Carbon Capture, Allocation, Transportation, and Sequestration (CCATS) in AEO2025

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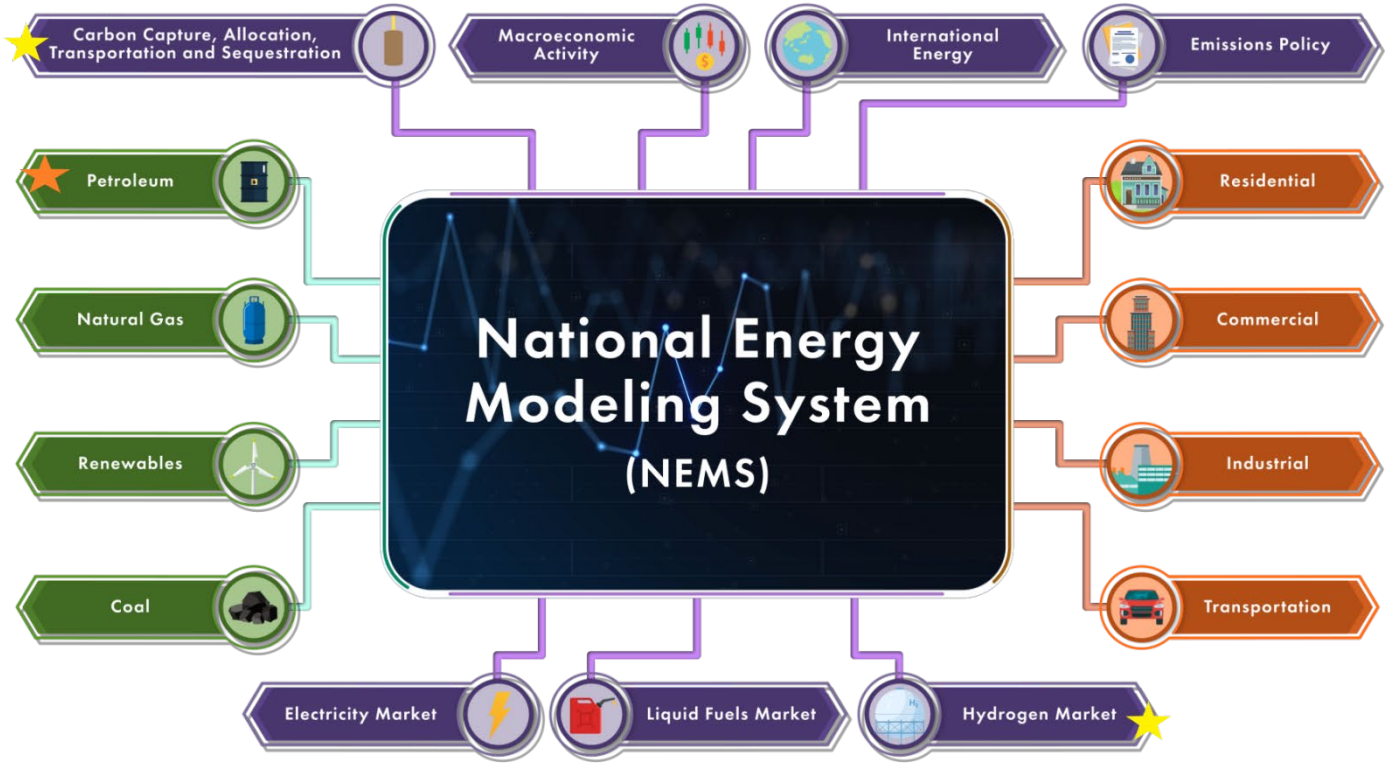
Annual Energy Outlook 2025

- EIA released the Annual Energy Outlook 2025 (AEO2025) in April 2025

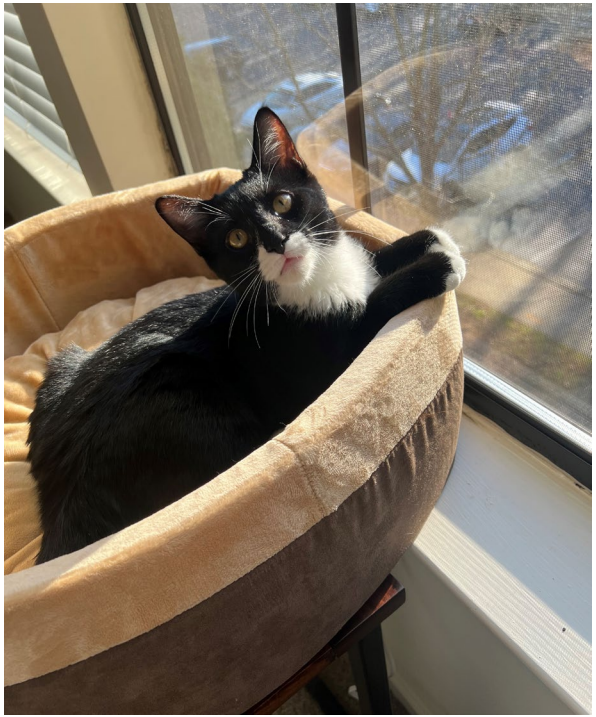
- AEO2025 included 3 new modules in the National Energy Modeling System (NEMS)
  - Hydrocarbon Supply Module (HSM)
  - Hydrogen Markets Module (HMM)
  - Carbon Capture, Allocation, Transportation, and Sequestration (CCATS)

National Energy Modeling System (NEMS) in AEO2025



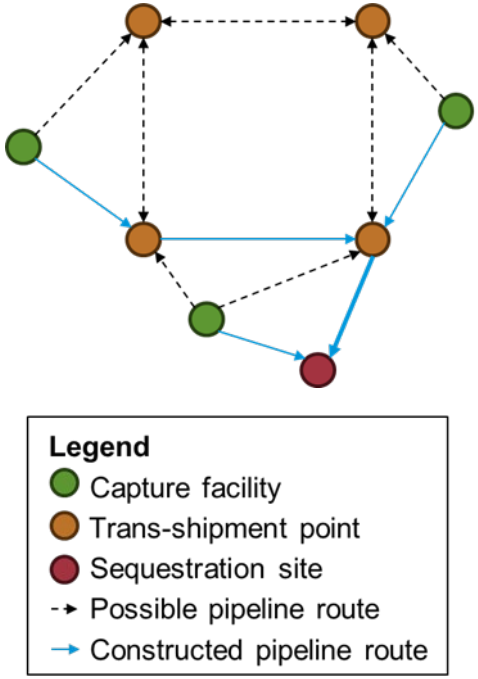
CCATS overview

- CCATS models the potential carbon capture industry in the US
- Optimization model that determines flow of endogenously produced CO_2 supplies from NEMS to CO_2 destinations
- Includes policy as of December 2024
- Designed to be flexible and accommodate potential future changes



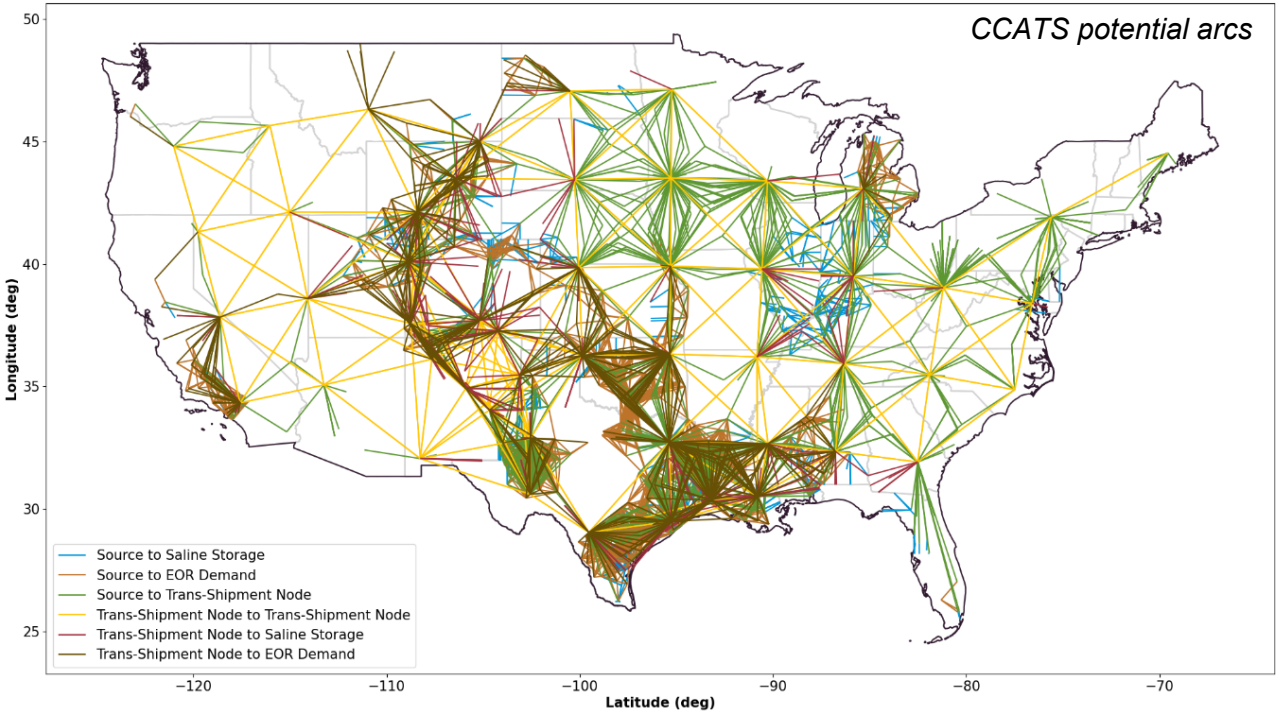
Market representation

- Plausibly economic sources of CO_2 from industries with significant carbon capture potential
  - Power generation, natural gas processing, ethanol, hydrogen, cement
- CO_2 transportation with pipelines, including existing pipeline network
- CO_2 enhanced oil recovery (EOR) demand and CO_2 sequestration in onshore saline formations
- Represented as a network of nodes and arcs on the US map



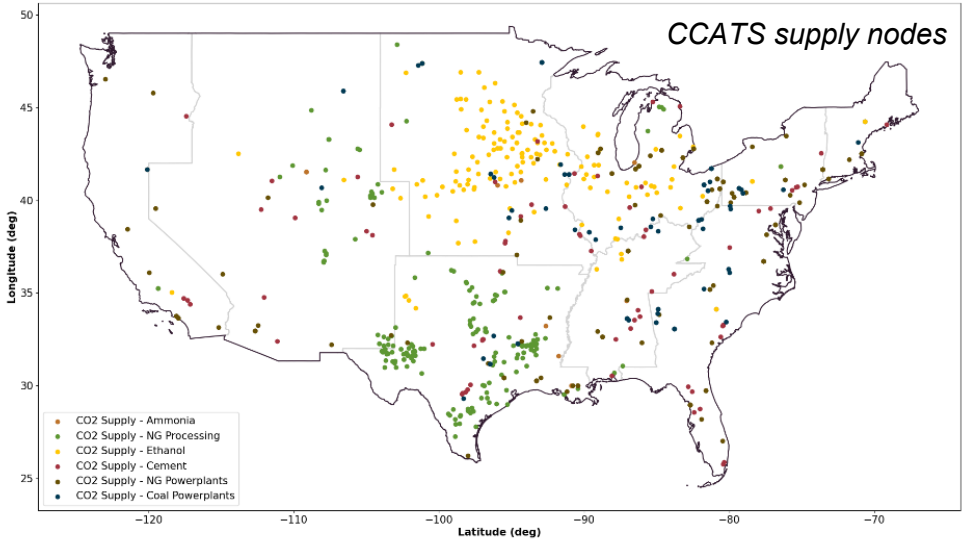
CO_2 potential network

- Node types:
  - Supply
  - Trans-shipment
  - CO_2 EOR
  - Storage
- Arc types:
  - Existing
  - Potential



CO_2 supply representation

- CO_2 supply from NEMS is at a census-division level
  - Too highly aggregated for CCATS to have meaningful results
  - CCATS disaggregates to point-source facilities
- Data source: National Energy Technology Laboratory Carbon Capture Retrofit Database (NETL-CCRD)

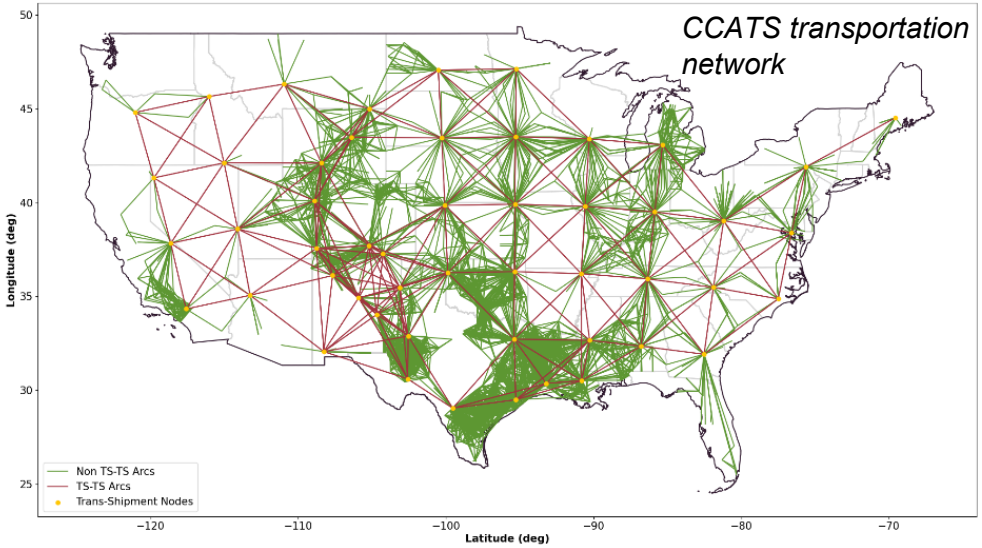


CO_2 supply representation: Capture potential

Census Division	Ammonia	Cement	Coal Power Plant	Ethanol	Natural Gas Power Plant	Natural Gas Processing
New England		0.3	8.8		36.4	
Mid Atlantic		5.1	67.1	0.5	165.8	
East North Central	0.8	8.2	303.1	12	219.5	0.5
West North Central	2.5	14.1	425.7	31.5	25.8	0
South Atlantic	1.1	13.7	444.1		238.9	
East South Central	0.9	6.4	214.5	1	147.8	
West South Central	9.7	12.7	326.9	1.4	332.4	9.7
Mountain	0.6	8	219.1		120.4	3.3
Pacific	0.1	10			121.1	
Total	15.6	78.6	2,009.30	46.4	1,408.10	13.6

CO_2 transportation representation

- By pipeline only
- New pipelines include different diameters and pumps:
  - Pass through trans-shipment nodes (*trunk)*
  - Directly from supply to demand or sequestration (*spur*)
- Data sources:
  - NETL CO_2 Transport Cost Model
  - Department of Transportation (DOT) National Pipeline Mapping System

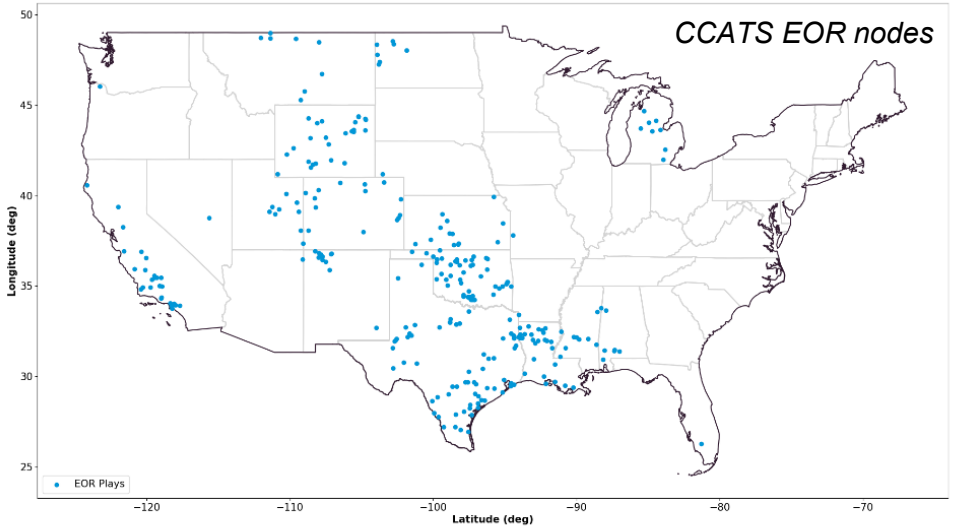


CO_2 transportation: Select cost curves

Pipeline Region	Pipeline Length (miles)	Cost Curve Slope ($/tonne CO_2)
New England	150	$51.42
Great Plains	150	$23.47
New England	400	$142.93
Great Plains	400	$68.67

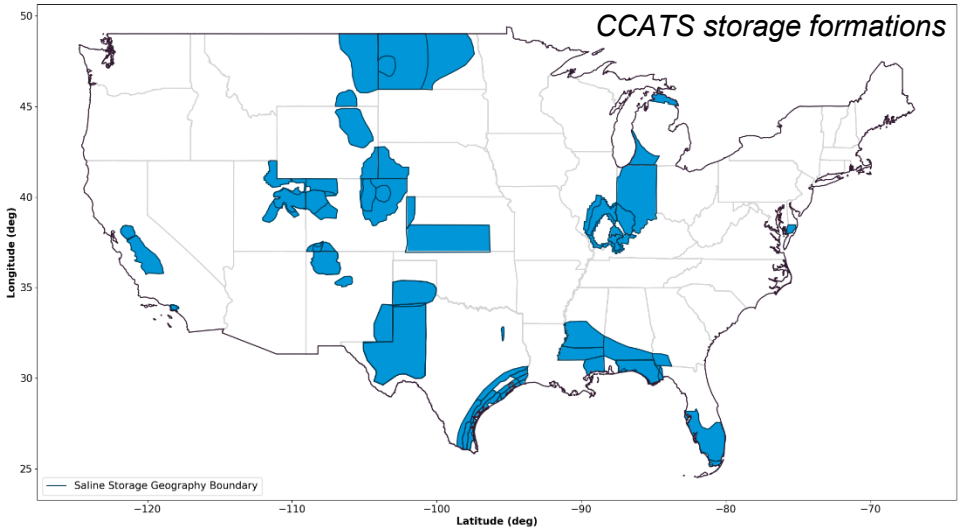
CO_2 EOR representation

- CO_2 demand is limited to endogenous demand from the Hydrocarbon Supply Module (HSM)
- EOR is represented at the geological formation and county level



CO_2 storage representation

- Limited to onshore storage in the Lower 48 U.S. states
- Saline formations from the NETL Saline Storage Cost Model
- Excludes overlaying protected state and federal lands, and urban areas

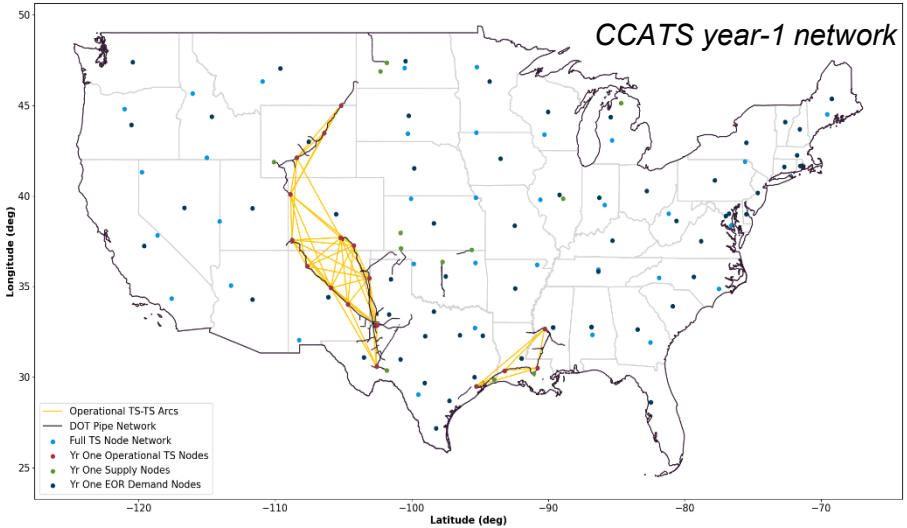


CO_2 storage representation: Summary

	South	Midwest	West	Mideast	Northeast
Area (sq miles)	675,703	262,009	375,353	17,128	8,201
Average maximim CO2 per injection project (Mmtonnes)	7,783,104	5,679,189	8,472,865	4,021,910	5,037,070
Maximum number of injection projects	9,145	3,172	4,357	90	30
Average injection rate per project (Mmtonnes/project/year)	2,334,931	1,135,838	1,694,573	104,064	167,902

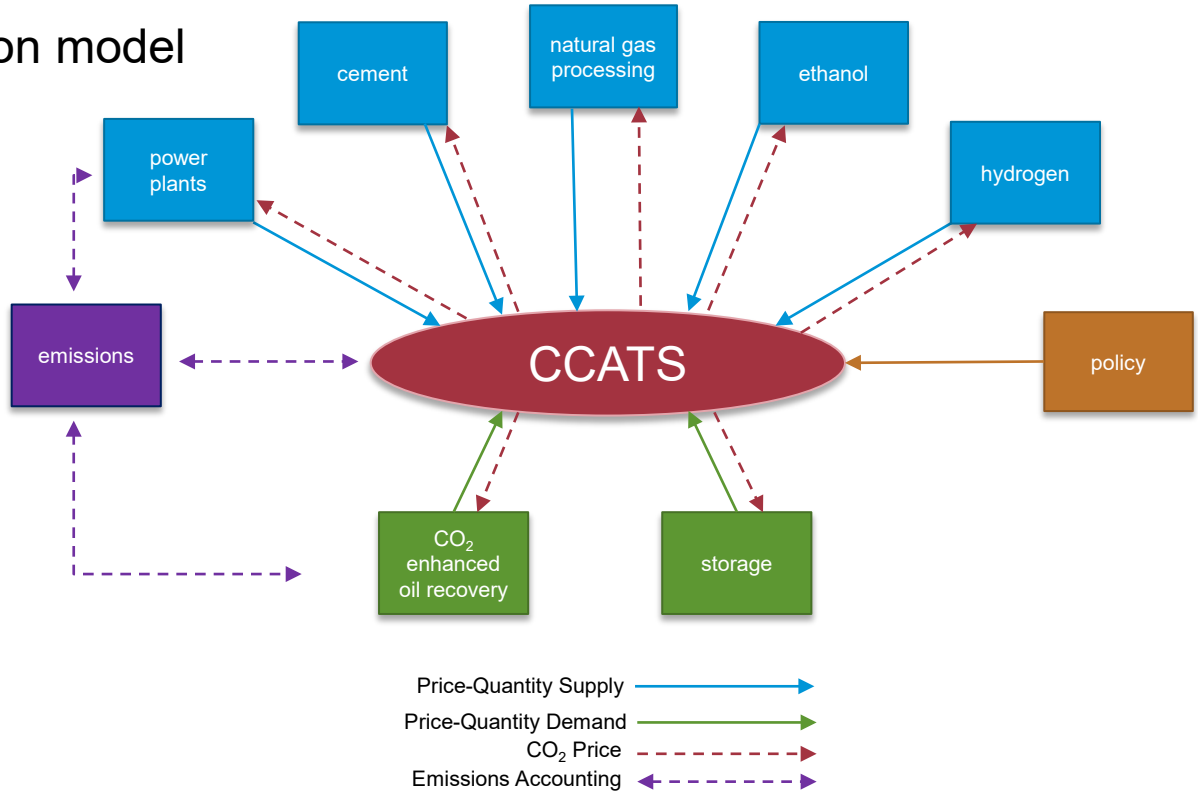
Initial network for early model years

- Existing carbon capture facilities
- Existing pipeline network as trans-shipment nodes
- Existing CO_2 EOR demand at the state or Texas RRC level
- Existing CO_2 sequestration volumes assigned to closest saline formation



Model structure

- CCATS is an optimization model that projects:
  - CO_2 transportation flows
  - CO_2 EOR demand
  - CO_2 storage
  - CO_2 prices



Model formulation

- Centralized optimization allocating CO_2 supply to demand, after assessing various costs and policy incentives

- Optimization problem solves for optimal CO_2 flows, transportation investment, and sequestration investment that minimizes total system costs:
  - Operations costs, investment costs, and policy incentives

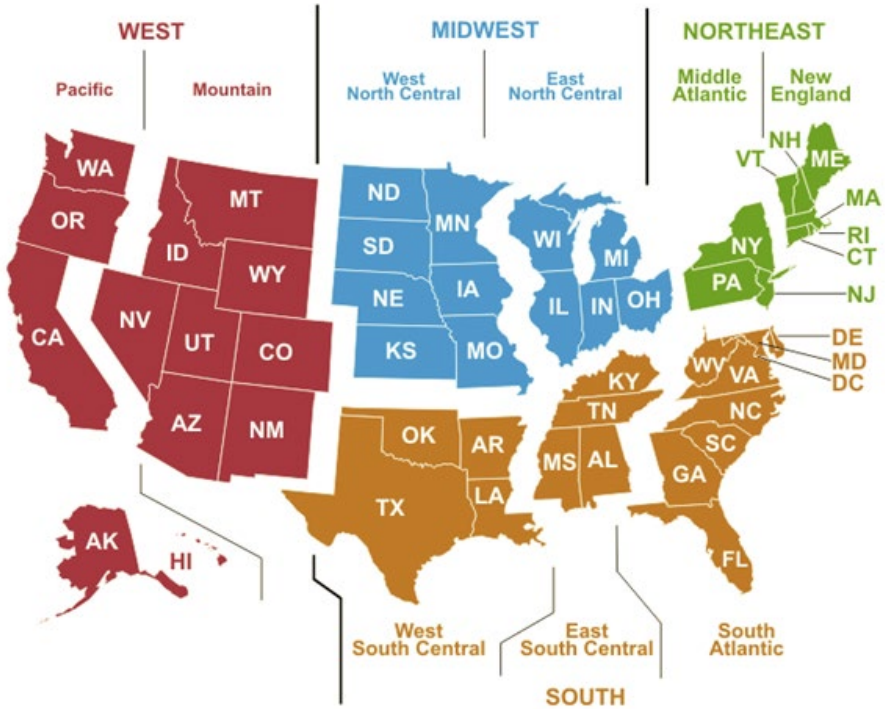
- Constraints:
  - Transportation capacity (changing over time with investment)
  - Demand capacity
  - Sequestration capacity (changing over time with investment)

Policy representation

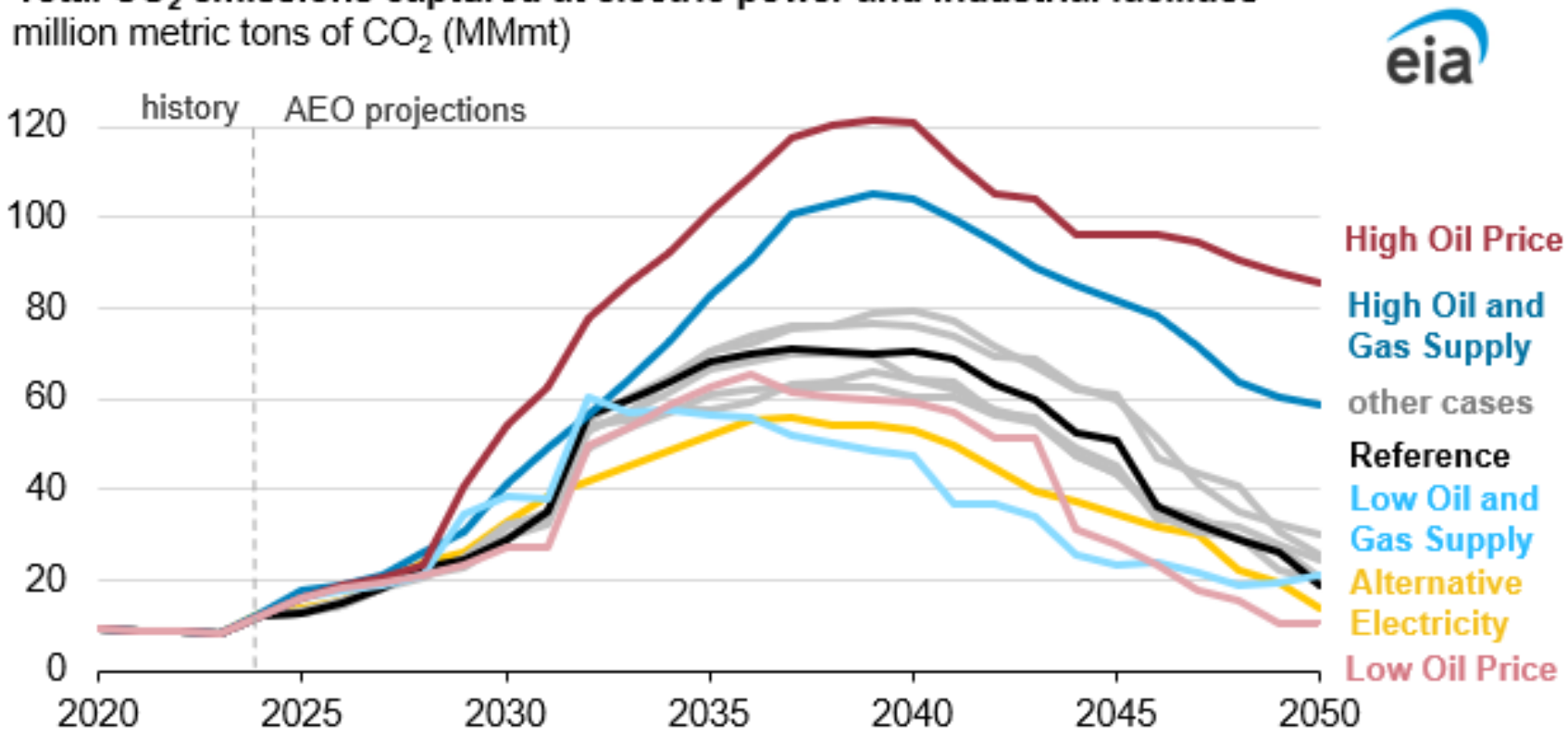
- Policies as of December 2024
  - 2022 Inflation Reduction Act; EPA Rule 111
- 45Q tax credits as legislated in the IRA:
  - CO_2 capture projects must begin construction by 2033 to qualify
  - CO_2 capture projects must meet minimum CO_2 capture volume thresholds
  - $65 for CO2 EOR, $80 for saline storage
- CCATS is designed to be flexible to support future policy changes

CCATS output

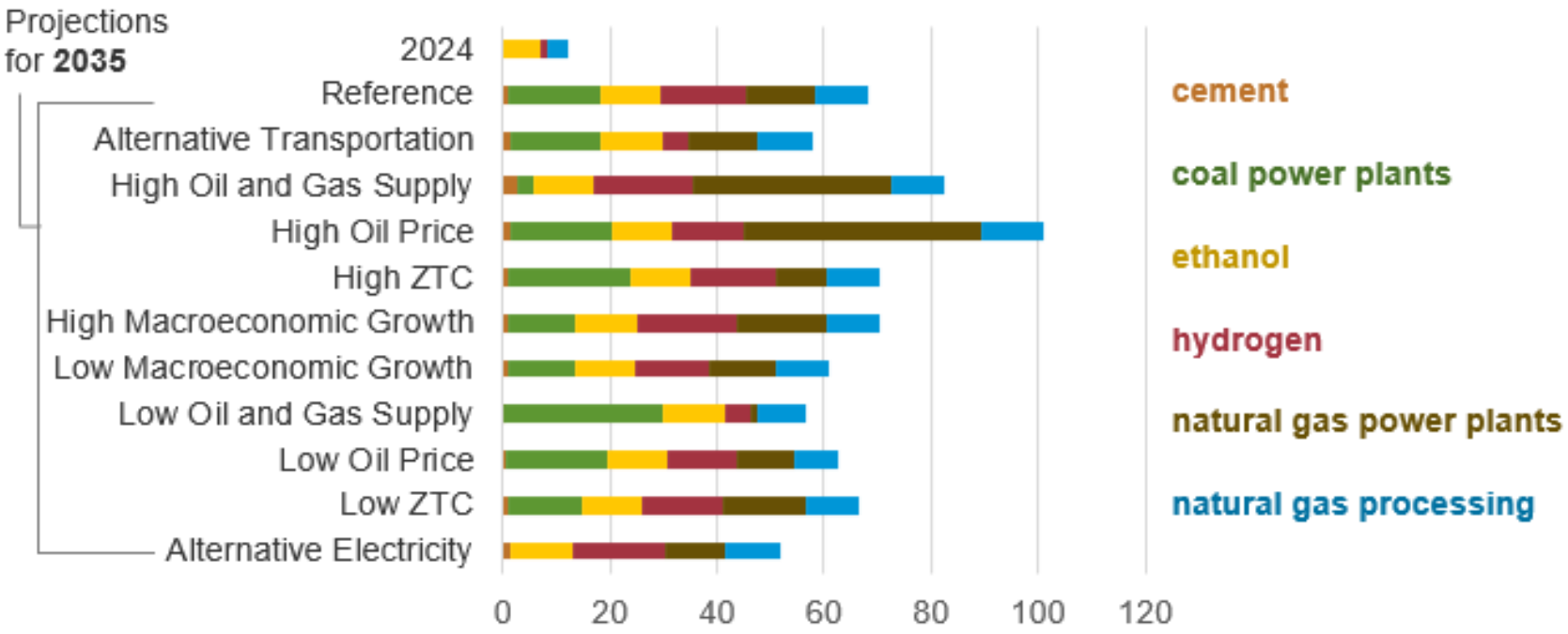
- On a regional level
- AEO2025 side case analysis:
  - Reference
  - High/low macro
  - High/low oil price
  - High/low oil and gas supply
  - High/low technology cost
  - Alternative electricity
  - Alternative transportation



Total CO_2 emissions captured at electric power and industrial facilities
million metric tons of CO_2 (MMmt)

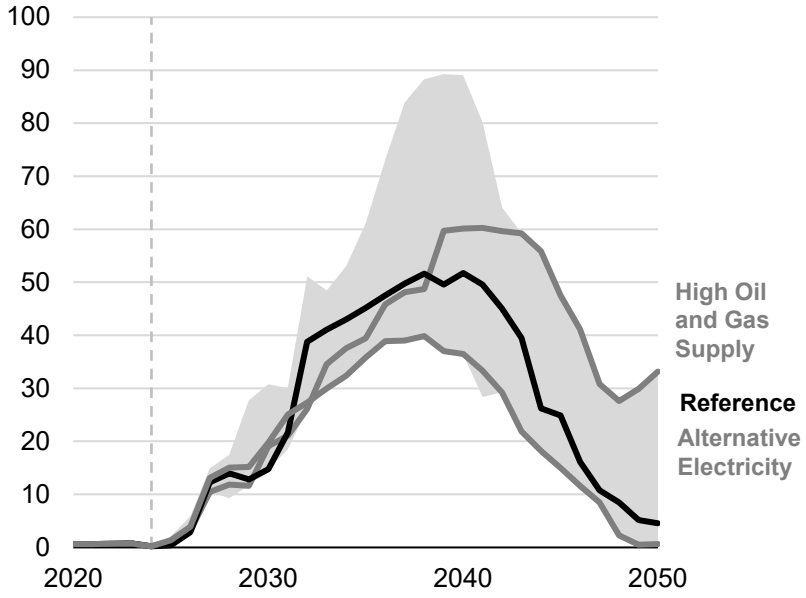


Captured CO_2 emissions by source, 2024 and 2035
million metric tons of CO_2 (MMmt)

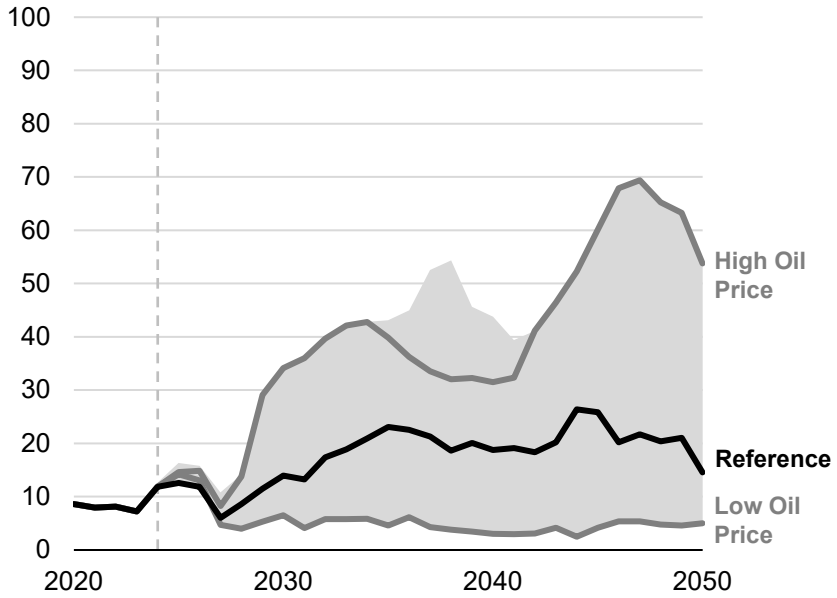


CO_2 saline storage and enhanced oil recovery (EOR) sequestration

CO_2 Saline Storage
million metric tonnes of CO_2



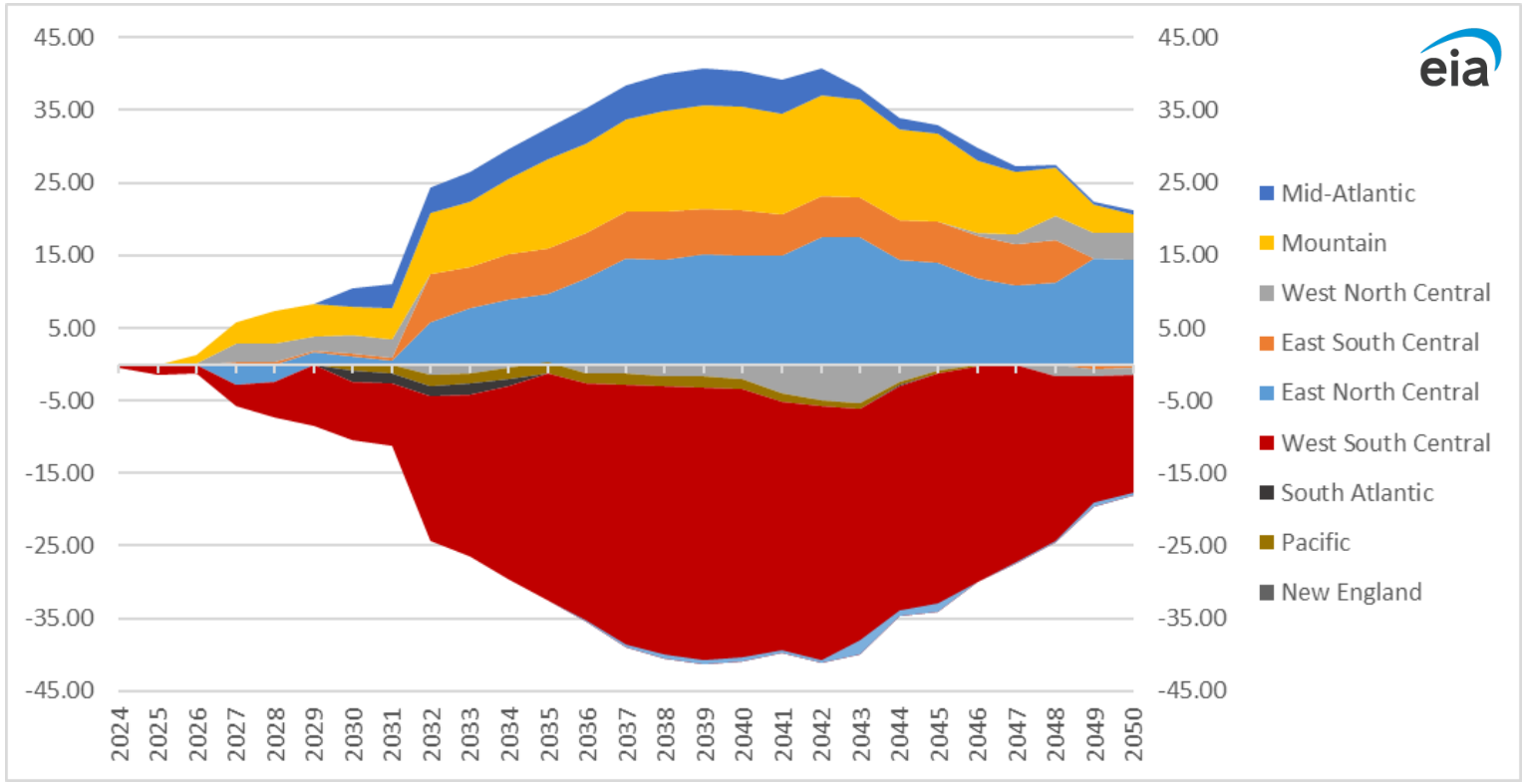
CO_2 EOR Sequestration
million metric tonnes of CO_2



Data source: U.S. Energy Information Administration, Annual Energy Outlook 2025 (AEO2025)

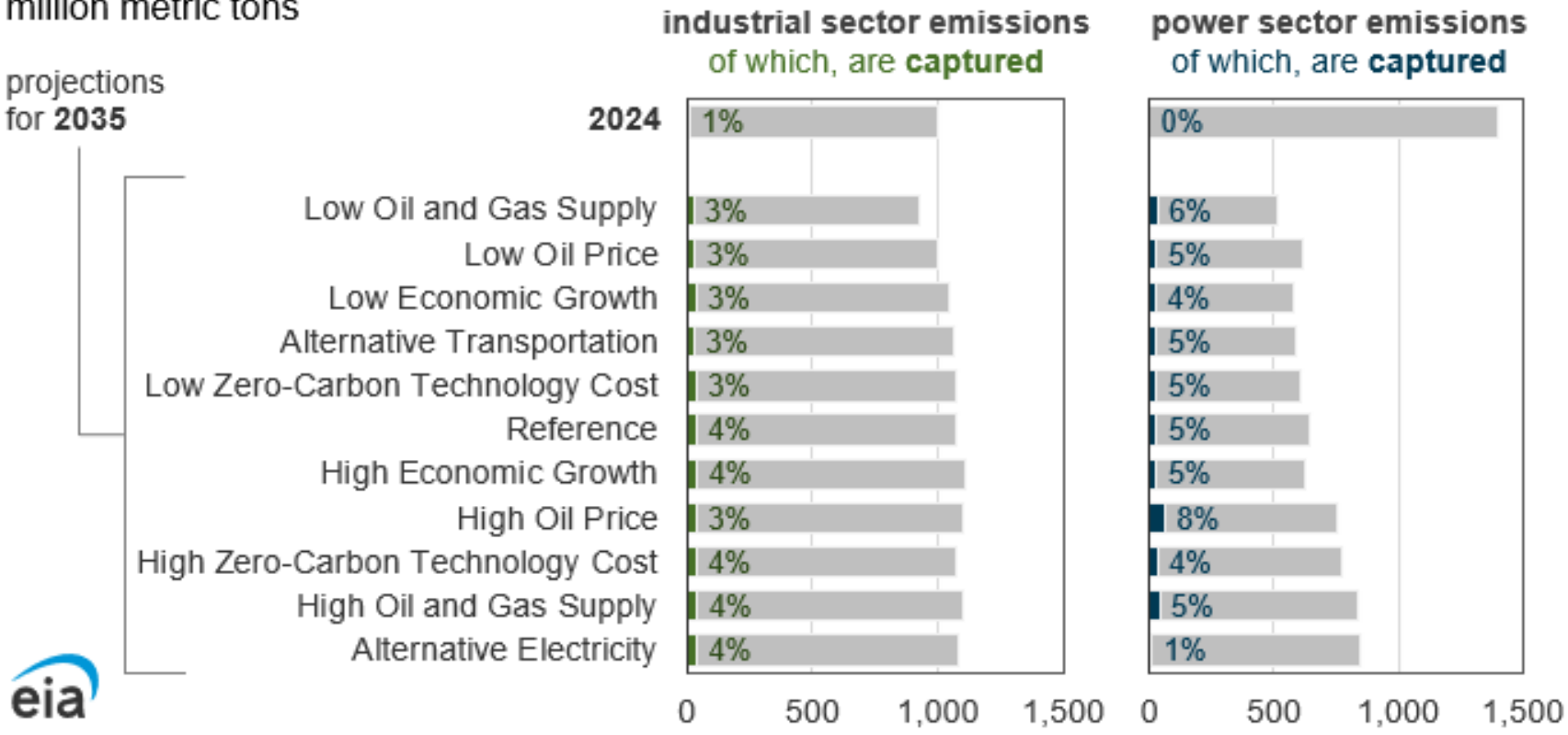
Note: Existing CO_2 supply is not assigned to discrete CO_2 sequestration sites until model year 2027. Shaded regions represent maximum and minimum values for each projection year across the AEO2025 Reference case and side cases.

Trans-regional pipeline networks to meet expanding demand

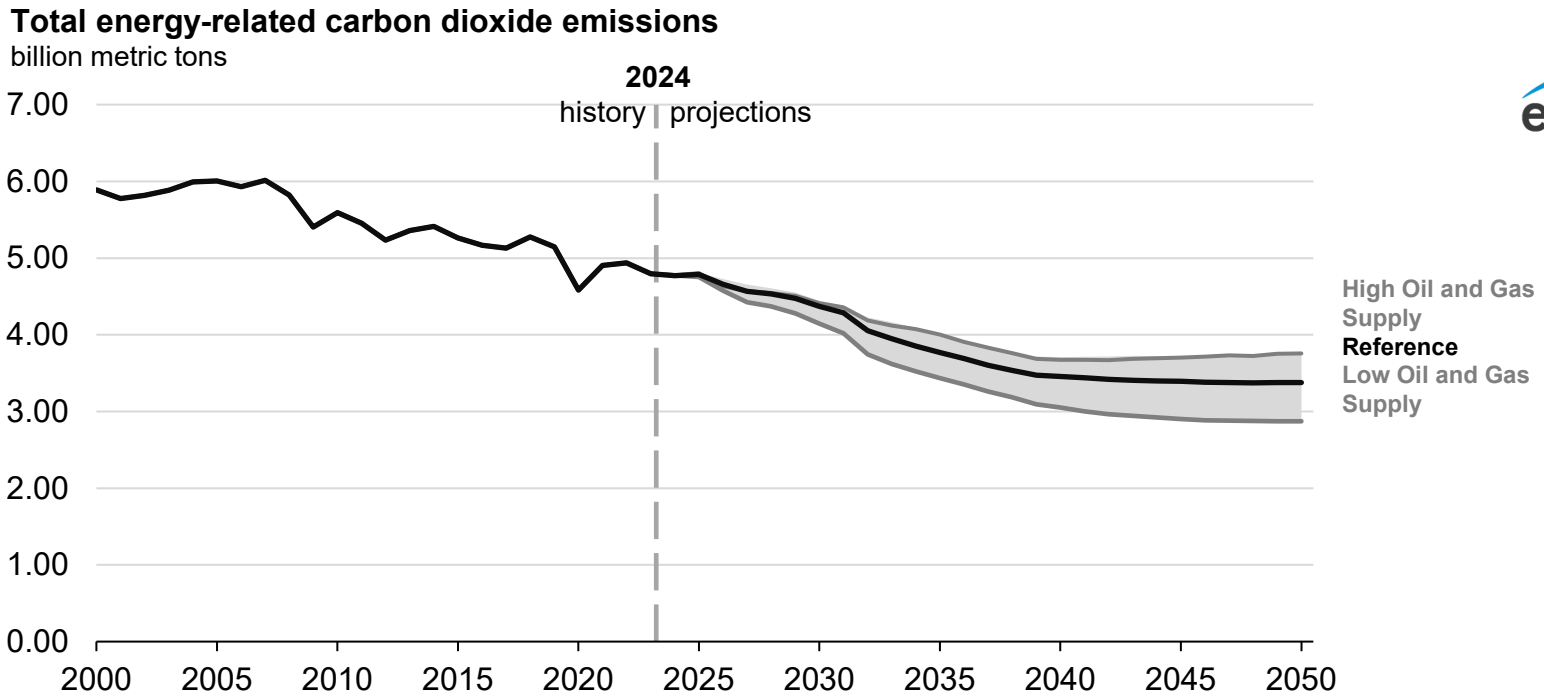


U.S. carbon dioxide emissions in selected sectors (2024 and 2035)

million metric tons



Total energy-related carbon dioxide emissions



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Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2025 Reference case and side cases.

Some next steps for future AEOs

- New policies such as the OBBBA
- Model natural sources of CO2
  - Major source of CO2 for EOR
- Incorporate feedback from our stakeholders

For more information

U.S. Energy Information Administration home page | www.eia.gov

Annual Energy Outlook | www.eia.gov/aeo

Short-Term Energy Outlook | www.eia.gov/steo

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

Today in Energy | www.eia.gov/todayinenergy

State Energy Profiles | www.eia.gov/state

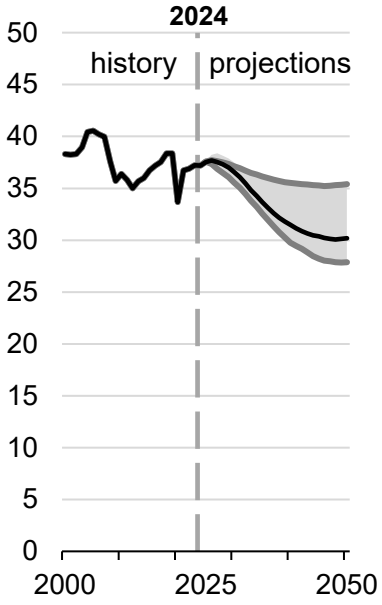
Drilling Productivity Report | www.eia.gov/petroleum/drilling/

International Energy Portal | http://www.eia.gov/international/overview/world

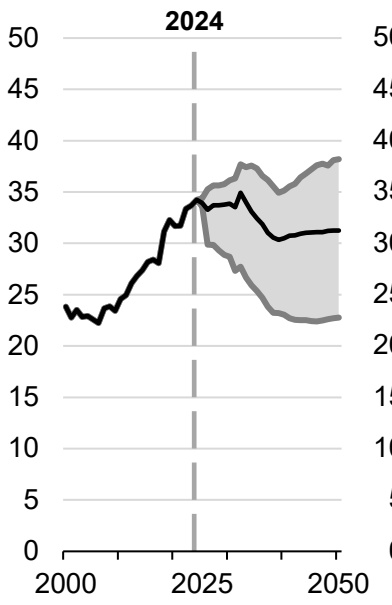
Appendix

Energy Consumption by Fuel

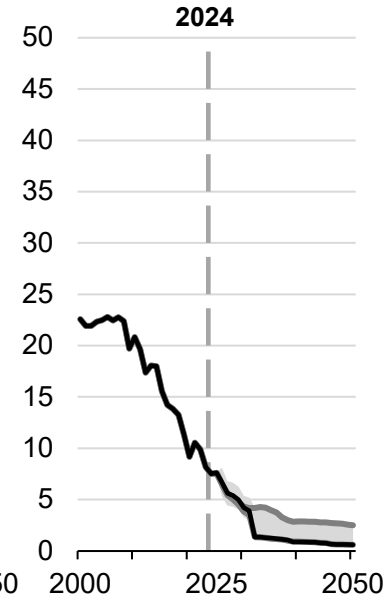
Petroleum and other liquids consumption
quadrillion British thermal units



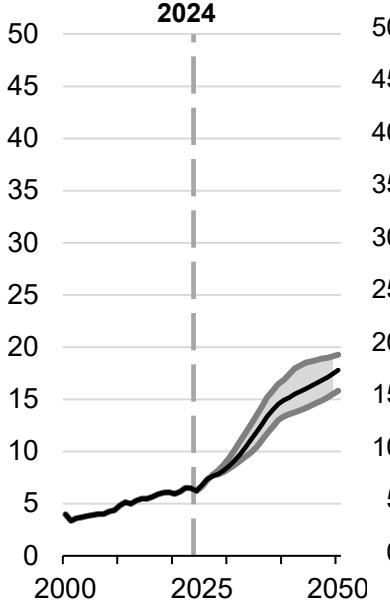
Natural gas consumption



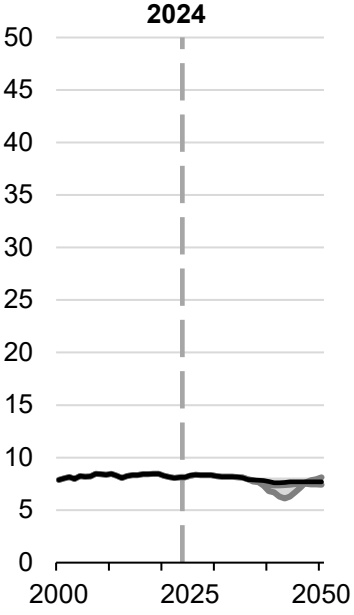
Coal consumption



Renewables (without biofuels) consumption



Nuclear consumption

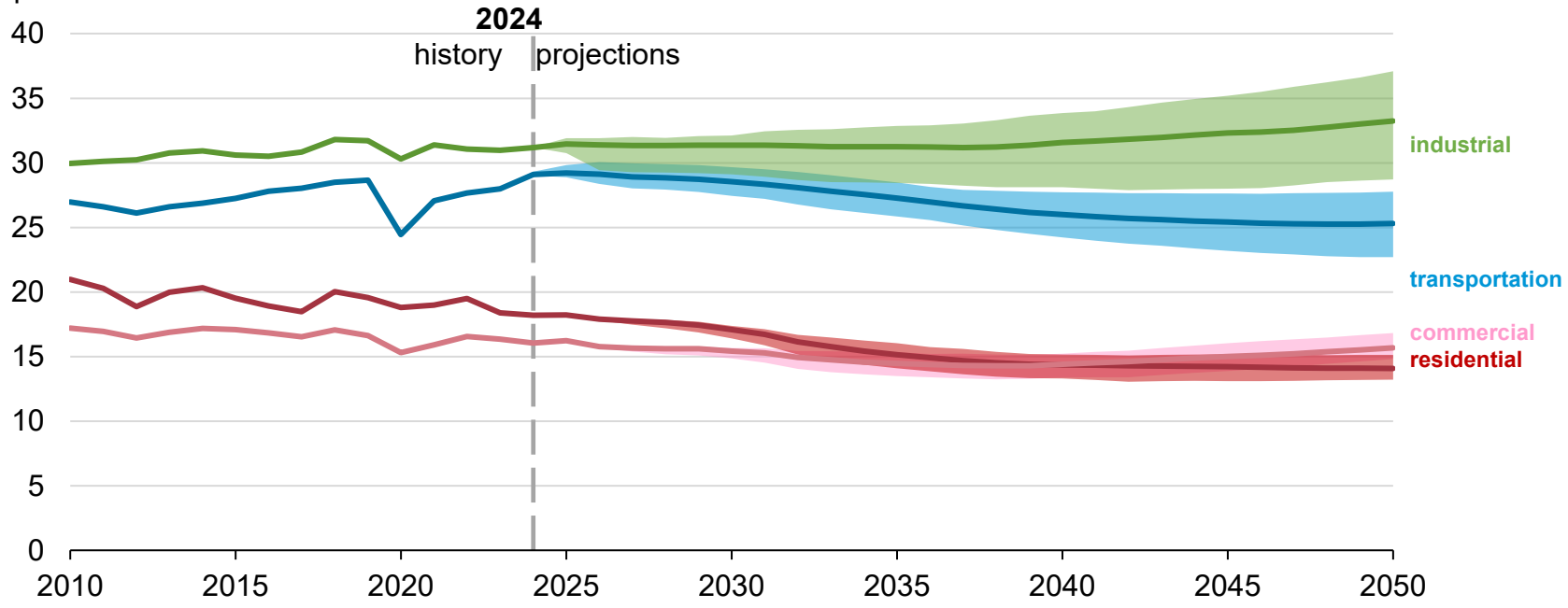


Data source: U.S. Energy Information Administration, Annual Energy Outlook 2025 (AEO2025)

Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2025 Reference case and side cases.

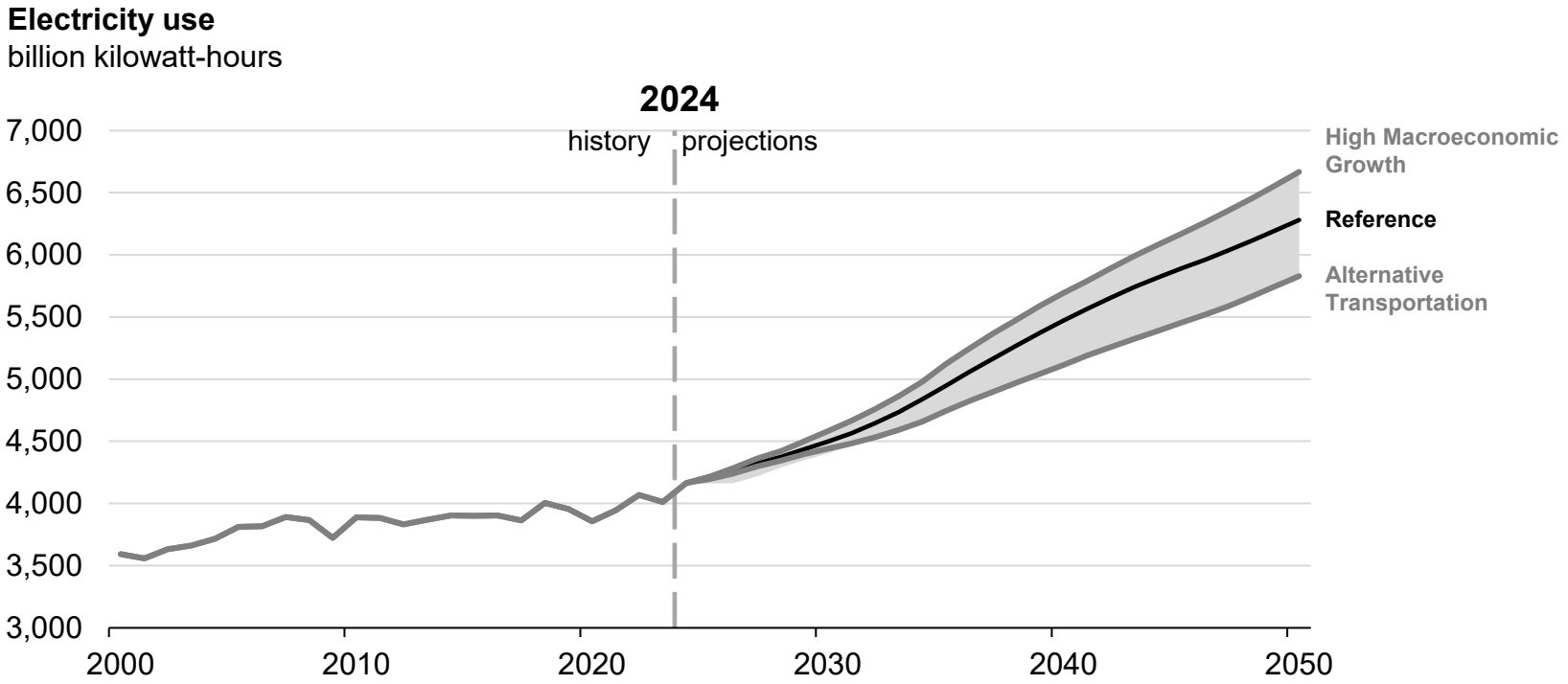
Energy consumption by sector

Total energy consumption by end-use sector
quadrillion British thermal units



Data source: U.S. Energy Information Administration, Annual Energy Outlook 2025 (AEO2025)
Note: Total consumption in end-use sectors includes purchased electricity and electricity-related losses. Each line represents AEO2025 Reference case projections. Shaded regions represent maximum and minimum values for each projection year across the AEO2025 Reference case and side cases.

Electricity use



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