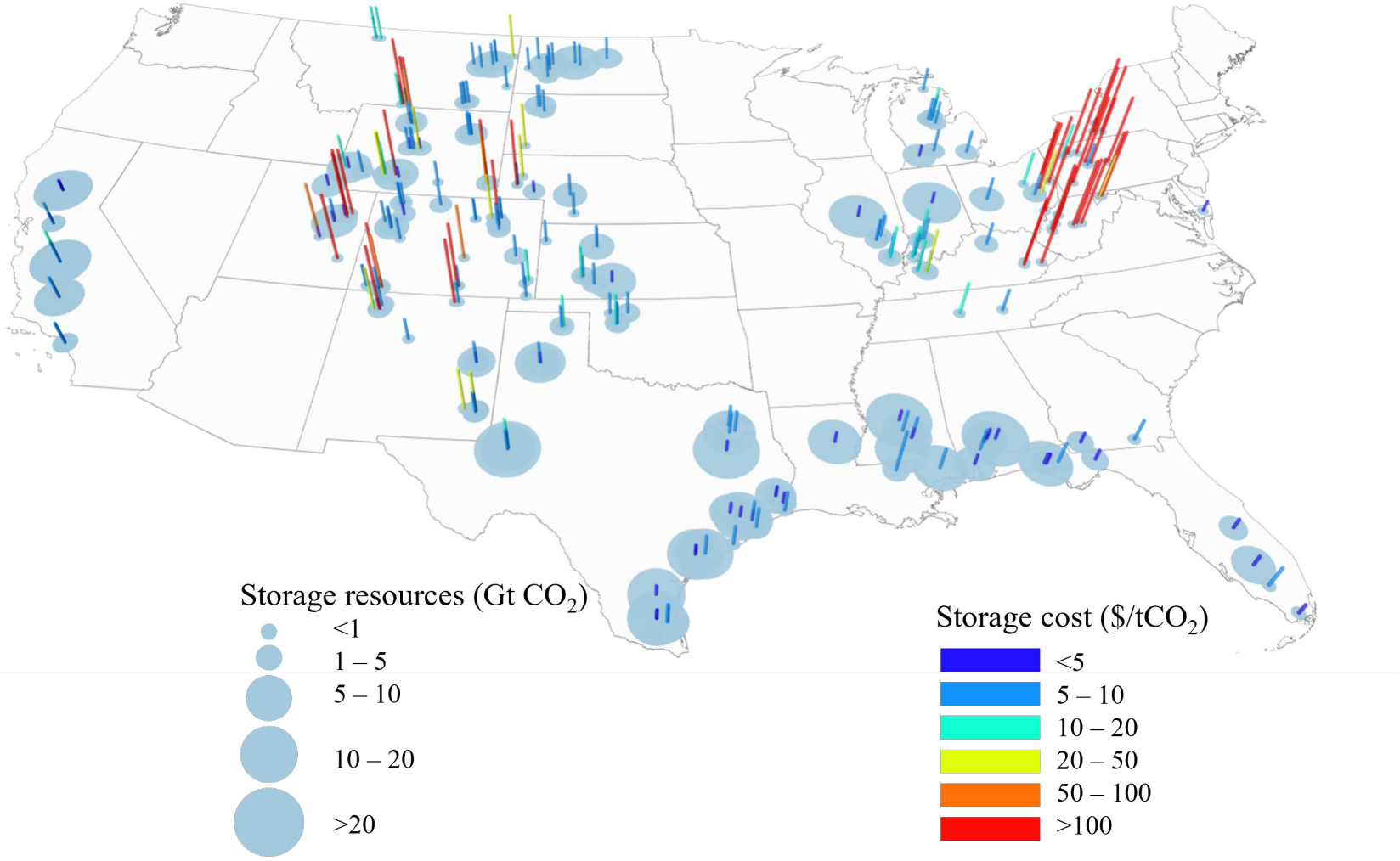
952 point sources

Direct Air Capture starting from 2034

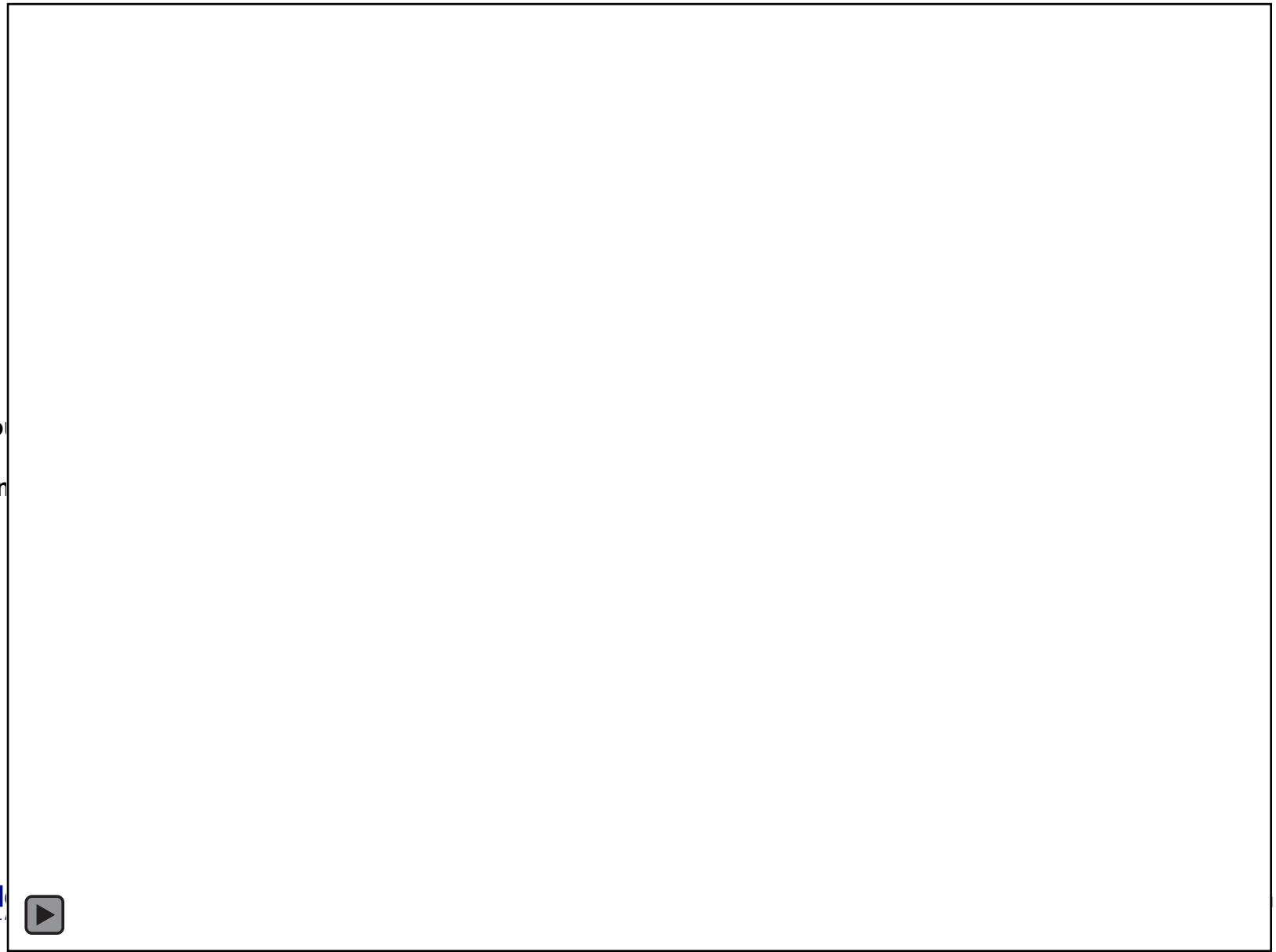
Point CO_2 capture amount



Nationwide saline storage cost and resource

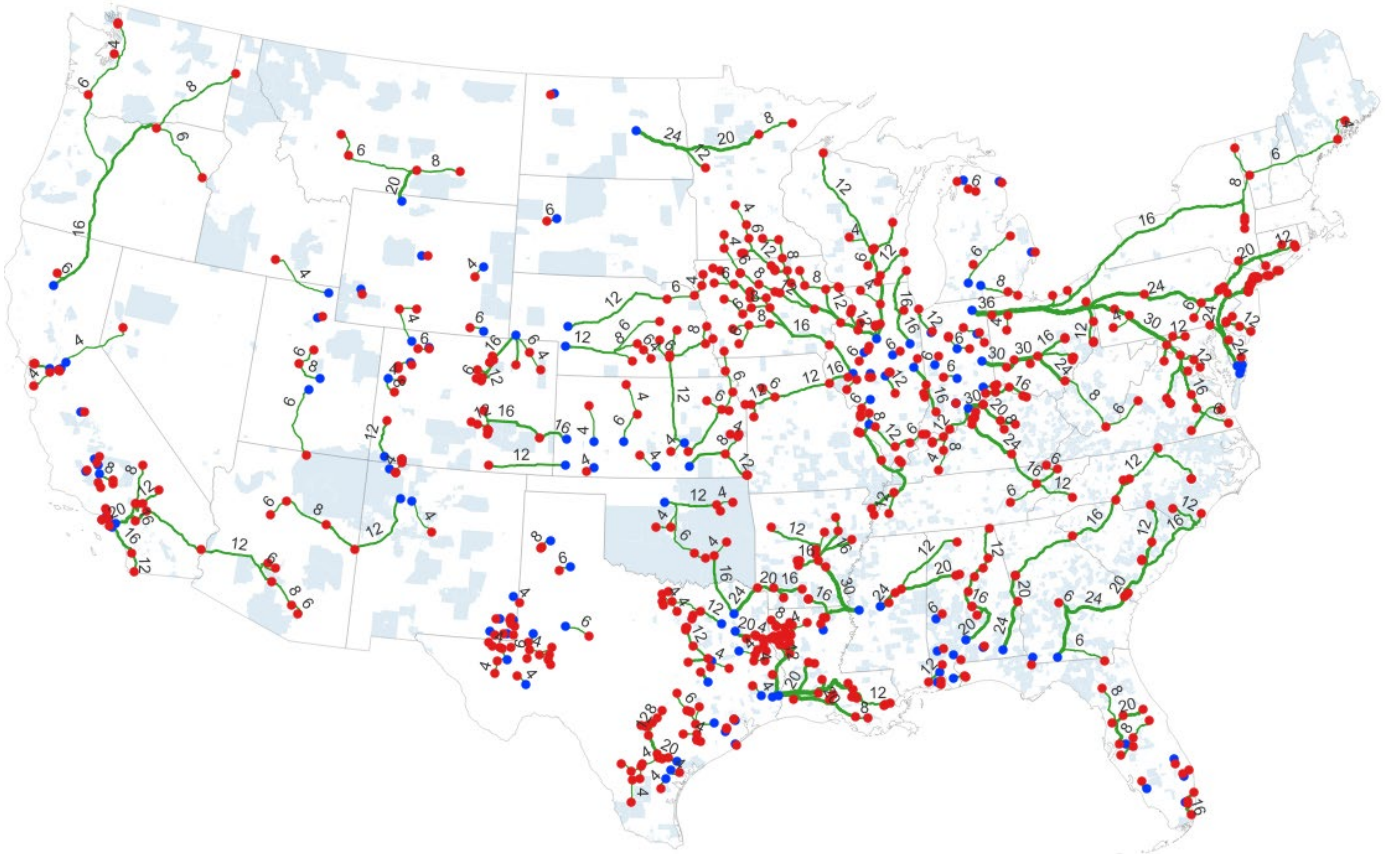


Evolution of pipeline infrastructure



- So
- Sin

Outlook of CO_2 pipeline in 2050



Total pipeline length: 27,438 miles

Summary

- ***SimCCS* demonstrates to be an effective toolset to support deployment of CCS transport infrastructure**
  - Phased-modeling
  - Multi-modal modeling: pipeline, truck, rail, and ship/barge
  - Re-use of existing pipeline and ROWs
  - Critical transport safety and risk assessment

- **National CCS infrastructure modeling results indicate:**
  - ~23,081-27,438 miles of new pipelines required to capture and store the CO_2 emissions (as identified in OnLocation scenarios)
    - *Over 90% to be constructed by 2035*

Thank you!

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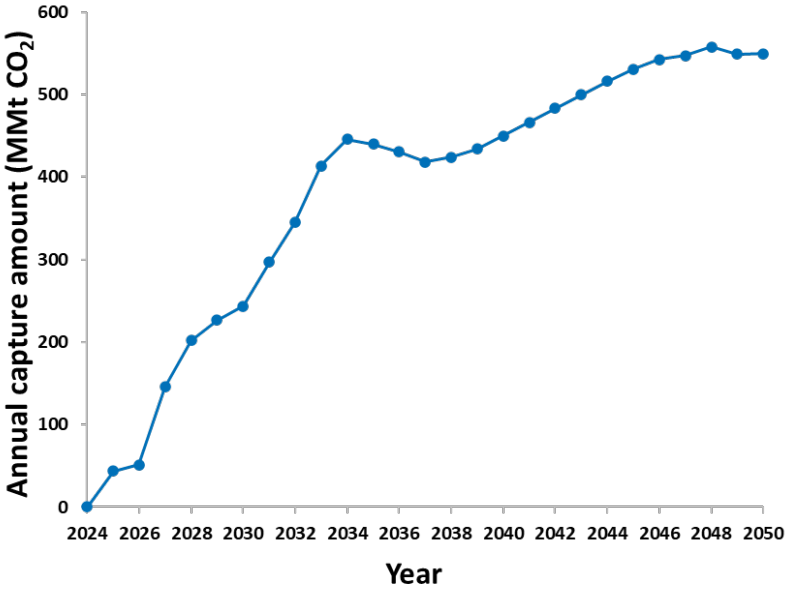
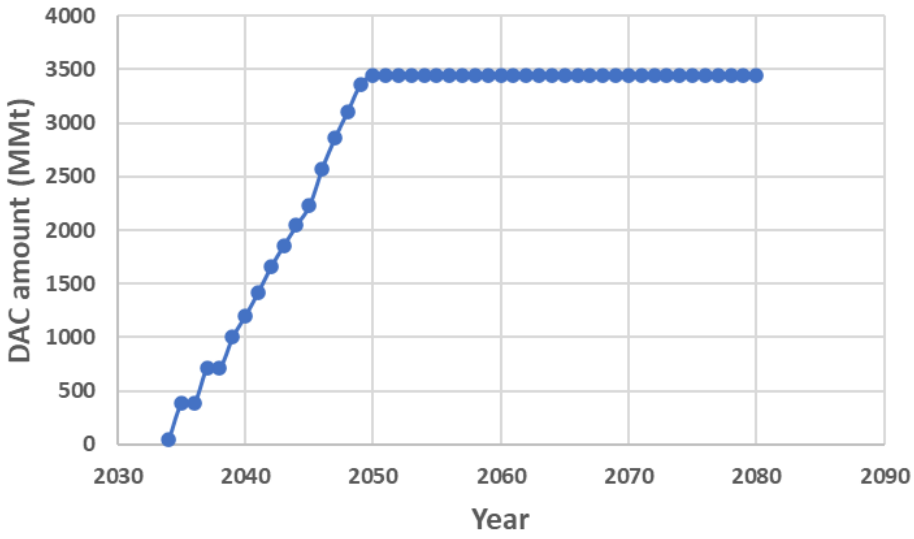
CO_2 capture amount



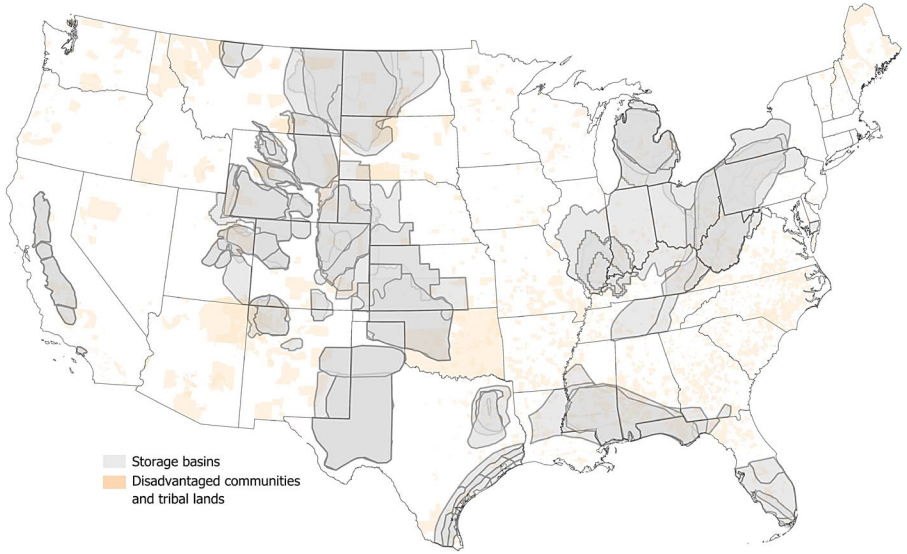
Point source capture



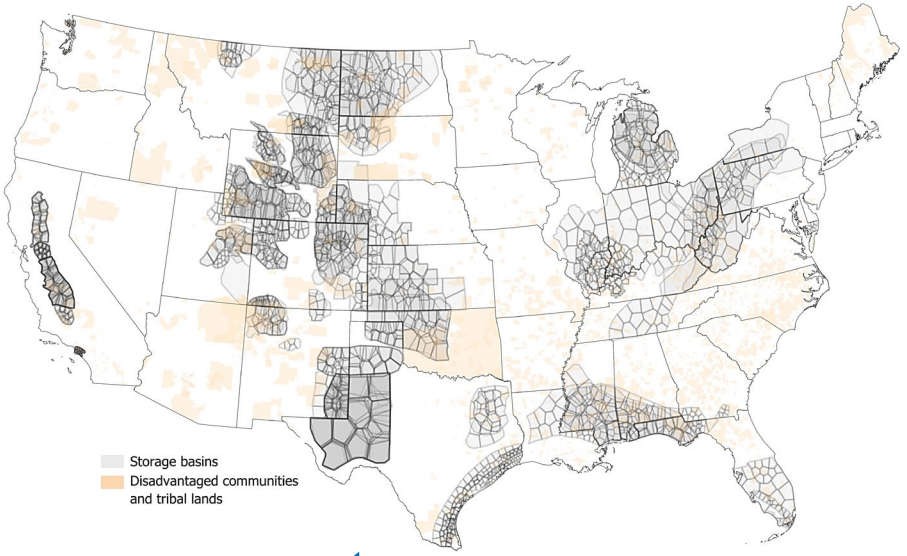
Direct air capture

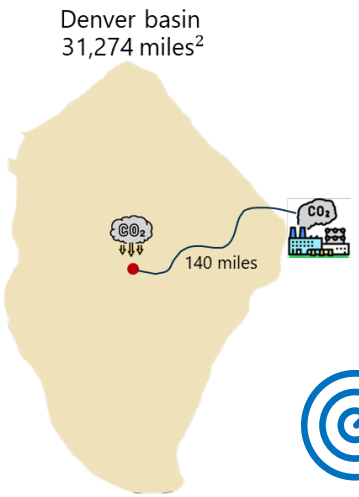
Geologic basin splitting

314 storage basins



2535 storage sub-basins





Optimize CO_2 transportation by shortening sink-source connectivity

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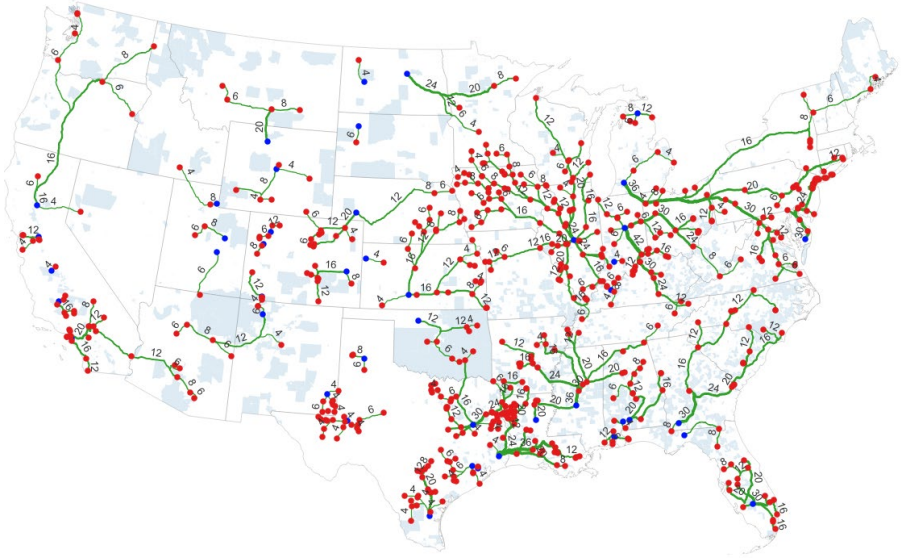
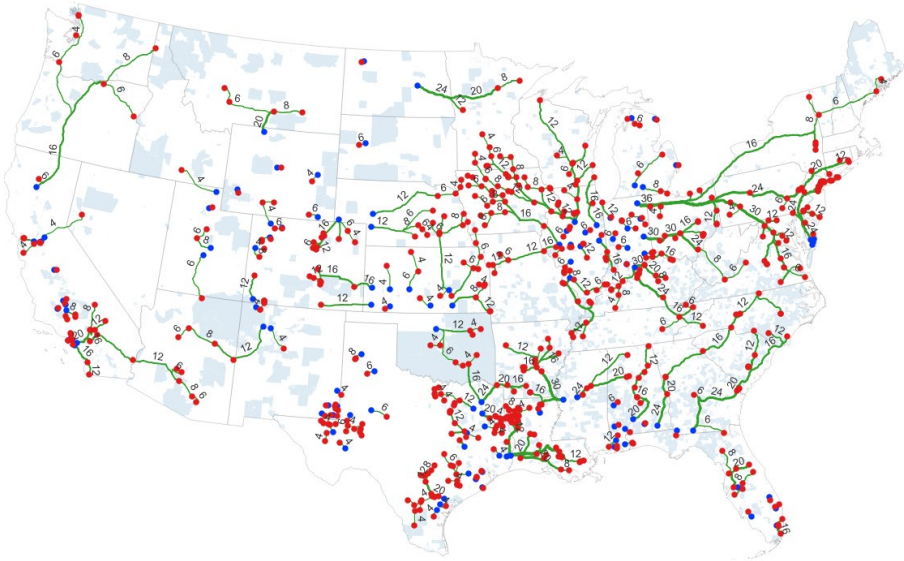
Comparison – Original and split geologic basins



- Total pipeline length: 30,837 miles



- Total pipeline length: 27,438 miles

Reduction of 3,399 miles (11%)

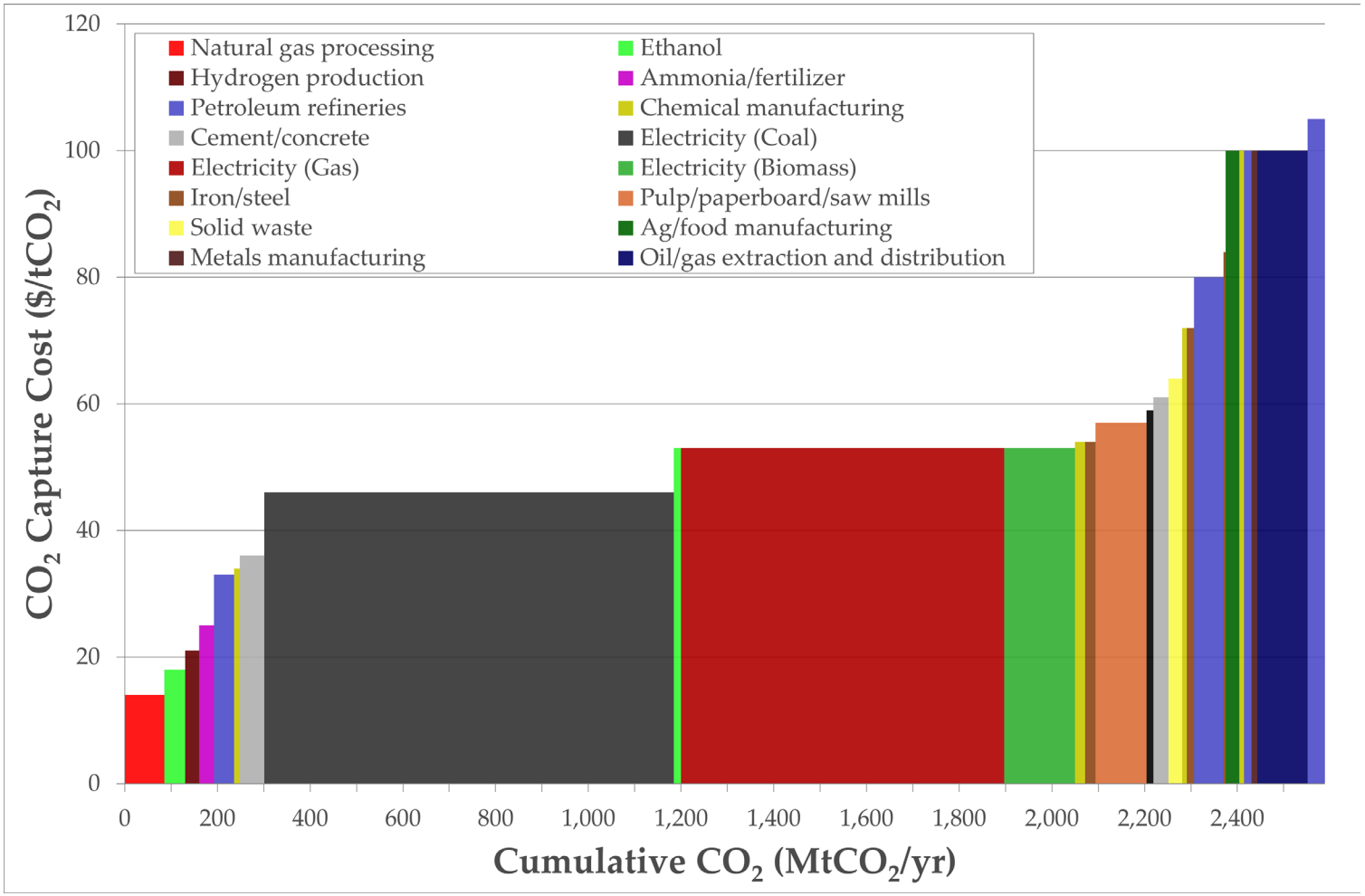
Reduce infrastructure and associated costs

Regulations

- **Pipeline and Hazardous Materials Safety Administration (PHMSA)**: PHMSA oversees the safety of CO_2 pipelines under the U.S. Department of Transportation (DOT). The regulations are outlined in the **Code of Federal Regulations (CFR)** Title 49, Part 195, which covers the safety standards for CO_2 pipelines, including design, construction, operation, and maintenance. Special attention is given to the unique risks posed by CO_2, such as potential leaks, corrosion, and the high-pressure nature of the transport.
- **National Environmental Policy Act (NEPA)**: NEPA requires environmental impact assessments for large pipeline projects that affect federal lands or resources.
- **Environmental Protection Agency (EPA)**: The EPA regulates the environmental impact of CO_2 transport and storage, particularly under the Clean Air Act and Safe Drinking Water Act.
- **Federal Energy Regulatory Commission (FERC)**: FERC may get involved in regulating CO_2 pipelines if they are linked to interstate energy projects, especially when CO_2 is used for enhanced oil recovery (EOR).

Capture all 45Q eligible point CO_2 sources?

CO_2 supply curve – based on point source characteristics



- Data source: EPA GHGRP & eGRID (2021)
- 2,087 CO_2 point sources - 2.27 Gtons/year
- Bipartisan Budget Act of 2018

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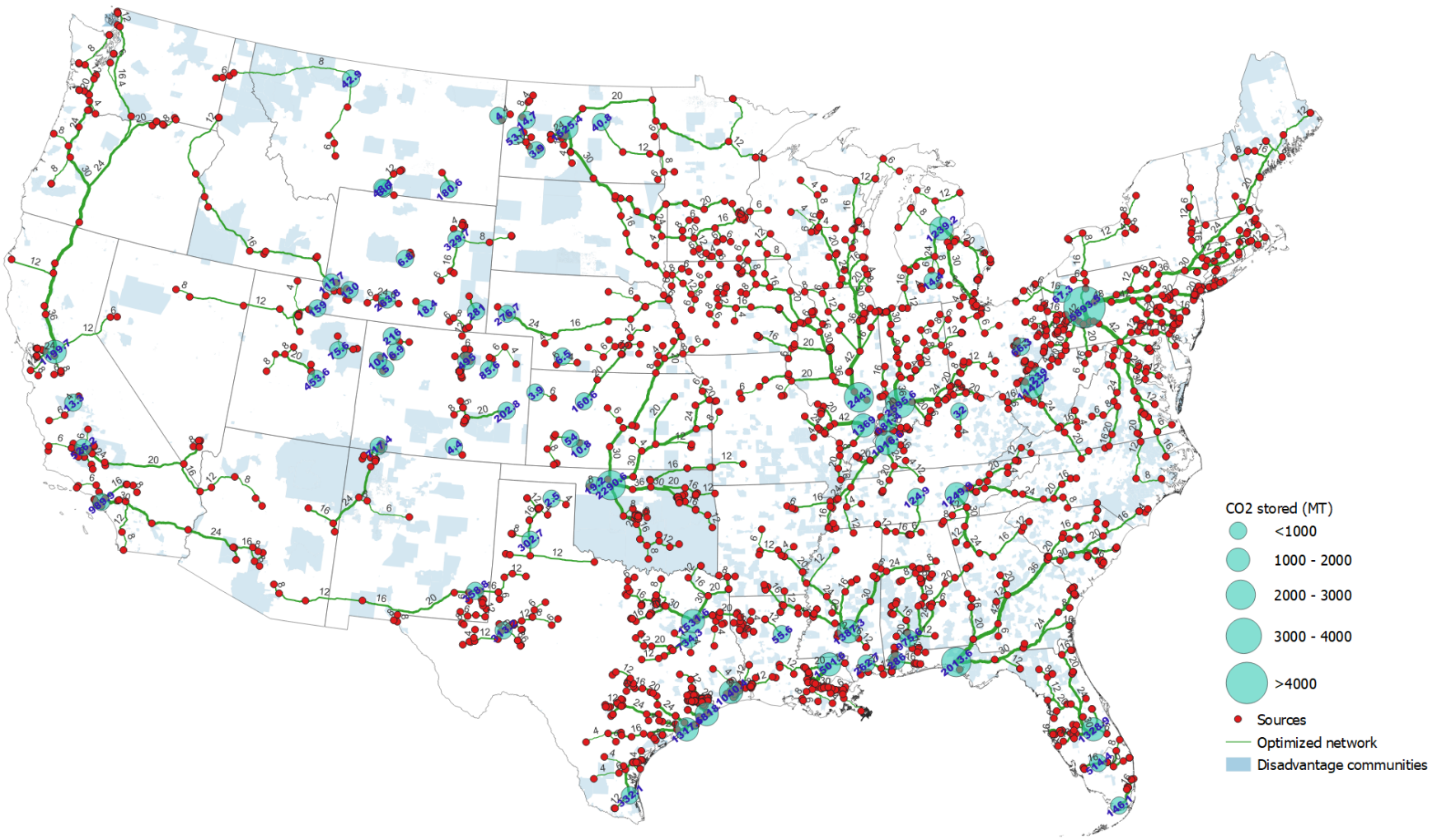
Pipeline network



- Total pipeline length: 42,038 miles

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