Carbon Capture & Sequestration in the California Context

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Overview

- Energy and carbon picture in California
- Goals of CA climate change legislation
- Role of CCS in meeting goals
- Work/projects to date on CCS in California
- Conclusions
Fossil fuels are major parts of the energy picture for California.

CCS is a potential application for reducing up to 45% of California’s emissions.
Carbon and energy flow across state boundaries

- Electricity imports into California
  - 22-32 % of electricity used
  - 39-57 % of GHG emissions

- Transportation fuels are exported to neighboring states—
  - 100% of Nevada’s
  - 60% of Arizona’s
  - 35% of Oregon’s

- Natural gas imports
California’s climate change mitigation policy

- Governor’s Executive Order, S-3-05, in 2005 established target GHG reduction levels:
  - 2000 GHG emissions levels by 2010
  - 1990 levels by 2020 (~436 million metric tons)
  - 80% below 1990 levels by 2050 (~97 million metric tons)

- Global Warming Solutions Act (AB 32) in 2006 put second goal into law

- AB 1925 in 2006 asked for recommendations to accelerate geologic sequestration of industrial CO₂

- SB1368 specified a GHG performance standard for long-term electricity contracts
The 2050 goal requires “HUGE” reductions, assuming moderate future growth: ~10 MMT/yr now; 14 MMT/yr if no action before 2015

From Schiller, 2007, CIEE
Work/projects to date on CCS in California

- Assessing CCS geologic potential (sources and sinks)
  - Statewide assessment
  - Detailed regional studies (CGS, Terralog)
- Establishing feasibility, process, and framework for widespread CCS
  - Technology development (discussed by other speakers)
  - Optimizing CCS components: NGCC study
  - Addressing barriers, gaps and ambiguities in existing regulations/policy
  - Public perception and education
- In demonstrating proof of concept
  - Pilots, First-of-kind industrial scale
California has large need and opportunity to deploy CCS

- California’s sedimentary basins are a large potential sequestration resource.
- NG power plants, refineries, and cement plants are largest CO2 sources.
- Numerous CCS projects are underway in the state.
The largest in-state point sources are natural gas power plants, cement plants, and refineries. 90% are within 50 km of a potential sequestration site.
Potential target formations in key regions are a focus of more detailed follow-up studies

- Isopach maps of target sand units
- Salinity
- Thickness of overlying seals
California also has potential sequestration resources offshore

- CA Geological Survey completed survey of offshore basins
- Terralog Technologies received ARRA funding to characterize Pliocene and Miocene Formations in the Wilmington Graben, Offshore Los Angeles,
- The Los Angeles Basin presents a very unique and special combination of high need and significant opportunity for large scale geologic storage of CO\textsubscript{2}.
CO₂ Capture & Storage Projects Consist of Three Domains (Systems)
Major technical areas relevant to storage component

- **Geology**
  - Lithological description
  - Geological correlations
  - Stratigraphic interpretations
  - Geological boundaries
  - Fracture and fault characterizations

- **Hydrogeology**
  - Conceptual model
  - Hydraulic properties
  - H measurements
  - K measurements
  - C measurements
  - Monitoring coverage
  - Transport properties

- **Geomechanics**
  - In-situ stress characterization
  - Fracture characterization
  - (Un)Drained geomechanical properties
  - Yield stresses
  - Injection pressures

- **Geochemistry**
  - Baseline geochemistry
  - Surface areas
  - Mineralogy
  - (Ad)Sorption
  - Chemical kinetics
  - Pressure, temperature
  - Scale of measurements

- **Delivery**
  - Integrity:
  - Completion
  - Injection interval
  - Leakage, seal
  - Cement alteration
  - Reliability of preexisting delivery pipe network

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**Geophysical Surveys, Surface and Subsurface Monitoring**

**Induced Seismicity, ± Subsidence, Leakage & Contamination, Health Risk & Safety**
Assessing options for California’s fleet of natural gas power plants: A systems analysis approach

**TECHNICAL & ENGINEERING EVALUATION**
- Capture Tech Suitability
- Source characteristics
- Gas separation efficiency
- Geological suitability
- Storage Characteristics
- Drilling (design & integrity)

**POLICY & REGULATIONS**
- Transport Options (optimal vs constraint)
- Safety (mitigation & control plans)
- Monitoring (pre-, during & post- GCS)

**COMMERCIAL SCALE EXECUTION**
- Value for Carbon
- Long-term Liability
- Indemnification
- Incentives
- Emissions Standards
- Pore Space
- Ownership
- Resource Protection
- Environmental Protection
- Climate change mitigation
- Health & Safety
- Community Impacts
- Economic Impacts
- Infrastructure Impacts
A complexity of agencies is involved in permitting for California projects

- **FEDERAL**
  - US EPA Region 9
  - US Army Corps of Engineers
  - US Fish and Wildlife Service
  - US Dept of Transportation
  - US Coast Guard

- **STATE**
  - California State Water Resources Board
  - California Dept of Fish and Game
  - Department of Toxic Substances Control
  - California Department of Transportation
  - California Public Utilities Commission
  - California Energy Commission
  - California Department of Conservation (DOGGR)

- **REGIONAL**
  - Area Air Quality Management Districts
  - Bay Conservation and Development Commission
  - Regional Water Quality Management District

- **LOCAL**
  - City or County Planning Commissions
  - Other county/city departments
California Carbon Capture and Storage Review Panel

- Formed in 2010 by the Energy Commission, California Public Utilities Commission, and the Air Resources Board
- Other state agencies interested and involved in the issue are the California Department of Conservation and the California State Water Resources Control Board
- Panel is to review carbon capture and storage (CCS) policy and develop recommendations that could help guide legislation and regulations regarding CCS in California
- CCS has been identified as a potential strategy in reducing greenhouse gas emissions from major industrial sites
- Held meetings in April and May; report of Panel recommendations scheduled for completion by end of 2010
Outreach and Education

- Public meetings, teacher workshops, and presentations at conferences
- Project-specific pages and drilling coverage on www.westcarb.org
- IEPR and AB 1925 reports to Legislature
- “Best practices” manuals with other DOE regional partnerships
Risk perception and awareness of CCS technology affect public acceptance

- Surveys show public’s greatest concerns are
  - Harm or damage to people, the environment, or property by leakage of CO$_2$
  - Accountability/stewardship over long time scales

- Other stakeholder risks
  - Induced seismic or brine migration from saline formations
  - Climate-change risk from cumulative slow leakage of CO$_2$ to the atmosphere

http://www.swri.org/4org/d20/home/what/subsurf.htm
Kimberlina

- Candidate site for WESTCARB development phase (Phase III) project
- Clean Energy Systems (CES) plans expansion from existing 5 megawatt (MWe) pilot ZEPP plant to 170 megawatts thermal (MWth)
- ZEPP power plant will use oxy-combustion technology (and initially fire natural gas) and produce a relatively pure stream of CO$_2$
- Plant would emit 227,000 metric tons of CO$_2$ per year.
- Injection would take place in the Vedder sandstone, a saline formation at a depth of about 7,000 feet
Projects in Solano County

• Projects:
  - C6’s Northern California CO2 Reduction Project (ARRA, ICCS)
  - WESTCARB CO2 Storage Pilot (DOE, NETL)
  - WESTCARB Phase III candidate site (DOE, NETL)

• Objective is to capture and transport by pipeline approximately one million tons per year of CO2 streams from industrial facilities located in the Bay Area

• Injection target is more than two miles underground in a saline formation

• Suite of projects is a staged collaboration with Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory which includes pilot and demonstration phases prior to commercial-scale injection.
Hydrogen Energy California (HECA) plans to build a solid-fuel power plant with CO$_2$ capture and beneficial use for EOR

- Petcoke and coal gasification will provide hydrogen for 250 MW of electric power generation
- About 2 million tons of CO$_2$/yr will be captured and piped to Occidental’s Elk Hills Field for EOR
- Planned operation by 2015
- ARRA-CCPI funding
- Project uses proven technology in all components (plant, capture, transmission, transport, injection, monitoring)
Calera Beneficial Use Project (ARRA, ICCS)

- Patented process converts captured CO$_2$ to green building products
- Pilot 5 ton/day with plans to scale-up to 1000 ton/day demo

Moss Landing Power Station
>1000 MW
Fuel: Natural Gas
Operator: Dynegy

Moss Landing Cement Co.

5 million tonnes of mineral waste

Courtesy of Calera
Conclusions

- Significant range of CCS activities happening in California
- No project has yet injected CO₂
- California geology and source locations favor widespread CCS deployment, but further regional and detailed studies are needed to reduce subsurface uncertainty
- CCS project statutory and regulatory uncertainty remains high
  - CCS Review Panel and similar interagency efforts can lead to new policy that will reduce these areas of risk
  - A major issue that creates regulatory, statutory and potentially financial barriers for projects is an absence of protocols that allow CCS (geologic or beneficial use) projects to receive “credit” for sequestered CO₂
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