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A North American CO_2 Storage Supply Curve: Key Findings and Implications for the Cost of CCS Deployment

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R.T. Dahowski, J.J. Dooley, and C.L. Davidson, Joint Global Change Research Institute, Battelle – Pacific Northwest Division, USA

S. Bachu, Alberta Energy and Utilities Board, Canada

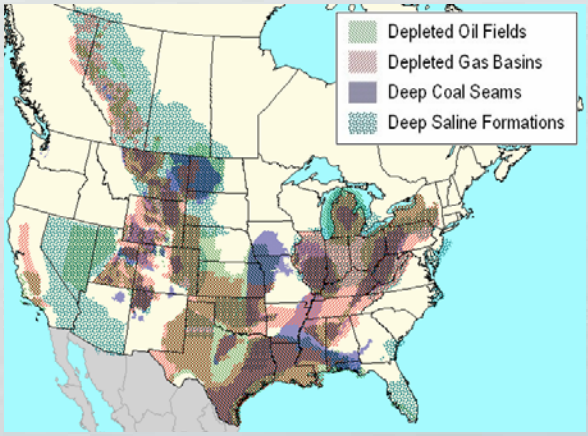
N. Gupta, Battelle, USA

J. Gale, IEA Greenhouse Gas R&D Programme, United Kingdom

Motivation and Overview

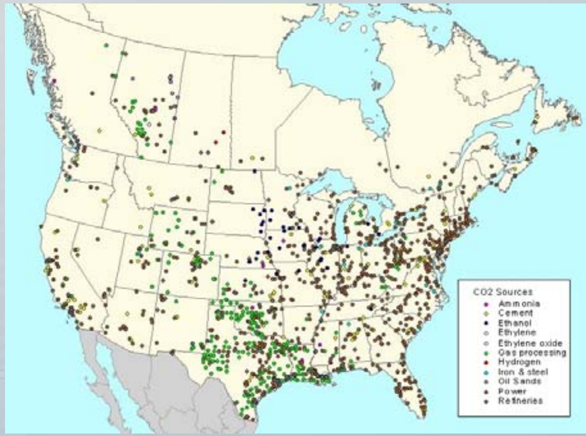
- In order to better understand how CCS systems will operate once they begin to deploy on a large scale,
  - We need a much better understanding of the market dynamics that will characterize how numerous large CO_2 point sources will vie for the large but nonetheless finite CO_2 storage resource in a given region,
  - We need to establish this level of understanding for the many key regions around the world.
- CO_2 Storage Cost Curves can be developed to enable a better understanding of the costs for accessing the CO_2 storage resource base within each region over the near and mid term.
- These CO_2 Storage Cost Curves (coupled with the cost of capture from various classes of large CO_2 point sources) can then be incorporated within energy and economic models to develop a more complete understanding of how CCS technologies will compete against other large scale emissions abatement technologies.

North America: 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 CO_2 Point 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

- The cost of capture (including initial compression and dehydration) was purposefully excluded from this analysis, in order to ensure a clear focus on transport and storage costs.

- Net Storage Cost = Cost of Transport (via pipeline from plant gate)

  + Cost of Injection (capital, operating, and MMV)

  - 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.

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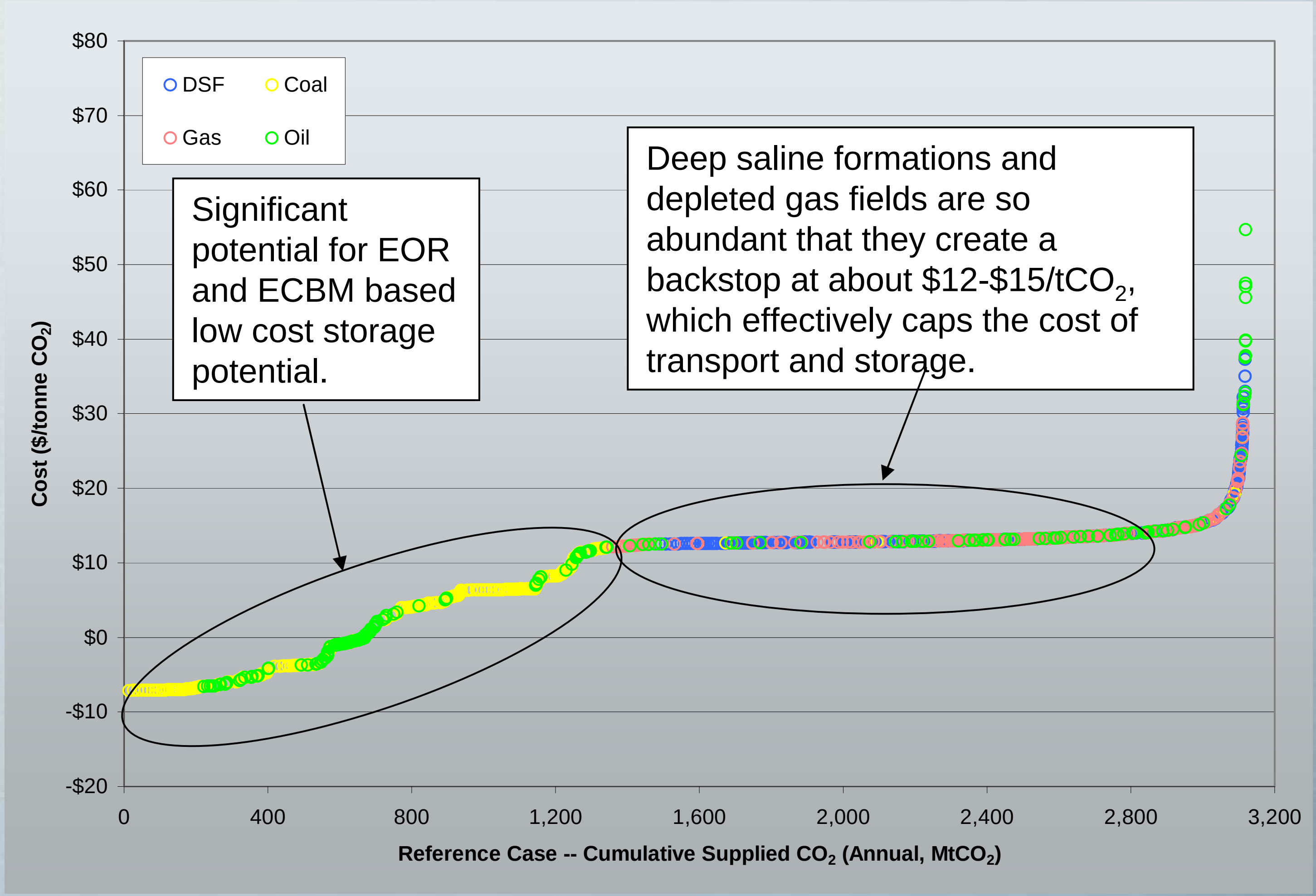
Cost Curve Methodology, Part 2: Identifying Least-Cost Pairings, Considering Reservoir Capacity Constraints

Source-Reservoir Pairing

- 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 required by source
  - Requirement that reservoir must be able to store at least 10 or 20 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$)

CO_2 Storage Supply Curve for North America (Reference Case)



- 96% of the total CO_2 emissions from large point sources can access at least one candidate storage reservoir within 100 miles.

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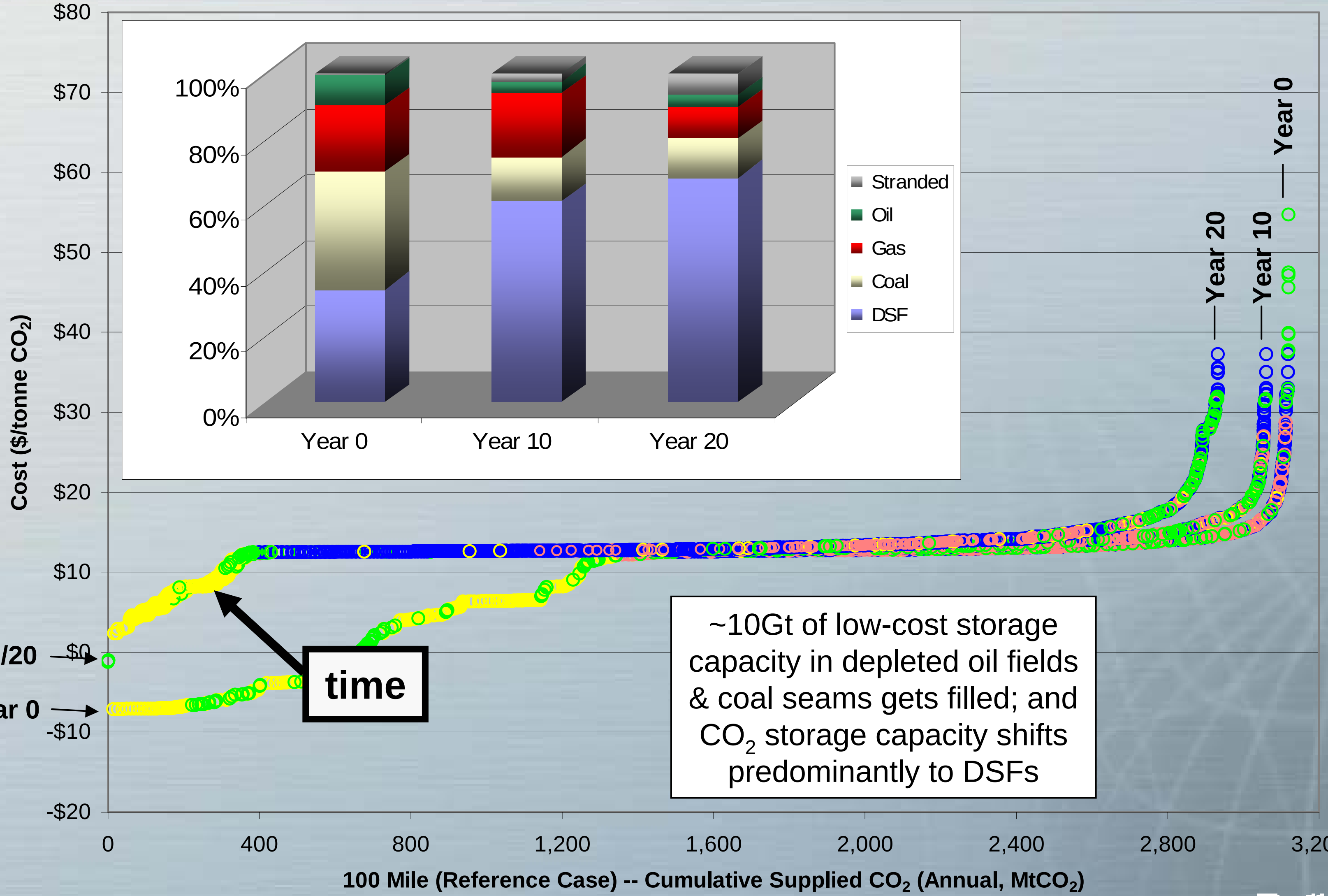
Impact of Reservoir Filling Over Time



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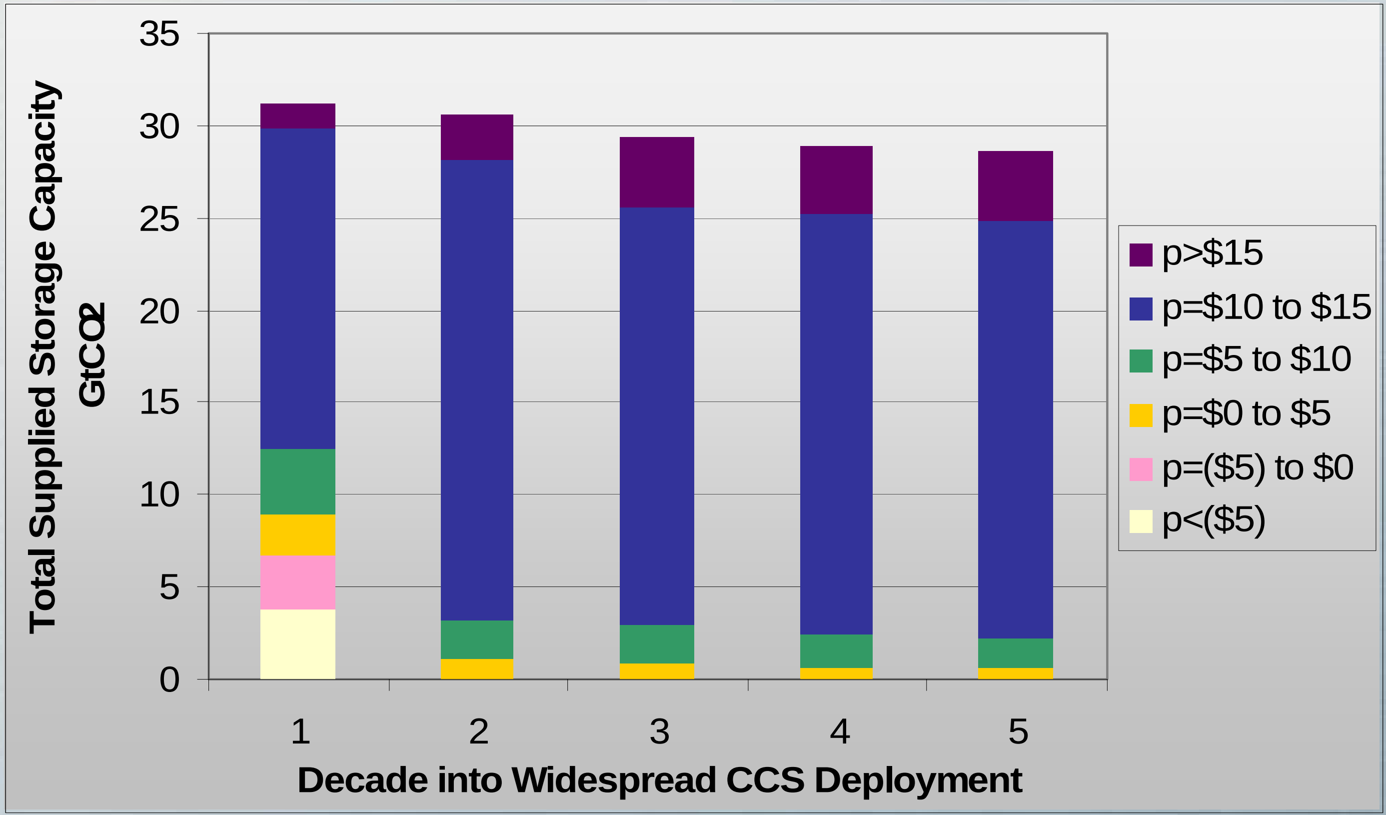
Persistence of Low-Cost Storage Capacity



- The lowest cost storage opportunities (p<($5/t$CO_2$)) are consumed quickly because of their value.
- Low cost (p<$10/t$CO_2$) capacity persists over time.

- Over 23 gigatonnes of this low-cost (p<$10/t$CO_2$) storage capacity is accessible over the first 50 years of widespread CCS deployment, which is enough to address US storage needs consistent with stabilization at approximately 550 ppmv.

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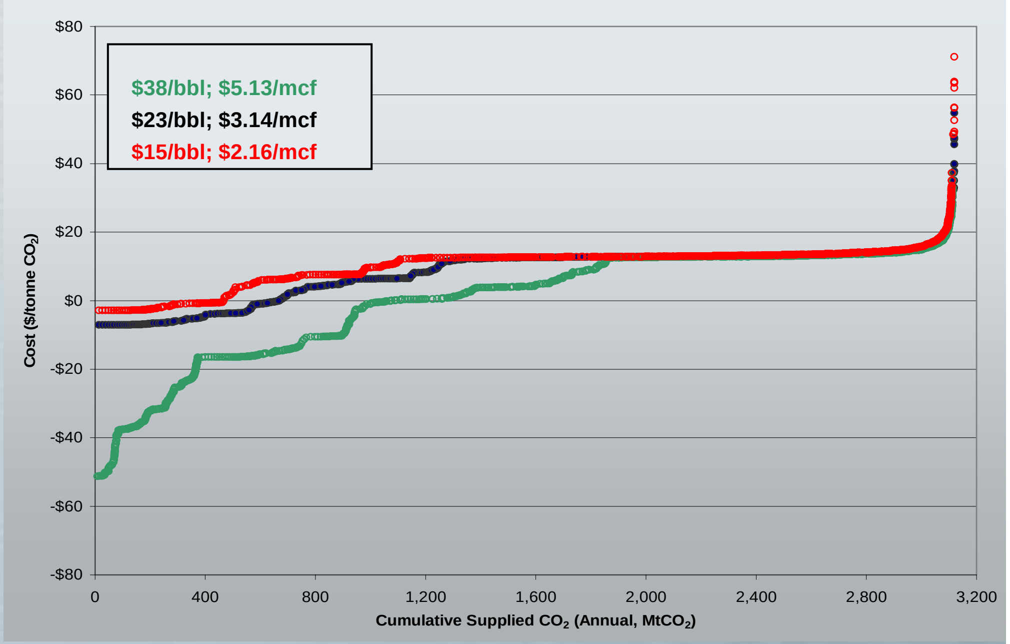
Sensitivity Analyses Around the Reference Case: Exploring Various Parameters that Influence the Extent of Low Cost CO_2 Storage Opportunities

- Higher <u>sustained</u> oil and natural gas prices can have a significant impact on the amount of available low cost storage capacity.

- Whether a project can leverage existing CO_2 storage infrastructure greatly influences the attractiveness of value-added reservoirs.



- The ability for sources (which will require sufficient and dependable storage volumes over their lifetimes) to reduce costs by sequentially or simultaneously accessing multiple nearby storage reservoirs and optimizing injection could also improve the attractiveness of many value-added reservoirs.

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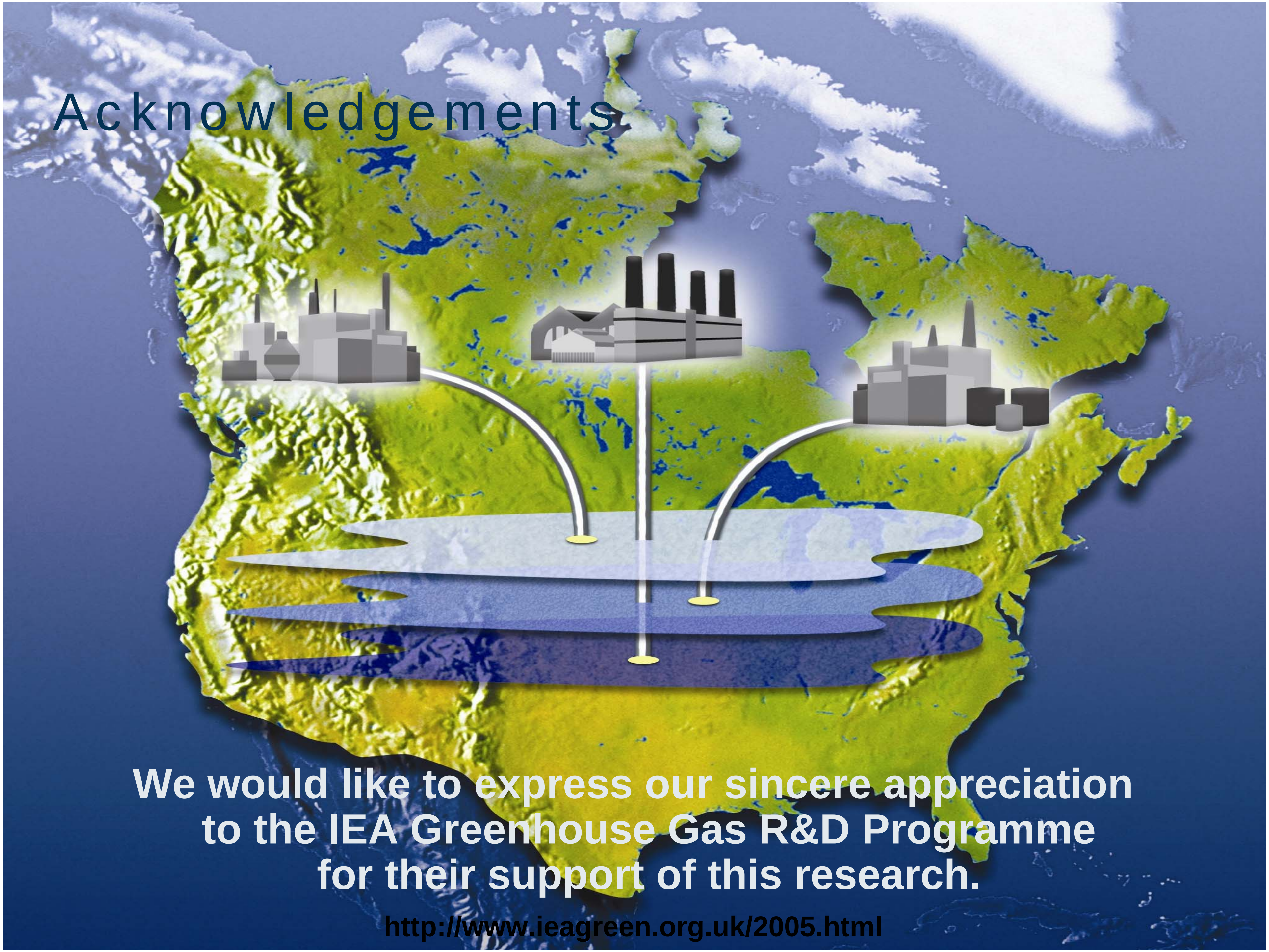
Summary: Good News for CCS

- The CO_2 storage resource is vast and well-distributed across much of North America, and offers the potential to address the possible future CO_2 reduction needs of literally trillions of dollars of productive industrial infrastructure (power plants, refineries, and other facilities).
- While the resulting cost curves span a wide range of costs, the most relevant metric is: W*hat is the cost of storage capacity that is likely to be used?*
  - Several $GtCO_2$ could be stored for less than -$5/ton$CO_2$
  - Tens of $GtCO_2$ could be stored for less than $10/ton CO_2
  - Thousands of $GtCO_2$ could be stored for less than $12-$15/tCO_2
- The size of the low-cost storage resource could be significantly larger if oil and gas prices remain above their historic norms and/or if we can evolve technology/operations to allow for enhanced access to smaller formations or to otherwise reduce infrastructure costs.
- For North America, CCS should be quite cost effective when compared to other large-scale abatement options.

Acknowledgements



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http://www.ieagreen.org.uk/2005.html