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Assessing CO_2 Capture and Storage (CCS) Opportunities in China

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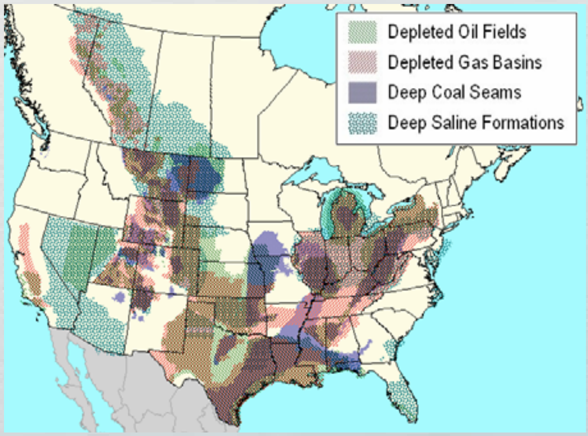
Overview

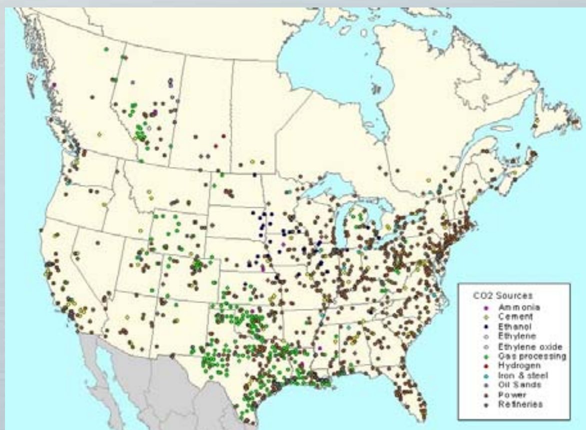
- We are building on recent work (IEA GHG, 2005)
  - Allows for significant cost savings
  - Allows for comparability of results across regions
  - Transfers knowledge
- We are building a truly multinational team for this project.
    - US/China Energy and Environmental Technology Center
    - US Department of Energy
    - Tsinguha University/ BP Energy Center
    - Chinese National Academy of Sciences/RITE
    - Chinese Ministry of Science and Technology
    - PetroChina
- This work is funded on both sides and this research is now underway.
- Assess the results in a broader context of energy / environmental developments.

An Abundance of CO_2 Storage Potential and a Large Potential User Market for CCS Technologies



3,800+ $GtCO_2$ Capacity within 330 US and Canadian Candidate Geologic CO_2 Storage Reservoirs

- 3,730 $GtCO_2$ in deep saline formations (DSF)
- 65 $GtCO_2$ in deep unmineable coal seams with potential for enhanced coalbed methane (ECBM) recovery
- 40 $GtCO_2$ in depleted gas fields
- 13 $GtCO_2$ in depleted oil fields with potential for enhanced oil recovery (EOR)



2,082 Large Sources (100+ $ktCO_2$/yr) with Total Annual Emissions = 3,800 $MtCO_2$/yr

- 1,185 electric power plants
- 447 natural gas processing facilities
- 154 petroleum refineries
- 53 iron & steel foundries
- 124 cement kilns
- 43 ethylene plants
- 9 oil sands production areas
- 40 hydrogen production
- 25 ammonia refineries
- 47 ethanol production plants
- 8 ethylene oxide plants

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Cost Curve Methodology, Part 1: Calculating the Full Set of Storage Options

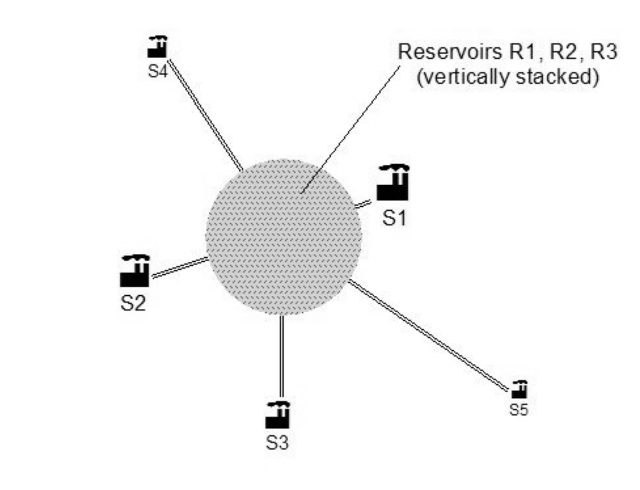
- GIS-based methodology develops levelized costs of transport and storage for each possible source-reservoir pair
- In order to ensure a clear focus on transport and storage costs, the cost of capture (including initial compression and dehydration) is purposefully excluded from this analysis.
- Net Storage Cost = Cost of Transport (via pipeline from plant gate)

  + Cost of Injection (capital & operating costs)

  - Revenue from Value-Added Hydrocarbon Recovery
- The cost curve methodology computes over 50,000 source-reservoir cost pairs in some scenarios for these point sources and candidate reservoirs, i.e., most CO_2 point sources in North America have many candidate storage options available within a reasonable distance.

Cost Curve Methodology, Part 2: Identifying the Least-Cost Pairings, Considering Reservoir Capacity Constraints

- Cost-minimizing decision process based on:
  - Source characteristics
  - Distance to reservoir
  - Reservoir characteristics
  - Oil and natural gas price
  - Remaining capacity of reservoir and minimum capacity commitment (years of injection) required by source
  - Requirement that reservoir must be able to store at least 10 years worth of the point source's CO_2
- Pairing requests are filled in order of net transport & storage cost
- Results in a cost curve of cumulative CO_2 capacity supplied on an annual basis vs. cost ($/t$CO_2$)

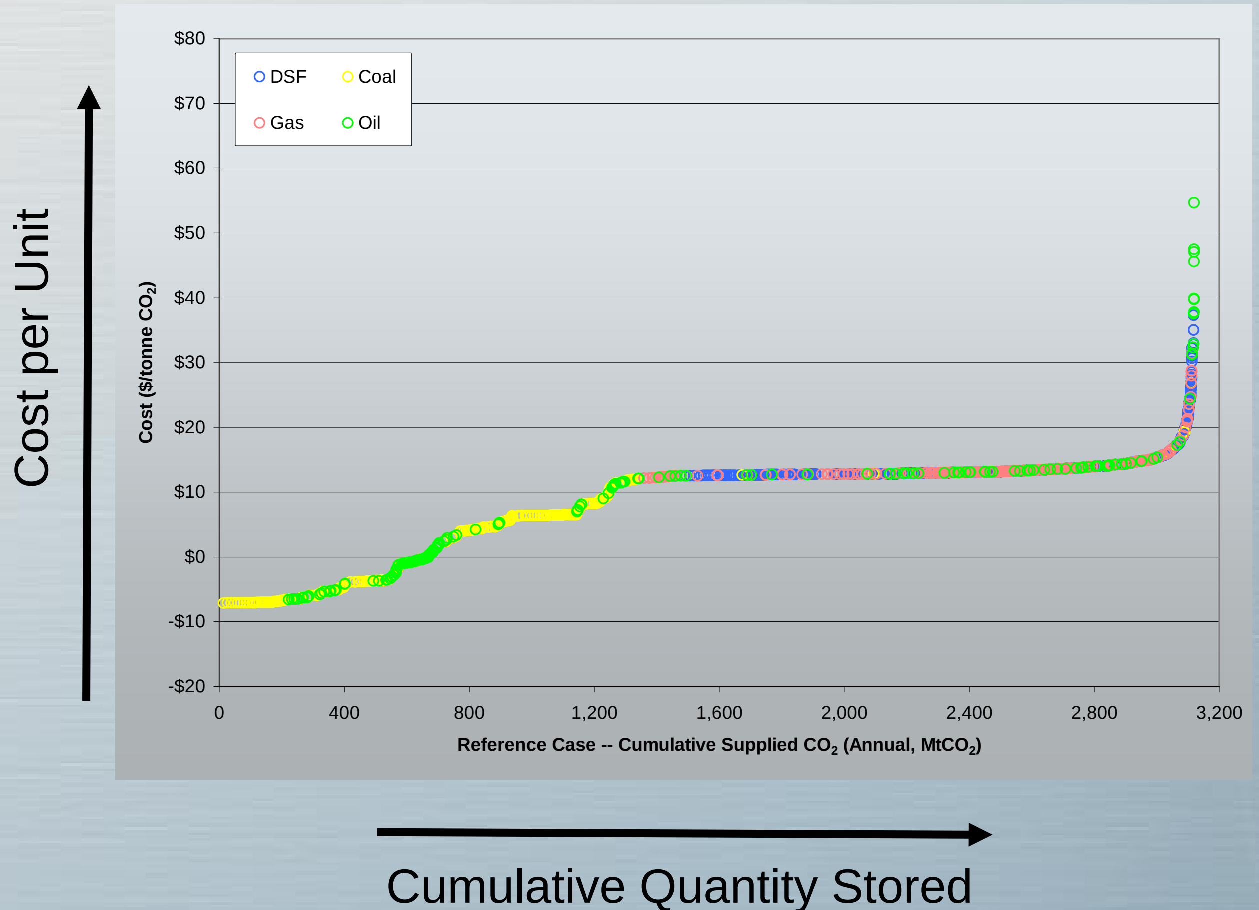


These steps represent a fundamental new aspect of this costing methodology.

Assessing CCS Market Opportunities
The Outcomes

- CCS Cost Curve

North American Example



- Allows us to describe the graded (heterogeneous) nature of the "CCS natural resource" for North America
- CCS usage in North American will not be constrained by lack of capacity
- $12-15/ton CO_2 appears to be upper bound for cost of CO_2 transport and storage

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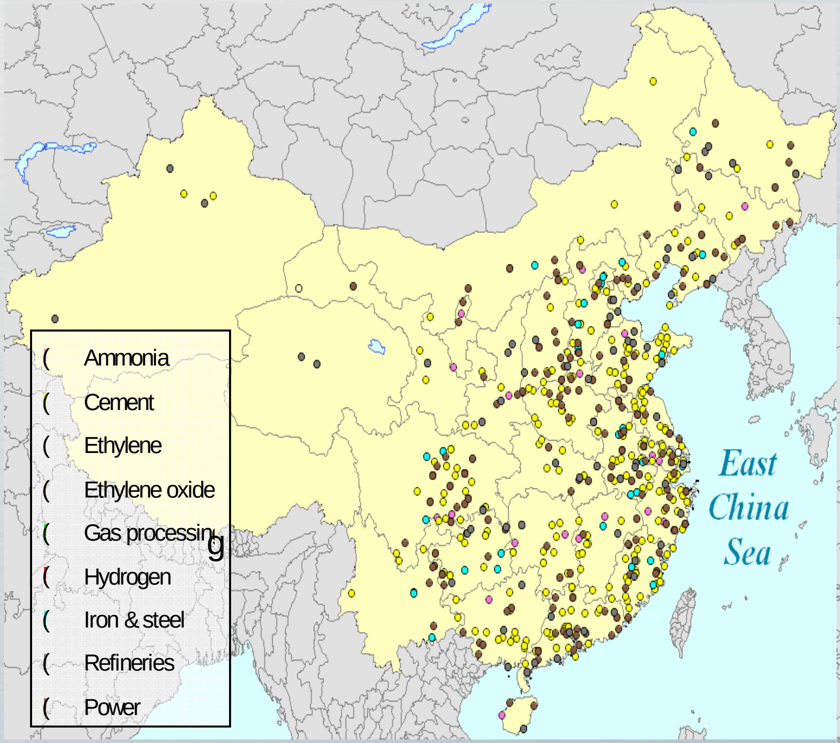
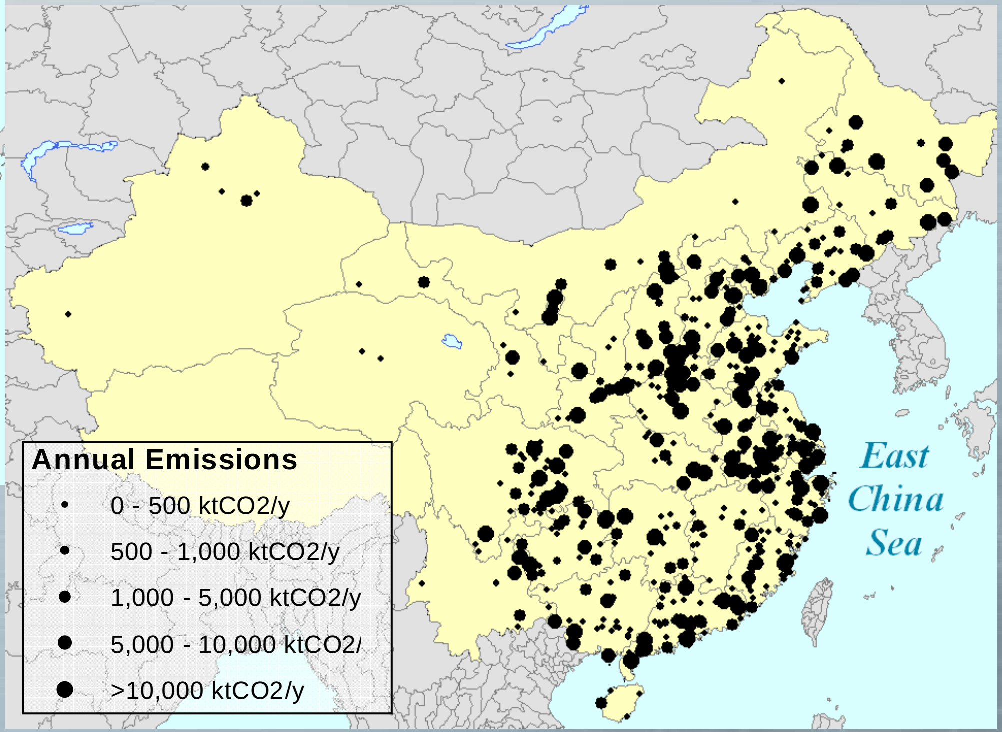
Stationary CO_2 point sources in China

Sources by type





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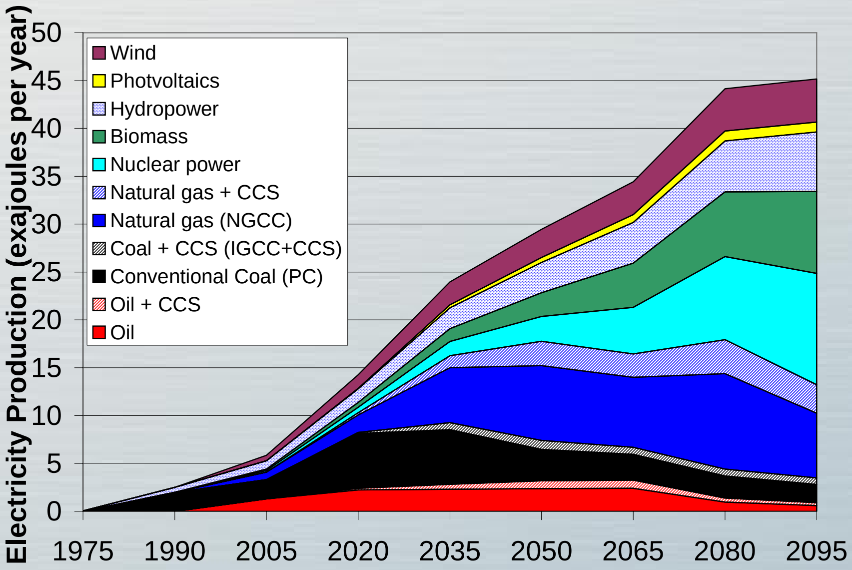
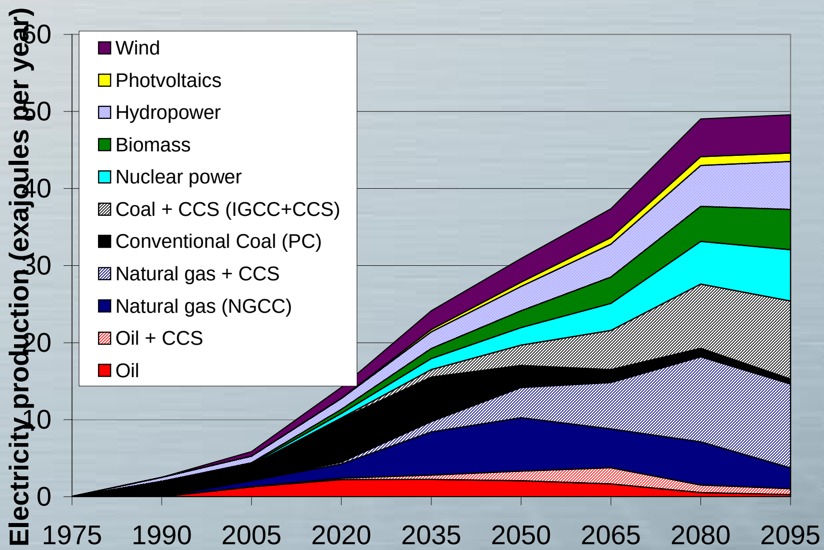
Assessing CCS Market Opportunities

Final Thoughts: The Potential Benefits of CCS in China

Very Limited China CCS



Unlimited China CCS



- The use of fossil fuels is severely curtailed in carbon-constrained world
- Nuclear power and biomass must be pushed, beyond cost-effective limits to meet energy demand
- High energy prices result

- Fossil fuel use increases while emissions are curtailed
- Balanced, stable electricity generation portfolio is maintained
- Lower energy prices
- $100s of billions to a $1 trillion in economic benefits

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The Benefits

- If we can establish the ability to broadly deploy CCS within China, that has tremendous potential economic value: $100s of billions to $1 trillion
- Essential to the deployment of "zero-emission" coal technology
- Preserves the societal benefits of fossil fuels in carbon-constrained world
- Identified as high technical priority at Carbon Sequestration Leadership Forum
- Chinese Ministry of Science and Technology (MOST) requested assistance
- DOE Under Secretary promoting additional US-China sequestration projects