Too much carbon in our atmosphere? Carbon sequestration – One option

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Ramón H. Treviño

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Too Much Carbon in Our Atmosphere?
Carbon Sequestration - One Option

Ramon H. Treviño
Gulf Coast Carbon Center, Bureau of Economic Geology
Jackson School of Geosciences, The University of Texas at Austin
www.gulfcoastcarbon.org

Bureau of Economic Geology - 100 Years of Scientific Impact
Gulf Coast Carbon Center (GCCC)

www.gulfcoastcarbon.org

Director Scott Tinker

GCCC Team:
Ian Duncan, Sue Hovorka, Tip Meckel, J. P. Nicot,
Jeff Paine, Becky Smyth, Changbing Yang, Katherine Romanak+
post-docs and students
Overview

• Climate Change Challenges / Dangers

• Carbon Emissions – Societal / Personal

• Potential Options / Solutions

• One Option = Carbon Sequestration (Geologic Storage)
Overview

• *Climate Change Challenges / Dangers*

• Carbon Emissions – Society / Personal

• Potential Options / Solutions

• One Option = Carbon Sequestration (Geologic Storage)
Greenhouse Gas Emissions Regional Risks

- Southeast US Vulnerabilities
  - Increased Hurricane Landfalls (Number? Intensity?)
  - Risk of tropical species invasion
  - Low Relief Coastline – Inundation
Overview

• Climate Change Challenges / Dangers

• *Carbon Emissions – Societal / Individual*

• Potential Options / Solutions

• One Option = Carbon Sequestration
US Carbon Emissions Per Person

19.8 metric tons CO$_2$ per person/year

376,000 cubic feet as gas

X 1000

Costs about $1000 each
Store your CO₂ as wood

8 ft

4 ft

55% CO₂ = 34 cords
Where is your CO₂ coming from?

19.8 metric tons total CO₂ per person emissions
12.6 metric tons from electricity

Electronics

In Texas, Air conditioning

Utilities, lights, water
CO₂ from Transportation

Driving (8 kg CO₂/gallon gasoline)
Flying
Busses
Trains

Greenpeace International's CO₂ emissions for 2007 showed a 9.8% reduction from our 2006 emissions.
Overview

• Climate Change Challenges / Dangers

• Carbon Emissions – Society / Personal

• *Potential Options / Solutions*

• One Option = Carbon Sequestration
How Do Emissions Reduction Methods Stack Up?

*Achieving all targets is very aggressive, but potentially feasible.*

**EIA Base Case 2007**

<table>
<thead>
<tr>
<th>Technology</th>
<th>EIA 2007 Reference</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Load Growth ~ +1.5%/yr</td>
<td>Load Growth ~ +1.1%/yr</td>
</tr>
<tr>
<td>Renewables</td>
<td>30 GWe by 2030</td>
<td>70 GWe by 2030</td>
</tr>
<tr>
<td>Nuclear Generation</td>
<td>12.5 GWe by 2030</td>
<td>64 GWe by 2030</td>
</tr>
<tr>
<td>Advanced Coal Generation</td>
<td>No Existing Plant Upgrades</td>
<td>150 GWe Plant Upgrades</td>
</tr>
<tr>
<td></td>
<td>40% New Plant Efficiency by 2020–2030</td>
<td>46% New Plant Efficiency by 2020; 49% in 2030</td>
</tr>
<tr>
<td>CCS</td>
<td>None</td>
<td>Widely Deployed After 2020</td>
</tr>
<tr>
<td>PHEV</td>
<td>None</td>
<td>10% of New Vehicle Sales by 2017; +2%/yr Thereafter</td>
</tr>
<tr>
<td>DER</td>
<td>&lt; 0.1% of Base Load in 2030</td>
<td>5% of Base Load in 2030</td>
</tr>
</tbody>
</table>

Solutions Must Work for Other People Also
Overview

• Climate Change Challenges / Dangers

• Carbon Emissions – Society / Personal

• Potential Options / Solutions

• One Option = Carbon Sequestration
What is Geologic Sequestration (Storage)?

To reduce CO₂ emissions to atmosphere from point sources...

Capture / concentrate high pressure fluid

Ship - pipeline

Inject & isolate (from water)

Store (rock pore space) - Geologically significant time
Geologic Sequestration
Ready to go?

• *Subsurface volumes adequate?*

• Storage security adequate?

• Whole system mature enough?
  – pipeline
  – well construction
  – permitting
Assessing Subsurface Volumes Adequacy: The Value of Compression

- At depths >800 m CO₂ stored as dense phase fluid
- (1 metric ton = about 1.6 cubic m)
What is Known about Storage Capacity?

- Storage volume abundant
- Microscopic spaces (pores) between grains
- Sedimentary rocks
- Now filled with brine (or locally oil or gas)

Sandstone thin section photomicrograph, Frio Fm.
Blue areas were completely filled with brine
Now 10-30% filled with CO₂
Subsurface Volumes – Map View

See also http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasII/

- Power Plants
- Pure CO₂ sources
- Oil and Gas (USGS)
- Coal (USGS)
- Brine Aquifer > 1000m

Completed small tests
Underway tests
Planned large tests
Geologic Sequestration
Ready to go?

• Subsurface volumes adequate?

• Storage security adequate?

• Whole system mature enough?
  – pipeline
  – well construction
  – permitting
Is this safe?

Substitute underground injection for air release

Escape of brine or CO₂ to groundwater, surface water, or air via long flowpath

Earthquake

Escape of CO₂ or brine to groundwater, surface water or air through flaws in the seal

Failure of well cement or casing resulting in leakage
## Current Techniques to Assure Safe CO₂ Injection

- CO₂ pipelines health and safety procedures
- Pre-injection characterization and modeling
- Isolate from Underground Drinking Water Sources
- Maximum allowable surface injection pressure (MASIP)
- Mechanical integrity testing (MIT) of engineered system
- Well completion / plug & abandonment standards
- Reservoir management
Assuring Security: Monitoring Options

- **Atmosphere**
  - Ultimate integrator but dynamic

- **Biosphere**
  - Assurance of no damage but dynamic

- **Soil and Vadose Zone**
  - Integrator but dynamic

- **Aquifer and USDW**
  - Integrator, slightly isolated from ecological effects

- **Above injection monitoring zone**
  - First indicator, monitor small signals, more stable.

- **In injection zone - plume**
  - Oil-field type technologies. Will not find small leaks

- **In injection zone - outside plume**
  - Assure lateral migration of CO$_2$ and brine is acceptable
GCCC Field Study Site – DOE Sponsor

Frío Test Site

- Pipelines for naturally occurring CO₂
- Natural CO₂ source
- CO₂-EOR candidate reservoirs
- Existing CO₂ pipelines
- Additional oil-production area with CO₂-EOR production and potential
- Major oil plays

0 100 200 miles
0 300 kilometers
Injection well

Observation well

Look down
5050 ft below ground
Looking at CO$_2$ underground
GCCC & SECARB Field Study Site

- Pipelines for naturally occurring CO₂
- Natural CO₂ source
- CO₂-EOR candidate reservoirs
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Cranfield Field
Gulf Coast Carbon Center (GCCC) Collaboration – Cranfield

- DOE-funded

- Southeast Regional Carbon Storage Partnership (SECARB)
  - Managed: Southern States Energy Board
  - Host: Denbury Resources, Inc.
    - Phase II “Stacked Storage” = EOR+Brine storage

- Phase III “Early” demonstration
Geologic Sequestration
Ready to go?

- Subsurface volumes adequate?

- Storage security adequate?

- Whole system mature enough?
  - pipeline
  - well construction
  - permitting
System Mature Enough to Proceed: Global CO₂ Injection Experience

From Peter Cook, CO₂CRC
Another GCCC Field Study Site

SACROC

- Pipelines for naturally occurring CO₂
- CO₂-EOR candidate reservoirs
- Existing CO₂ pipelines
- Natural CO₂ source
- Additional oil-production area with CO₂-EOR production and potential
- Major oil plays

Location: Texas, USA
KM currently operates SACROC and is providing much assistance with the project.

- ~140 Million Tons CO₂ (since 1972)
- ~60 Million Tons CO₂ Recovered

GCCC Research
Test for detectable CO₂ in groundwater

Rebecca Smyth BEG
Southwest Partnership
Led by New Mexico Tech / Utah
DOE / NETL
System Mature: US Gas Storage Experience

Slide from Sally Benson, LBNL
Geologic Sequestration (Storage) Ready

- Subsurface volumes adequate
- Available technology adequate / storage security
- Whole system (pipeline, well construction, permitting)
  - mature enough to proceed
- **Work Remaining – Current Research**
Geologic Storage of Carbon – Put it Back

Carbon extracted from coal or other fossil fuel…

Return into the Earth; whence it came
Gulf Coast Carbon Center

www.gulfcoastcarbon.org
Bureau of Economic Geology

• First organized research unit of
  The University of Texas at Austin
• State Geological Survey of Texas
• One of three units of the
  Jackson School of Geosciences
• Staff—140, which includes, 80 researchers
• Fossil energy
• Environment
• Outreach
• Advise State & Federal Government
• Maintaining collections for research
Bureau at UT Pickle Campus