Geological Formations in the San Joaquin Valley -- Potential for Carbon Sequestration

Dr. Jan Gillespie
California State University Bakersfield
Target formations for CO$_2$ storage
Figure 2. Schematic diagram of petroleum generation, migration, and accumulation. Redrawn from a copyrighted diagram by ExxonMobil presented by the American Geological Institute in the Earth Science World Image Bank (as image h5inrc) at http://www.earthscienceworld.org/images/index.html; used with permission.
At the depths of most conventional oilfields, CO2 will have a similar density to oil and it can dissolve in either oil or water.
There are a great number of different types of traps to prevent oil and gas from reaching the surface.
In the absence of a trap, there is a greater likelihood that CO2 may reach the surface.
Status of Sedimentary Basins in California

LEGEND:
- Sedimentary Basin Status:
  - Baseline with Carbon Sequestration Potential
  - Baseline Lacking Carbon Sequestration Potential

Other Layers:
- Natural Gas Field
- Oil Field
- County Boundary

Central Valley
Sacramento Basin
San Joaquin Basin
Kern County produces 76% of California’s oil and 60% of its gas

( CA DOGGR 2007 Annual Report)
Data Sources

- WESTCARB GIS Database – California Oilfields and Power Plants
- California DOGGR – Cumulative oil production from each reservoir in each oilfield, oilfield water salinities, temperatures, average depths and formation volume factors.
USGS criteria for carbon storage

- 3000 feet minimum depth

Burruss et al., 2009
Figure 4. Pressure-temperature diagram of the phase behavior of CO$_2$ showing the liquid-vapor coexistence curve terminating in the critical point. At pressures and temperatures higher than this point, CO$_2$ is a fluid with variable density commonly referred to as a supercritical fluid. The vertical bar to the left of the pressure axis shows the approximate depth in feet for a hydrostatic pressure gradient. The red line labeled 25°C/km shows the pressures and temperatures in the subsurface for this thermal gradient and a hydrostatic pressure gradient.
Kern County oil and gas fields over 3000 feet deep
USGS criteria for carbon storage

- 3000 feet minimum depth
- Formation water salinity greater than 10,000 ppm Total Dissolved Solids (TDS) (based on US EPA guidelines)

Burruss et al., 2009
Deep Kern Oil and Gas fields with salinities over 10,000 ppm
USGS criteria for carbon storage

- 3000 feet minimum depth
- Formation water salinity greater than 10,000 ppm Total Dissolved Solids (TDS) (based on US EPA guidelines)
- Minimum storage size 12.5 MM Bbls (equivalent to 1 to 1.4 MM metric tons of CO₂)

Burruss et al., 2009
Cumulative production calculations

- Used only oil production (DOGGR 2007) — did not consider produced water or gas.
- Corrected volume of produced oil for shrinkage
  -- Used formation volume factors from DOGGR reports to convert produced oil from surface barrels (Stock Tank Barrels) to reservoir barrels
1 reservoir bbl of oil and dissolved gas

1 surface bbl of oil

Gas that has come out of solution in the produced oil
Fields meeting depth, salinity and cumulative production criteria

Target Fields Cumulative Oil Production
Reservoir barrels

- 13,590,059 - 200,000,000
- 200,000,001 - 400,000,000
- 400,000,001 - 600,000,000
- 600,000,001 - 800,000,000
- 800,000,001 - 1,000,000,000
Guidelines for miscible CO$_2$ floods

- API = >28° and depths greater than 3300 ft
- API = 22-28° and depths greater than 4000 ft
- API < 22 fails miscible CO$_2$ screening

Taber et al. (1997)
Target Fields with API gravity greater than 22
Temblor Fm.
~512,291,000 Reservoir Bbls.
in the target fields
Legend

Producing Formations

Prod_Fm

- Chanac
- Kreyenhagen
- Monterey
- Reef Ridge
- Santa Margarita
- Temblor
- Vedder

Vedder Fm.
Vedder Fm.
~422,877,000 Reservoir Bbls.
in the target fields
Monterey Fm. (primarily Stevens Sand)

~2,043,686,000 Reservoir Bbls.
in the target fields
California CO$_2$ Emissions

- 103.7 MM metric tons/yr (DOE NETL NATCARB Atlas, 2008)
- 16.2% from electricity generation with most of this coming from oil and gas powered plants (Benson, 2001)
- 82% of these emissions come from plants generating over 50 MW (Benson, 2001)
Kern County CO₂ Sources and Potential Sinks

Most of the target fields are within 10 miles of a CO₂ emission source.
CO$_2$ generation and storage capacity in Kern County

- Power plants in the San Joaquin Valley portion of Kern County produce about 17 MM tons of CO$_2$/yr (WESTCARB GIS Database)
- Target fields have a total cumulative oil production of 3.2 Bbbls (reservoir bbls)
- Burrus et al. (2009) note that 12.5 MM bbls of reservoir pore space can accommodate 1 to 1.4 MM metric tons of CO$_2$
- Therefore, the target reservoirs should be able to accommodate at least 250 MM tons of CO$_2$ and provide about 15 years of storage potential at current emission rates.
Conclusions

- At least twenty three fields in the Kern County portion of the San Joaquin Valley meet the criteria for CCS as established by the USGS.
- All but two of the 23 fields have potential for miscible CO$_2$ enhanced oil recovery programs.
- The main subsurface targets for CCS are the Temblor, Vedder and Monterey formations.
- At a minimum, the 23 fields can store at least 250 MM tons of CO$_2$. At current annual rates, this would supply 15 years of Kern power plant emissions.