

Carbon Capture Utilization and Storage: *US Project Status, Drivers, and Barriers*



Council of Industrial Boiler Owners

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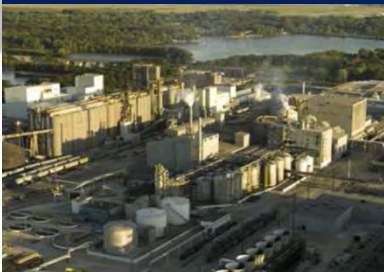
Acknowledgements

- **The Industrial Carbon Capture and Storage (ICCS) project is administered by the U.S. Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory (award number DE-FE-0001547) and by a cost share agreement with the Archer Daniels Midland Company, University of Illinois through the Illinois State Geological Survey, Schlumberger Carbon Services, and Richland Community College. This ICCS project received DOE funding from the American Recovery and Reinvestment Act of 2009 (\$141.4 million).**
- **The Midwest Geological Sequestration Consortium is funded by the U.S. Department of Energy through the National Energy Technology Laboratory via the Regional Carbon Sequestration Partnership Program (contract number DE-FC26-05NT42588) and by a cost share agreement with the Illinois Department of Commerce and Economic Opportunity, Office of Coal Development through the Illinois Clean Coal Institute.**
- **The Midwest Geological Sequestration Consortium (MGSC) is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky**



CCUS Demonstration Projects

ADM IL-ICCS



Archer Daniels Midland ICCS - Illinois

- Direct Capture - Ethanol Plant
- 350 MM gal Ethanol
- 90% CO₂ capture, 1.0 MMT - Geologic Storage, Saline Reservoir
- Total Project: \$208 million; DOE share: \$142 million

FutureGen 2.0



FutureGen 2.0 CCDP - Illinois

- Oxy-Combustion - Power Generation
- 175 MW power
- 90% CO₂ capture, 1.0 MMT - Geologic Storage, Saline Reservoir
- Total Project: \$1.65 billion; DOE share: \$1.0 billion

Petra Nova CCS



The Petra Nova Carbon Capture CCPI - Texas

- Post Combustion – Power Generation
- 240 MW power
- 90% CO₂ capture 1.6 MMT - Enhance Oil Production (EOR)
- Total Project: \$469 million; DOE share: \$167 million

Air Products SMR



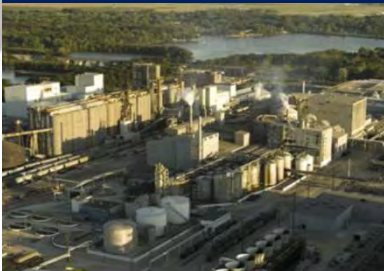
Air Products ICCS - Texas

- Steam Methane Reforming - Vacuum Swing Adsorption
- 130 MMscfd Hydrogen
- 90% CO₂ capture; 1.0 MMT - EOR
- Total Project: \$431 million; DOE share: \$284 million



CCUS Demonstration Projects

ADM IL-ICCS



Archer Daniels Midland ICCS - Illinois

- Direct Capture - Ethanol Plant
 - 350 MM gal Ethanol
 - 90% CO₂ capture, 1.0 MMT - Geological Storage, Saline Reservoir
 - Total Project: \$208 million; EOR share: \$142 million
- Permitted - Q3 2014**
Under construction
Operations - Q1 2015

FutureGen 2.0



FutureGen 2.0 CCDP - Illinois

- Oxy-Combustion - Power Generation
 - 175 MW power
 - 90% CO₂ capture, 1.0 MMT - Geological Storage, Saline Reservoir
 - Total Project: \$1.55 billion; EOR share: \$1.0 billion
- Permitted - Q3 2014**
Securing financing
Operations - 2017

Petra Nova CCS



The Petra Nova Carbon Capture CCPI - Texas

- Post Combustion - Power Generation
 - 240 MW power
 - 90% CO₂ capture, 1.0 MMT - Enhanced Oil Production (EOR)
 - Total Project: \$450 million; EOR share: \$167 million
- Permitted**
Under construction
Operations - 2016

Air Products SMR



Air Products ICCS - Texas

- Steam Methane Reforming - Vacuum Swing Adsorption
 - 130 MMscfd Hydrogen
 - 90% CO₂ capture, 1.0 MMT - EOR
 - Total Project: \$131 million; EOR share: \$284 million
- Permitted**
Operations - March 2013
Over 1.1 MMT captured



CCUS Demonstration Projects

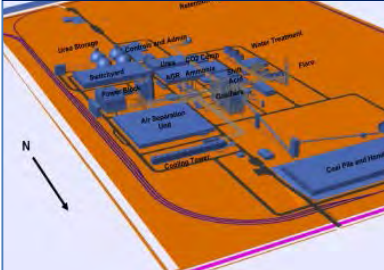
Southern Co. IGCC



Southern Company CCPI - Mississippi

- Pre-combustion ; IGCC - Power Generation
- 582 MW power
- 67% CO₂ capture (Selexol® process), 3.0 MMT - EOR
- Total Project: \$6.1 billion; DOE share: \$270 million

Summit IGCC Polygen



Summit Texas Clean Energy CCPI - Texas

- Pre-combustion; IGCC - Polygeneration
- 200 MW power, 0.9 MMT Urea
- 90% CO₂ capture, 2.63 MMT - EOR
- Total Project: \$3.85 billion; DOE share: \$450 million

HECA IGCC Polygen



Hydrogen Energy California CCPI - California

- Pre-combustion; IGCC - Polygeneration
- 300 MW power, 1.0 MMT Urea/Urea Ammonium Nitrate
- 90% CO₂ capture 3.02 MMT - EOR
- Total Project: \$5.0 billion. DOE share: \$408 million

Leucadia IGCC



Leucadia Petcoke to Methanol & Hydrogen ICCS - Louisiana

- Pre-combustion; IGCC - Methanol & Hydrogen
- 700 MM gal methanol, 110 MMscfd Hydrogen
- 89% CO₂ capture (Rectisol®); 4.5 MMT - EOR
- Total Project: \$436 million; DOE share: \$261 million



CCUS Demonstration Projects

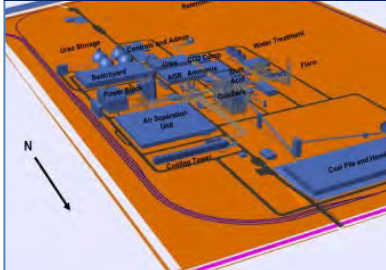
Southern Co. IGCC



Southern Company CCPI - Mississippi

- Pre-combustion: IGCC - Power Generation
 - 582 MW power
 - 67% CO₂ capture (pre-combustion), 1.0 MMT - EOR
 - Total Project: \$1.69 billion; DOE share: \$270 million
- Permitted**
Under construction
Operations - Q4 2015

Summit IGCC Polygen



Summit Texas Clean Energy CCPI - Texas

- Pre-combustion: IGCC - Polygeneration
 - 200 MW power, 0.9 MMT Urea
 - 90% CO₂ capture, 0.55 MMT - EOR
 - Total Project: \$1.25 billion; DOE share: \$450 million
- Engineering & design**
Securing financing
Operations - 2019

HECA IGCC Polygen



Hydrogen Energy California CCPI - California

- Pre-combustion: IGCC - Polygeneration
 - 300 MW power, 1.0 MMT Urea/Urea Ammonium Nitrate
 - 90% CO₂ capture, 0.2 MMT - EOR
 - Total Project: \$511 million; DOE share: \$408 million
- Engineering & design**
Securing financing
Operations - 2020

Leucadia IGCC



Leucadia Petcoke to Methanol & Hydrogen ICCS - Louisiana

- Pre-combustion: IGCC - Methanol & Hydrogen
 - 700 MM gal methanol, 1.10 MMscfd Hydrogen
 - 89% CO₂ capture (pre-combustion), 4.5 MMT - EOR
 - Total Project: \$436 million; DOE share: \$261 million
- Engineering & design**
Securing financing
Project on hold



CCUS Demonstration Projects

Complex billion \$ projects that rely on subsidies & product off-take agreements to offset commercial & policy risk.

Southern Co. IGCC

Southern Company CCPI - Mississippi

- Pre-combustion; IGCC - Power Generation
- 582 MW power
- 67% CO₂ capture (Selexol® process), 3.0 MMT - EOR
- Total Project: \$1.6 billion; DOE share: 70 million

Summit IGCC Polygen

Summit Texas Clean Energy CCPI - Texas

- Pre-combustion; IGCC - Polygeneration
- 300 MW power, 0.5 MMT Urea
- 90% CO₂ capture, 2.63 MMT - EOR
- Total Project: \$3.85 billion; DOE share: \$450 million

Hatch Energy Canada CCPI - Alberta

Hatch Energy Canada CCPI - Alberta

- Pre-combustion; IGCC - Polygeneration
- 300 MW power, 1.0 MMT Urea/Urea Ammonium Nitrate
- 90% CO₂ capture, 0.5 MMT - EOR
- Total Project: \$5.0 billion; DOE share: \$408 million

Leucadia IGCC

Leucadia Petrochemical Methanol & Hydrogen ICCS - Louisiana

- Pre-combustion; IGCC - Methanol & Hydrogen
- 700 MM gal methanol, 110 MMscfd Hydrogen
- 89% CO₂ capture (Rectisol®); 4.5 MMT - EOR
- Total Project: \$436 million; DOE share: \$261 million



Potential Regulatory Drivers for CCS



• Clean Power Plan – Proposed Rule

- 30% reduction in CO₂ emissions by 2030
- 1,100 lb CO₂/MWh gross - New Plant

• UIC Class VI – Underground Injection of CO₂

• Global Warming Solutions Act of 2006 (AB-32)

- GHG Emissions at 1990 levels by 2020
- GHG emissions 80% below 1990 level by 2050
- Allowance, offset, cap, and trade program
- **No offset program category for CCS**



• Regional Greenhouse Gas Initiative (RGGI)

- 83 MMT cap in 2014
- 2.5% per year reduction from 2015-2020
- Allowance, offset, cap, and trade program
- **No offset program category for CCS**

RGGI Inc.



Potential Regulatory Drivers for CCS

Comprehensive federal regulatory or legislative policies are needed to stimulate deployment of Carbon Capture & Storage.

• Clean Power Plan – Proposed Rule

- 32% reduction in CO₂ emissions by 2030
- 1,100 lb CO₂/MWh for new plants

• UIC Class VI – Underground Injection of CO₂

• Global Warming Solutions Act of 2006 (AB-32)

- GHG Emissions at 1990 levels by 2020
- GHG Emissions 50% below 1990 levels by 2050
- Allowance, offset, cap, and trade program
- No offset program category for CCS

• Regional Greenhouse Gas Initiative (RGGI)

- 83 MMT cap in 2014
- 2.5% per year reduction from 2015-2020
- Allowance, offset, cap, and trade program

- No offset program category for CCS



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RGGI Inc.

Financial Drivers for CCS Projects



• Clean Coal Power Initiative (CCPI-3)

- \$1.4 billion – 6 projects
- 4 projects remaining

• Industrial Carbon Capture & Storage (ICCS)

- \$1.3 billion – 3 projects
- 2 projects remaining

• Loan Guarantee Program - Advanced Fossil Energy

- \$8.0 billion
- Accelerate deployment of clean fossil energy technologies

• 45Q Tax Credits for CCS & EOR

- \$20 MT Geologic Storage (\$31 rev.)
- \$10 MT Enhanced Oil Recovery (\$16 rev.)
- **75 MMT Cap - first come first serve basis**

• 48A/B Advanced Coal Investment Credits

- 15-20% on investment in tax year
- **\$1.65 billion Cap - first come first serve basis**





Financial Drivers for CCS Projects

Increased federal subsidies or other policies are needed to stimulate deployment of Carbon Capture & Storage.

• Clean Coal Power Initiative (CCPI-3)

- \$1.4 billion – 6 projects

• Industrial Carbon Capture & Storage (ICCS)

- \$1.3 billion – 3 projects

• Loan Guarantee Program - Advanced Fossil Energy

- \$8.0 billion
- Average deployment of Clean Coal and other technologies

• 45Q Tax Credits for CCS & EOR

- \$20 MT Geologic Storage (\$21 rev.)
- \$20 MT Enhanced Oil Recovery (\$16 rev.)
- 75 MMT Cap - first come first serve basis

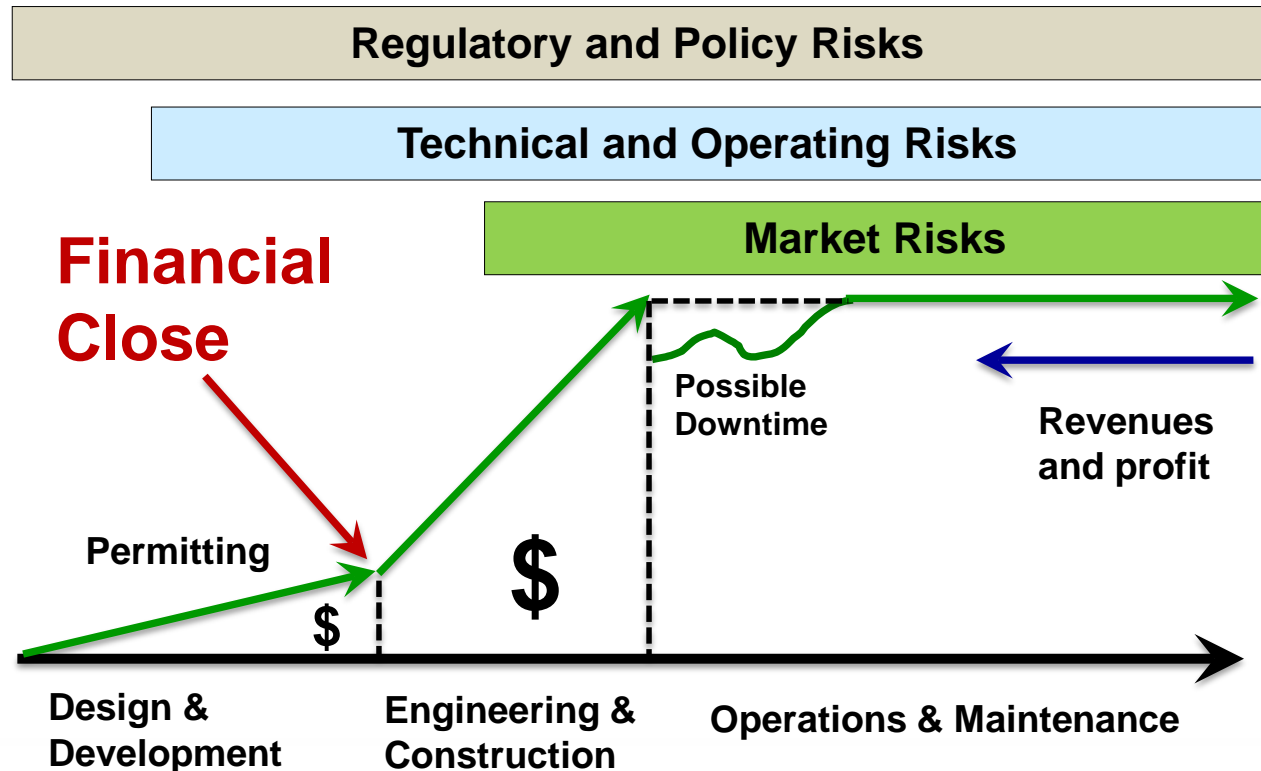
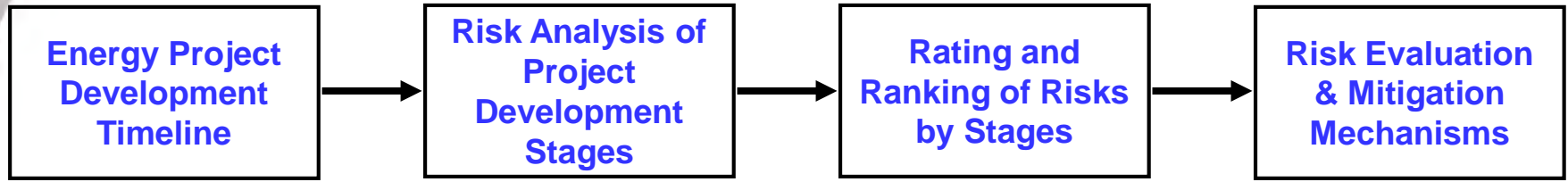
• 48C/B Advanced Coal Investment Credits

- 15-20% on investment in tax year
- **\$1.65 billion Cap - first come first serve basis**





Commercial Risk Framework





Commercial Risk Framework

Creditors will demand a comprehensive commercial risk analysis within a project finance framework.

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commercial risk analysis within a project finance framework.

analysis within a project finance framework.

project finance framework.

framework.



Hurdles to Achieve Financial Closure



- Project Complexity
 - FEED & System Integration
 - Performance Guarantees
 - Capital Cost Estimate



- Contracts & Agreements
 - Power Purchase
 - Product Off-take
 - Engineering, Procurement, & Construction

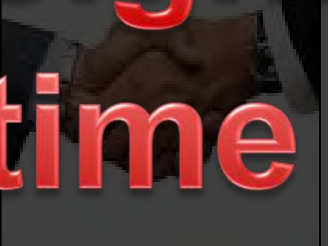


- Environmental Permits
 - Air, Water, & Waste Permits
 - UIC Class VI Permit – Geologic Storage
 - UIC Class II Permit - EOR



Hurdles to Achieve Financial Closure

Project developers will have to expend a significant amount of time and capital to achieve financial closure.



Project Complexity

- FEED & System Integration
- Performance Guarantees
- Capital Cost Estimate

Contracts & Agreements

- Power Purchase
- Product offtake
- Engineering, Procurement, & Construction

Environmental Permits

- Air, Water, & Waste Permits
- UIC Class VI Permit – Geo Storage
- UIC Class II Permit - EOR

Construction Related Risks



- Labor Force
 - Availability
 - Productivity
 - DBA Compliance & Costs



- Materials & Equipment
 - Long lead time
 - Source & quality of materials



- EPC Contractor
 - Engineering errors & omissions
 - Non-performance & rework
 - Delays & cost overruns
- Commissioning and Start-up Activities



Construction Related Risks

Significant upfront engineering, contracting, and construction planning are required to reduce cost escalation.

- Labor Force
 - Availability
 - Productivity
- DBA Compliance & Costs
- Materials & Equipment
 - Long lead time
 - Inconsistent quality of materials
- EPC Contractor
 - Insufficient experience
 - Non-performance and rework
 - Cost overruns
- Commissioning and Start-up activities





Environmental Related Risks



- Air, Water, & Waste Permits
- Underground Injection Control Permit
 - Site Characterization
 - Monitoring, Verification and Accounting
 - Post Injection Site Monitoring Period
 - Financial Responsibility
- Pollution and Liability Insurance
- Long Term Liability
 - Limits on Claims
 - Trust Fund
 - Transfer of Liability



Environmental Related Risks

Comprehensive long-term liability and stewardship frameworks are needed to stimulate Geologic Storage.

- Air, Water, & Waste Permits
- Underground Injection Control Permit
 - Site Characterization
 - Spilling Verification and Accounting
 - Post Injection Site Monitoring Period
 - Financial Responsibility
- Pollution and Liability Insurance
- Long Term Liability
 - Limit on Claims
 - Trust Fund
 - Transfer of Liability





Thank You!

Questions?

Industrial Carbon Capture and Storage Project:

- U.S. Department of Energy Award No. DE-FE-0001547
- Administered by the DOE's Office of Fossil Energy
- Managed by the National Energy Technology Laboratory
- DOE cost share from American Recovery and Reinvestment Act of 2009

Cost Share Agreements:

- Archer Daniels Midland Company
- University of Illinois through the Illinois State Geological Survey
- Schlumberger Carbon Services
- Richland Community College

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