Carbon Capture and Sequestration in New York

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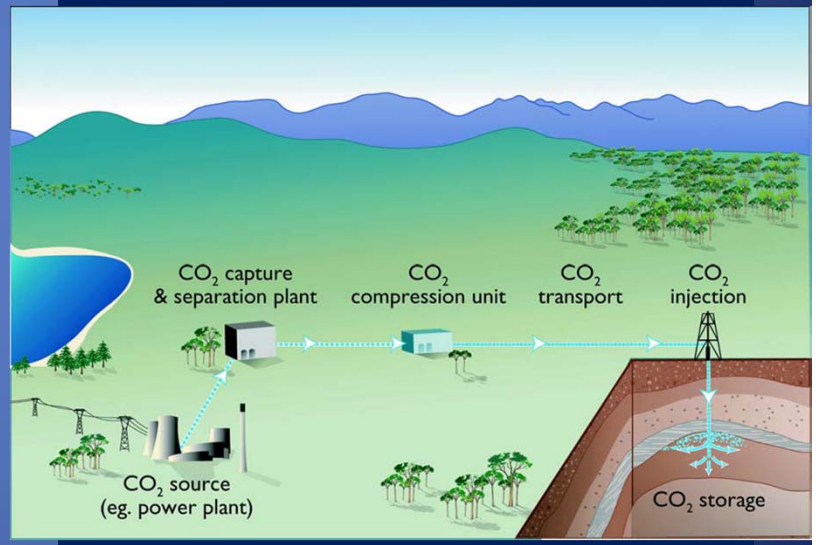
Carbon Capture Systems

- Coal gasification (e.g. IGCC) or coal-to-methane plants
  - CO_2 capture is less expensive
  - Enables the use of efficient turbines
- Oxy-fuel combustion
  - CO_2 capture is less expensive
  - Enables the use of conventional boilers
  - O_2 separation is energy intensive
- Post-combustion capture
  - CO_2 capture is energy intensive and very expensive
  - Conventional pollutant controls are still necessary
- Terrestrial capture

1. Capture and separate at source
2. Compress and transport in pipelines
3. Inject for permanent sequestration

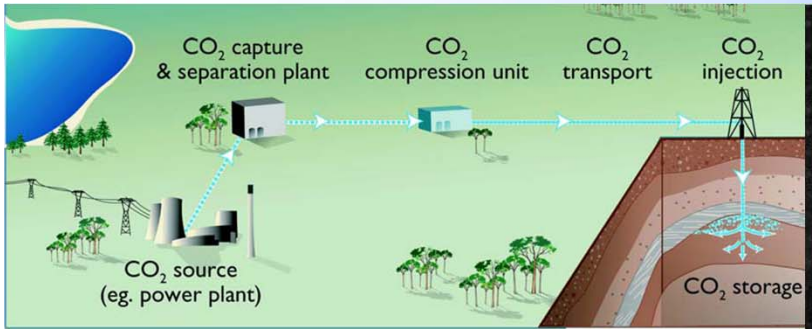


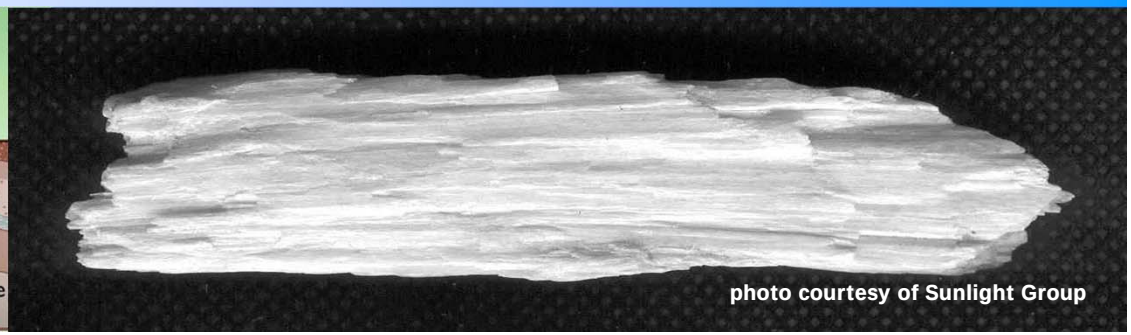
IEA, ***Geological Storage of Carbon Dioxide: Staying Safely Underground***, January, 2008

Source: Steelman, John, *Meeting the Climate Change Challenge in Time*, presentation to the Apollo Alliance, Albany, NY, January 15, 2008

Carbon Sequestration Options and Technical Development Timeline

- ***Near Term***
  - **Enhanced Oil Recovery (EOR)**
  - **Depleted Oil and Gas Reservoir**
  - **Gas Storage Caverns**
- ***Medium Term***
  - **Coal Enhanced Gas Recovery (EGR)**
  - **Onshore Saline Formations**
  - **Offshore Formations**
- ***Long Term***
  - **Shale EGR**
  - **Ocean Sediment Sequestration**
  - **Mineralization of CO_2**





New York Point Source and Volumetric Storage Capacity

Stationary Source Emissions Estimates by State/Province

State/Province	CO2 Emissions Million Metric Ton/Year	Number of Sources	Percent of Total
NEW YORK	111.4	412	0.35
USA/Canada	3,212	4,674	100

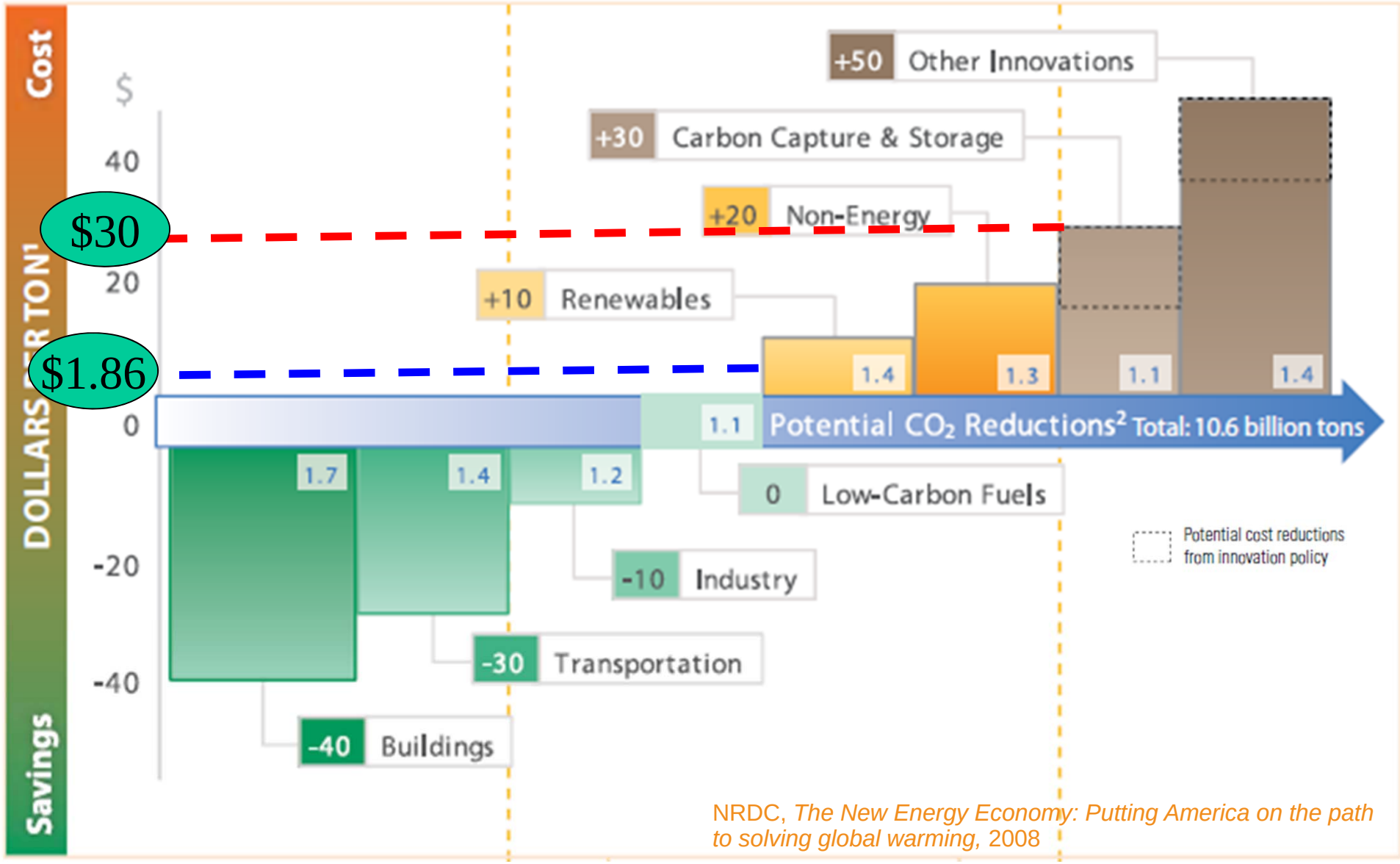
Total CO2 Storage Resource Estimates by State/Province

State/Province	Million Metric Tons		Million Tons	
	Low Est.	High Est.	Low Est.	High Est.
NEW YORK	2,969	10,869	3,273	11,981
USA/Canada	3,591,506	12,933,868	3,958,953	14,257,132

NETL, *Carbon Sequestration Atlas of the United States and Canada, 2nd Edition*, 2008

Obstacles to Deployment: Economic

Cutting U.S. Global Warming Pollution 80% by 2050: Cost and Payoff by Sector



NRDC, *The New Energy Economy: Putting America on the path to solving global warming*, 2008

"Earthquake activity will increase significantly because of pressurizing and dissolving the earth's mantle, thus releasing the stored carbon dioxide to the atmosphere in a very short period of time. People will die quickly from asphyxiation or will die slowly from the rapid global warming that will occur."

"A coal-electric plant that sequesters carbon dioxide releases twice as much carbon dioxide to the atmosphere compared to a far more efficient power plant that does not sequester the carbon dioxide."

"World leaders must stop promoting the sequestering of carbon dioxide produced at coal electric power plants because it will cause both the cost of electricity and the release of carbon dioxide from the use of coal to escalate to infinity. Further, if this advice is ignored and storage in deep bedrock is implemented, mega-disaster earthquakes will release billions of tons of carbon dioxide ***killing billions of people***."

Obstacles to Deployment: Legal and Regulatory Framework

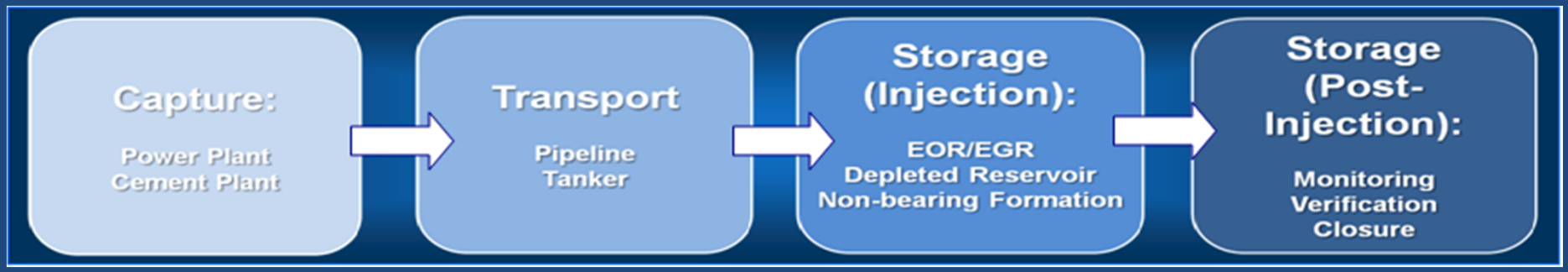
Develop regulation based on sound science

Better understanding of property rights/stewardship

- Ownership of pore space (the container)
- Ownership of injected CO2 (the contents)
- Liability

Use precedents from natural gas storage, hazardous waste disposal, enhanced oil recovery, and further research on CCS to formulate regulations

POSSIBLE ACTIONS AND APPROACHES



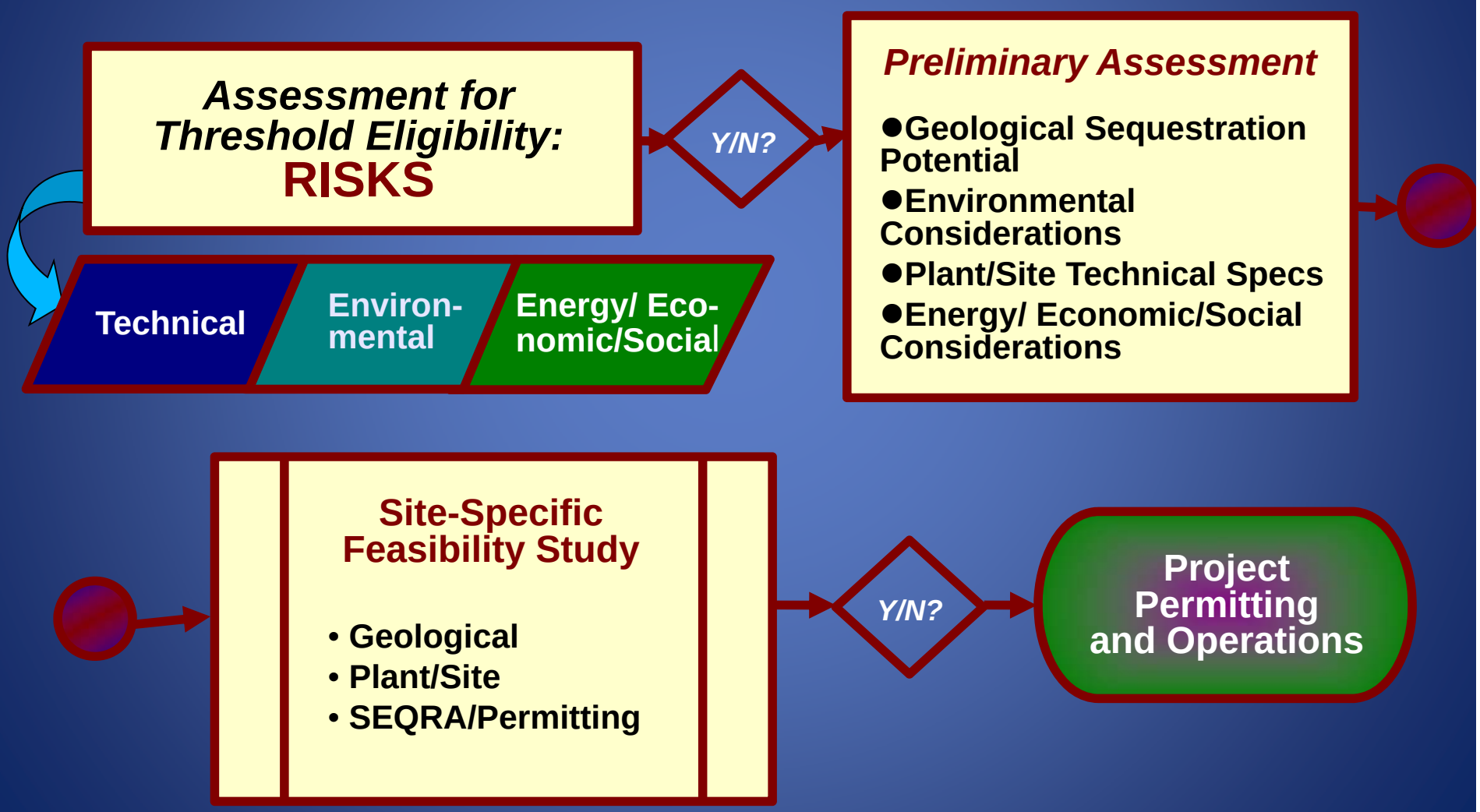
-The NYS Legislature is considering greenhouse gas emissions regulations to limit allowable CO2 emissions

-NYS will require a statutory change to allow regulation by either the NYS DPS, the NYS DOT, or the NYS DEC on all the issues of transportation of CO2

-NYS can modify the existing statute for natural gas storage to include CO2.
-New regs will be required to use of eminent domain. -
-No regs can conflict with UIC due to lack of an exemption.

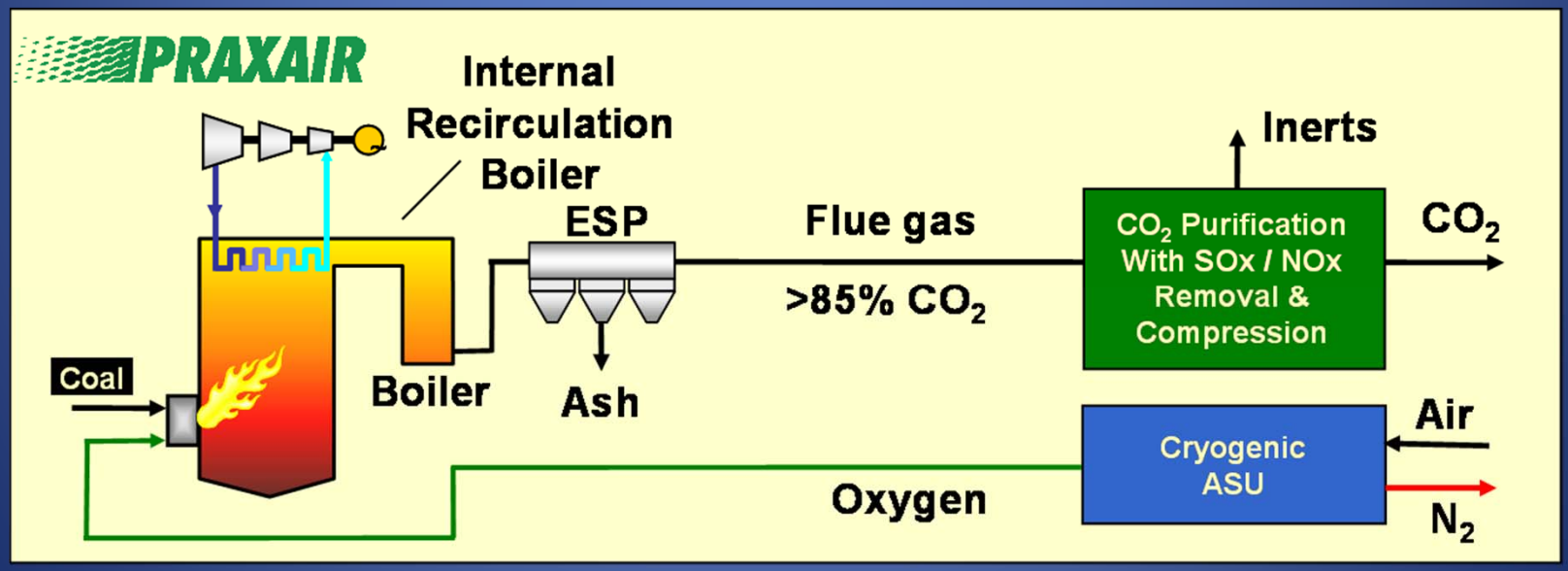
-Member of the Assembly Parment introduced legislation that combines NYS gas storage regulations with conditions similar to the recent Wyoming Legislation.
-New York introduced early-mover legislation.

Obstacle to Deployment: Evaluating Major Issues



Ongoing Capture Research: Oxycombustion Technology

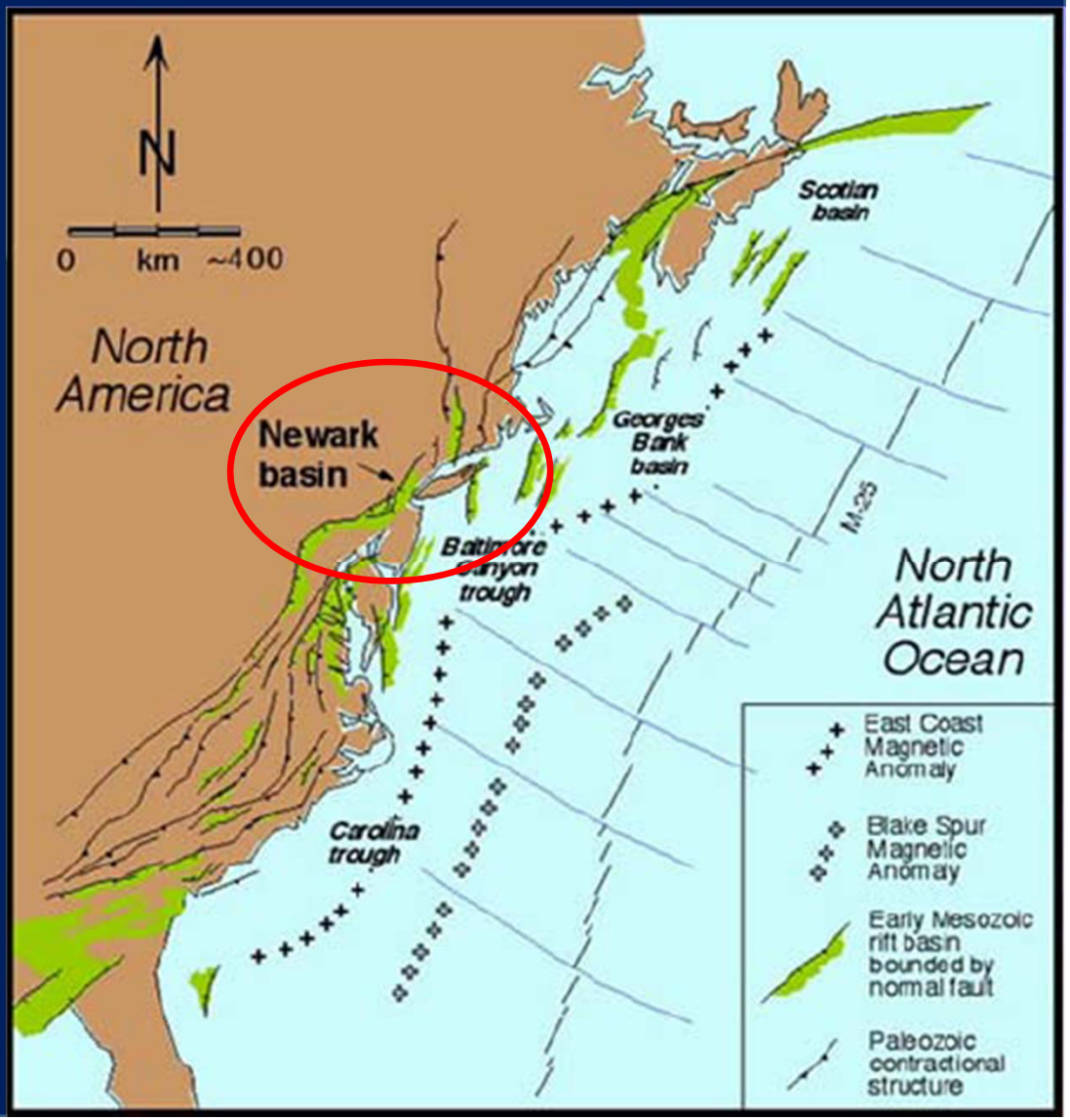
NYSERDA is working with ***Praxair*** to develop a ceramic membrane separation technology for use in an advanced oxycombustion boiler design. This can reduce substantially the energy needed for CCS.



Ongoing Sequestration Research: Geologic Characterization

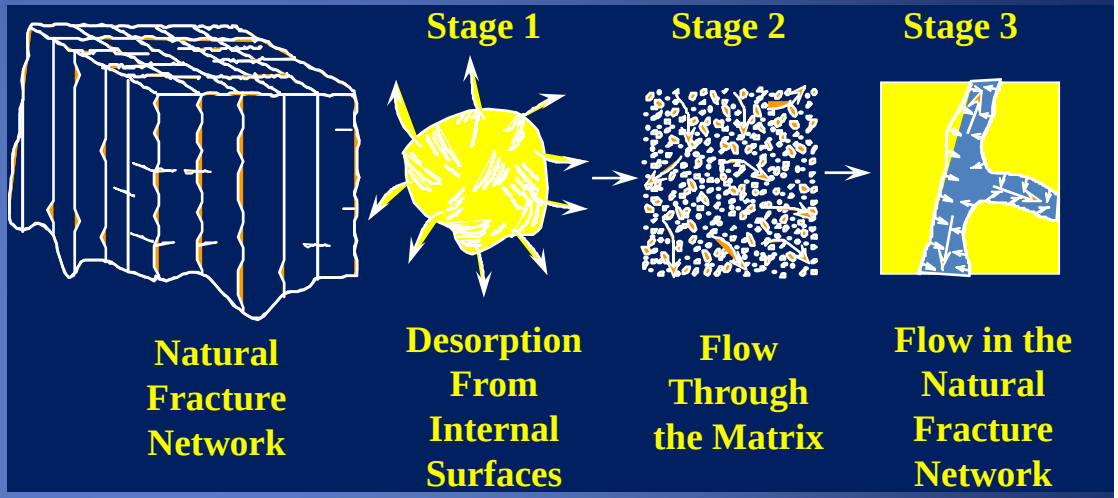
Looking at Mesozoic Basin and younger sediments with Tricarb Consortium and Lamont Doherty Earth Observatory

Includes both “exposed” and “buried” basins of Jurassic- Triassic Age (Newark Basin is exposed) and offshore basins

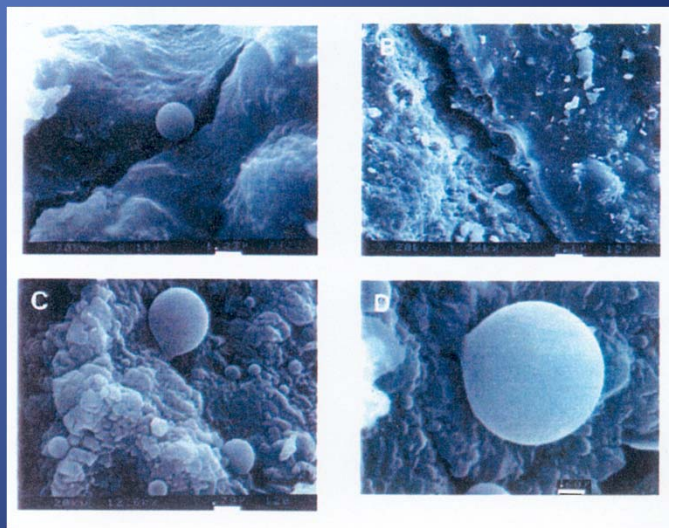


Sequestration Potential: Enhanced Gas Recovery from Shale

- Black shales may offer both CO_2 sequestration and enhanced gas recovery
- Black shales can store CO_2 in both matrix (voids) and bound to organics (adsorption)
- Enhanced gas recovery capitalizes on the preferential adsorption of CO_2 over methane



Laboratory SEM Image of hydrocarbon generation in the Woodford Shale



SOURCES: Schlumberger Data Services and O'Brien, N., M. Cremer and D. Canales, "The Role of Argillaceous Rock Fabric in Primary Migration of Oil," in Depositional Processes and Characteristics of Siltstones, Mudstones and Shales, a special symposium – 2002 GCAGS Annual Meeting.

Conclusions

- Carbon capture and sequestration is a feasible technology.
- Good geological characterization is key to reducing project uncertainty (and key to reducing regulatory risk).
- NYSERDA and its partners are working to characterize the geological conditions necessary for CCS projects both on- and offshore.
- Ultimately, fossil fuel plant siting may be driven by geological sequestration opportunities as well as access to power lines, supply lines, etc...

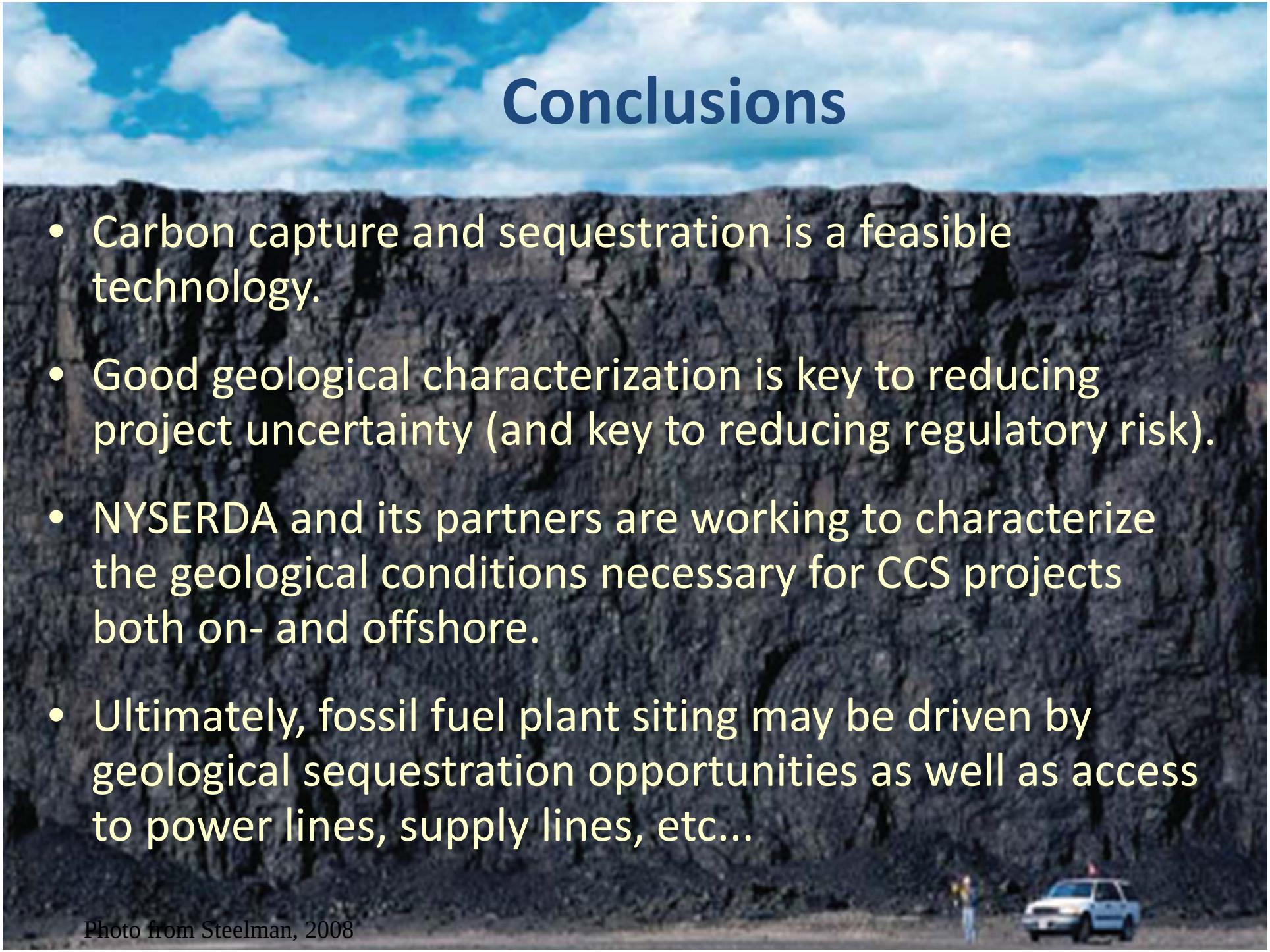


Photo from Steelman, 2008