Scalability and Implementation of CCS with Bio-Feedstocks

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GLOBAL CHALLENGES – GLOBAL SOLUTIONS – GLOBAL OPPORTUNITIES
Comparative Evaluation of CCS with Biomass and Fossil Fuels

Fossil Fuels (inc. co-firing)  Biomass Feedstocks

- Large central power generating stations or industry
  - 100 to 1000 MW
  - (1-10 MT CO$_2$/year)
- Efficient and reliable fuel delivery systems
- Consistent fuel source
- Year-round 24/7 operations
- Potentially smaller scale power generation
  - 50 MW (1/10 size of fossil plants)
  - < 1 MT CO$_2$/year
- Significant scale-up and logistical issues with biomass delivery/storage
- Variable fuel sources
- Potentially variable operations depending on biomass feedstock availability
Some Key Issues for Large Scale Deployment of BECCS

• Availability of sustainably and reliably produced biomass feedstocks for 30-50 years
• Flue gas composition and capture options
• Co-location of geological storage resources with demand for electricity/heat and biomass resources
• Ability to cost-effectively scale (up/down) each element in the BECCS technology chain
Carbon Dioxide Capture and Sequestration Involves 4 Steps

1. Capture
2. Compression
3. Pipeline Transport
4. Geological Sequestration
Post-Combustion Capture

Air
Fuel

Boiler

Steam

Turbine
Electricity

Carbon dioxide + Nitrogen + Water

Chemical wash

Compressed and dehydrated

Nitrogen + Water

Transport and storage

$\text{CO}_2$ is captured after fuel has been burned

Image after ZEP
Pre-Combustion Capture

CO₂ is captured before fuel is burned

Image after ZEP
Oxyfuel-Combustion Capture

Air separation unit

Nitrogen

Air

Oxygen

Fuel

Boiler

CO₂ is captured during combustion

Turbine

Steam

Electricity

Recirculate to control boiler temperature

Carbon dioxide + Water

Transport and storage

Image after ZEP
Capture: Key Questions

• Which biomass sources are most amenable to capture?
  – What would the properties of a purpose-designed biomass source for BECCS?

• Which capture technology scales most cost-effectively?

• Which capture technology can best manage variable biomass feedstocks?

• Which capture technique will operate most reliably in the regions where BECCS will be deployed?
Carbon Dioxide Capture and Sequestration Involves 4 Steps

Capture → Compression → Pipeline Transport → Geological Sequestration
U.S. Existing and Planned CO$_2$ Pipeline Network

Currently transporting about 50 MT/year
Cost of Building Pipelines

Transport Cost Per Tonne of $CO_2$

Transportation: Key Issues

• Costs are highly scale dependent
  – Large returns with scale

• Long distance CO\textsubscript{2} transport unlikely without development of a common CO\textsubscript{2} pipeline system
  – Would help to piggyback on infrastructure developed for CCS with fossil fuels
Carbon Dioxide Capture and Sequestration Involves 4 Steps
CO₂ Sequestration Options

- Deep geological formations
  - Oil and gas
  - Coal
  - Saline aquifers
  - Basalts
  - Deep ocean sediments
- Oceans
  - Direct injection
  - Calcium bicarbonate formation
- Solids
  - Minerals
  - Cement
  - Other
Potential sequestration sites are broadly distributed around the globe.
Options for Geological Storage

Overview of Geological Storage Options

1. Depleted oil and gas reservoirs
2. Use of CO₂ in enhanced oil and gas recovery
3. Deep saline formations - (a) offshore (b) onshore
4. Use of CO₂ in enhanced coal bed methane recovery
## Global Sequestration Capacity Estimates

<table>
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<th>Region</th>
<th>Depleted Oil and Gas Reservoirs</th>
<th>Saline Formations</th>
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From KM13 GEA, 2012.
Basic Concept of Geological Sequestration of CO₂

- Injected at depths of 1 km or deeper into rocks with tiny pore spaces
- Primary trapping
  - Beneath seals of low permeability rocks

Image courtesy of ISGS and MGSC

Courtesy of John Bradshaw
How Do You Get CO$_2$ into the Ground?

- **Drill Rig**
- **Injection Well**
- **Wellhead**
- **Casing**
Seismic Monitoring Data from Sleipner

Monitoring

- Geophones
- Active Source Thermal Sensors
- Pressure Transducer
- Injection
- Well
- Wellhead Pressure
- Annulus Pressure
- Casing Logs
- CO$_2$ Sensors
- Flux Accumulation Chamber
- Flux Tower
- Walk Away VSP
- Injection Rate

Injection Well
Monitoring Well
Pressure Transducer
Geophones
Active Source Thermal Sensors
Storage: Key Issues

• In principle, no technical limitations to small scale storage

• But, major cost drivers are likely to be scale dependent (e.g. cost per tonne CO$_2$ will be greater for smaller projects)
  – Site characterization
  – Injection wells
  – Monitoring

• Institutional regulatory capacity to ensure and enforce safe and environmentally sound storage operations
Summary: Scalability of CCS

• BECCS influenced by issues of scale and implementation strategy
  – Capture
  – Transport
  – Storage
• CCS strategies and technologies tailored to bio-energy are needed
  – What are the most important areas to focus on?
• BECCS would benefit by taking advantage of a CCS infrastructure built to manage fossil fuel and industrial emissions
• Technology needs highly dependent on buildup of BECCS
  – Global biomass supply chain with large scale deployment
  – Local to regional biomass supply chain with small scale deployment