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

UNFCC – CCUS Meeting
October 21, 2014
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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
ADM Company Profile

Core Purpose
Connecting the harvest to the home and transforming crops into products that serve vital needs for food and energy.

Key Facts
• Facilities: Over 700 with sales in 140 Countries
• FY 2013 Net Sales: $90 billion
• Employees: 31,000

Processing
• 74,000 MTD of corn
• 164,000 MTD of oilseeds
• 28,000 MTD of wheat
• 1,800 MTD of cocoa

Logistics
• 27,400 Rail cars
• 2,500 Barges
• 600 Trucks – 1,300 Trailers
• 52 Oceangoing vessels
Core Purpose
Corn, oilseeds, and wheat are transformed into products that serve vital needs for food and energy.

Key Facts
• Facilities: Over 700 with sales in 140 Countries
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Processing
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Logistics
• 27,400 Rail cars
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• 52 Oceangoing vessels

One of the largest logistic fleets in the world
CCUS Demonstration Projects

**Archer Daniels Midland ICCS - Illinois**
- Direct Capture - Ethanol Plant
- 350 MM gal Ethanol
- 90% CO$_2$ capture, 1.0 MMT - Geologic Storage, Saline Reservoir
- Total Project: $208 million; DOE share: $142 million

**FutureGen 2.0 CCDP - Illinois**
- Oxy-Combustion - Power Generation
- 175 MW power
- 90% CO$_2$ capture, 1.0 MMT - Geologic Storage, Saline Reservoir
- Total Project: $1.65 billion; DOE share: $1.0 billion

**The Petra Nova Carbon Capture CCPI - Texas**
- Post Combustion – Power Generation
- 240 MW power
- 90% CO$_2$ capture 1.6 MMT - Enhance Oil Production (EOR)
- Total Project: $469 million; DOE share: $167 million

**Air Products ICCS - Texas**
- Steam Methane Reforming - Vacuum Swing Adsorption
- 130 MMscfd Hydrogen
- 90% CO$_2$ capture; 1.0 MMT - EOR
- Total Project: $431 million; DOE share: $284 million

*Source: Proceedings of Freiberg IGCC & Pittsburgh Coal Conferences, 2014*
CCUS Demonstration Projects

**Archer Daniels Midland ICCS - Illinois**
- Permitted - Q3 2014
- Under construction - Q1 2015
- Direct Capture - Ethanol Plant
- 350 MM gal Ethanol
- 90% CO₂ capture, 1.0 MMT Geologic Storage, Saline Reservoir
- Total Project: $478 million; DOE Share: $142 million

**FutureGen 2.0 CCDP - Illinois**
- Permitted - Q3 2014
- Securing financing - 2017
- Oxy-Combustion - Power Generation
- 175 MW power
- 90% CO₂ capture, 1.0 MMT Geologic Storage, Saline Reservoir
- Total Project: $475 million; DOE Share: $1.0 billion

**The Petra Nova Carbon Capture CCPI - Texas**
- Permitted - Under construction - 2016
- Post Combustion - Power Generation
- 240 MW power
- 90% CO₂ capture, 1.0 MMT Enhanced Oil Production (EOR)
- Total Project: $512 million; DOE Share: $167 million

**Air Products ICCS - Texas**
- Permitted Operations - March 2013
- Over 1.1 MMT captured
  - Steam Methane Reforming - Vacuum Swing Adsorption
  - 130 MMscfd Hydrogen
  - 90% CO₂ capture, 1.0 MMT
  - Total Project: $311 million; DOE Share: $84 million

Source: Proceedings of Freiberg IGCC & Pittsburgh Coal Conferences, 2014
CCUS Demonstration Projects

Southern Company CCPI - Mississippi
- Pre-combustion; IGCC - Power Generation
- 582 MW power
- 67% CO₂ capture (Selexol® process), 3.0 MMT - EOR
- Total Project: $4.69 billion; DOE share: $270 million

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

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 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

Source: Proceedings of Freiberg IGCC & Pittsburgh Coal Conferences, 2014
CCUS Demonstration Projects

**Southern Company CCPI - Mississippi**
- Permitted
- Under construction
- Operations - Q4 2015
- Pre-combustion IGCC - Power Generation
- 582 MW power
- 67% CO₂ capture (RecStor), 3.0 MMT - EOR
- Total project: $269 million; DOE share: $1270 million

**Summit Texas Clean Energy CCPI - Texas**
- Engineering & design
- Securing financing
- Operations - 2019
- Pre-combustion IGCC - Polygeneration
- 200 MW power, 0.9 MMT Urea
- 90% CO₂ capture, 1.55 MMT - EOR
- Total project: $225 million; DOE share: $450 million

**Hydrogen Energy California CCPI - California**
- Engineering & design
- Securing financing
- Operations - 2020
- Pre-combustion IGCC - Polygeneration
- 300 MW power, 1.0 MMT Urea/Urea Ammonium Nitrate
- 90% CO₂ capture, 2 MMT - EOR
- Total project: $215 billion; DOE share: $408 million

**Leucadia Pet coke to Methanol & Hydrogen ICCS - Louisiana**
- Engineering & design
- Securing financing
- Project on hold
- Pre-combustion IGCC - Methanol & Hydrogen
- 700 MM gal methanol, 110 MMScf/d Hydrogen
- 89% CO₂ capture (RecStor), 4.5 MMT - EOR
- Total project: $1.35 billion; DOE share: $261 million

Source: Proceedings of Freiberg IGCC & Pittsburgh Coal Conferences, 2014
CCUS Demonstration Projects

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

Southern Co. IGCC
- 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

Summit IGCC Polygen
- Pre-combustion; IGCC - Methanol & Hydrogen
- 200 MW power, 0.9 MMT Urea/Ammonium Nitrate
- 89% CO₂ capture, 2.63 MMT - EOR
- Total Project: $3.85 billion; DOE share: $450 million

Summit Texas Clean Energy CCPI - Texas
- Pre-combustion; IGCC - Polygeneration
- 582 MW power, 1.69 MMT Urea
- 67% CO₂ capture (Selectol® process), 50 MMT - EOR
- Total Project: $1.62 billion; DOE share: $700 million

Hydrogen Energy California CCPI - California
- Pre-combustion; IGCC - Polygeneration
- 300 MW power, 1.0 MMT Urea/Ammonium Nitrate
- 85% CO₂ capture, 3.02 MMT - EOR
- Total Project: $5.0 billion; DOE share: $500 million

Leucadia IGCC
- Pre-combustion; IGCC - Methanol & Hydrogen
- 89% CO₂ capture (Rectisol®); 4.5 MMT - EOR
- Total Project: $436 million; DOE share: $261 million

Source: Proceedings of Freiberg IGCC & Pittsburgh Coal Conferences, 2014
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
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**
  - 30% reduction in CO₂ emissions by 2030
  - 1,100 lb CO₂/MWh at New Plant

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  - No offset program category for CCS
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
Increased federal subsidies or other policies are needed to stimulate deployment of Carbon Capture & Storage.

**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
  - Federal government of clean fossil energy technologies

- **45Q Tax Credits for CCS & EOR**
  - $20 MT Geologic Storage (111 rev.)
  - $10 MT Enhanced Oil Recovery (111 rev.)
  - 75 MMT Cap - first come first serve basis

- **48A/B Advanced Coal Investment Credits**
  - 10-20% on investment in tax year
  - $1.65 billion Cap - first come first serve basis
Commercial Risk Framework

- Energy Project Development Timeline
- Risk Analysis of Project Development Stages
- Rating and Ranking of Risks by Stages
- Risk Evaluation & Mitigation Mechanisms

- Regulatory and Policy Risks
- Technical and Operating Risks
- Market Risks

Financial Close

- Permits
- Revenues and profit

Timeline:
- Design & Development
- Engineering & Construction
- Operations & Maintenance

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

**Commercial Risk Framework**

- **Financial Close**
- **Permitting**
- **Design & Development**
- **Engineering & Construction**
- **Operations & Maintenance**

**Regulatory and Policy Risks**

**Technical and Operating Risks**

**Markets Risks**

**Risk Analysis of Project Development Stages**

**Rating and Ranking of Risks by Stages**

**Risk Evaluation & Mitigation Mechanisms**

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 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

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

- Labor Force
- Availability
- Productivity
- DBA Compliance & Costs
- Long lead time
- Inconsistent quality of materials
- EPC Contractor
- Engineering omissions
- Non-performance and rework
- Cost overruns

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

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

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

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