Possibilities for CO_2 Sequestration and CO_2-Enhanced Oil Recovery in Louisiana

Presentation to

JonesWalker Briefing
The Carbon Emissions Continuum
LSU Center for Energy Studies
Baton Rouge, LA

By
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July 23, 2009

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Possibilities for CO_2 Sequestration and CO_2-Enhanced Oil Recovery in Louisiana

PRESENTATION OUTLINE

- Background for CO_2-EOR
  - U.S.
  - Louisiana
- GHG Regulation (Carbon Capture & Storage) as a Source of CO_2
- Combining CO_2 Sequestration with CO_2-EOR
- Summary Remarks
- Questions/Discussion

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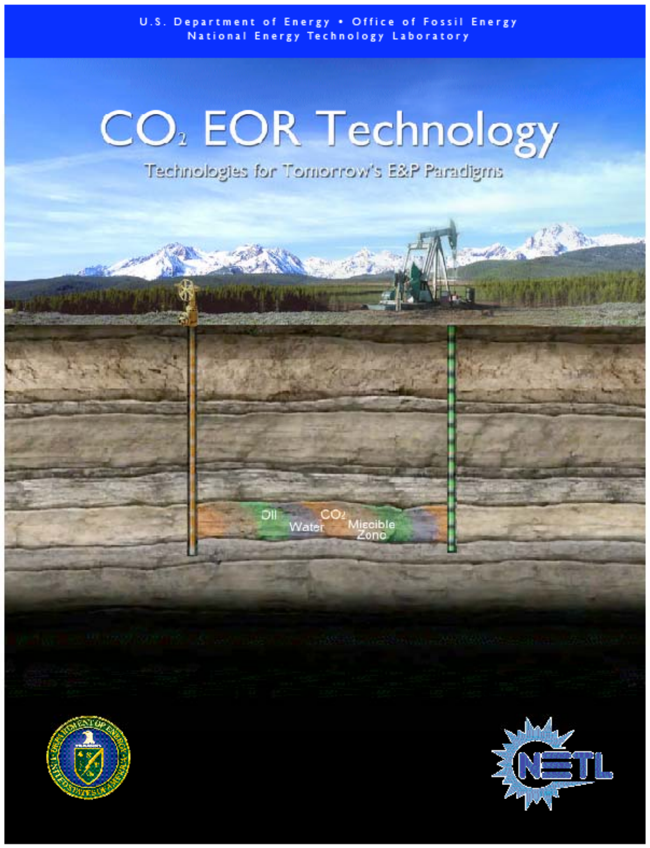
CO_2-Enhanced Oil Recovery (CO_2-EOR)



Large Volumes Of Domestic Oil Remain "Stranded" After Traditional Primary/Secondary Oil Recovery

Original Oil In-Place: 596 B Barrels*

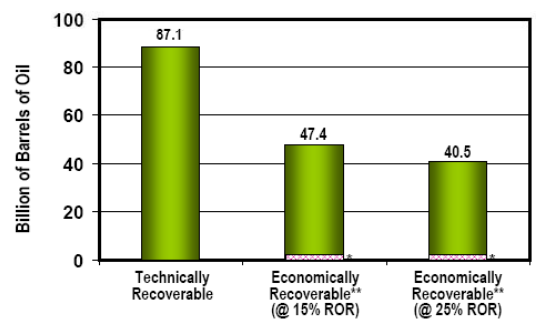
"Stranded" Oil In-Place: 400 B Barrels*

*Based on field-by-field assessment of over 2,011 large U.S. oil fields accounting for 74% of domestic oil production; excludes deep-water GOM.
Source: Advanced Resources International (2008)

May 6, 2008

Advanced Resources International

Economically Recoverable w/CO_2-EOR



*Already produced or place into proved reserves with CO2-EOR.
**Assuming oil price of $70/B (real); CO2 costs (delivered to field at pressure) of $45/metric ton ($2.38/Mcf); investment hurdle rate (15% and 25% ROR, real).

May 6, 2008

Advanced Resources International

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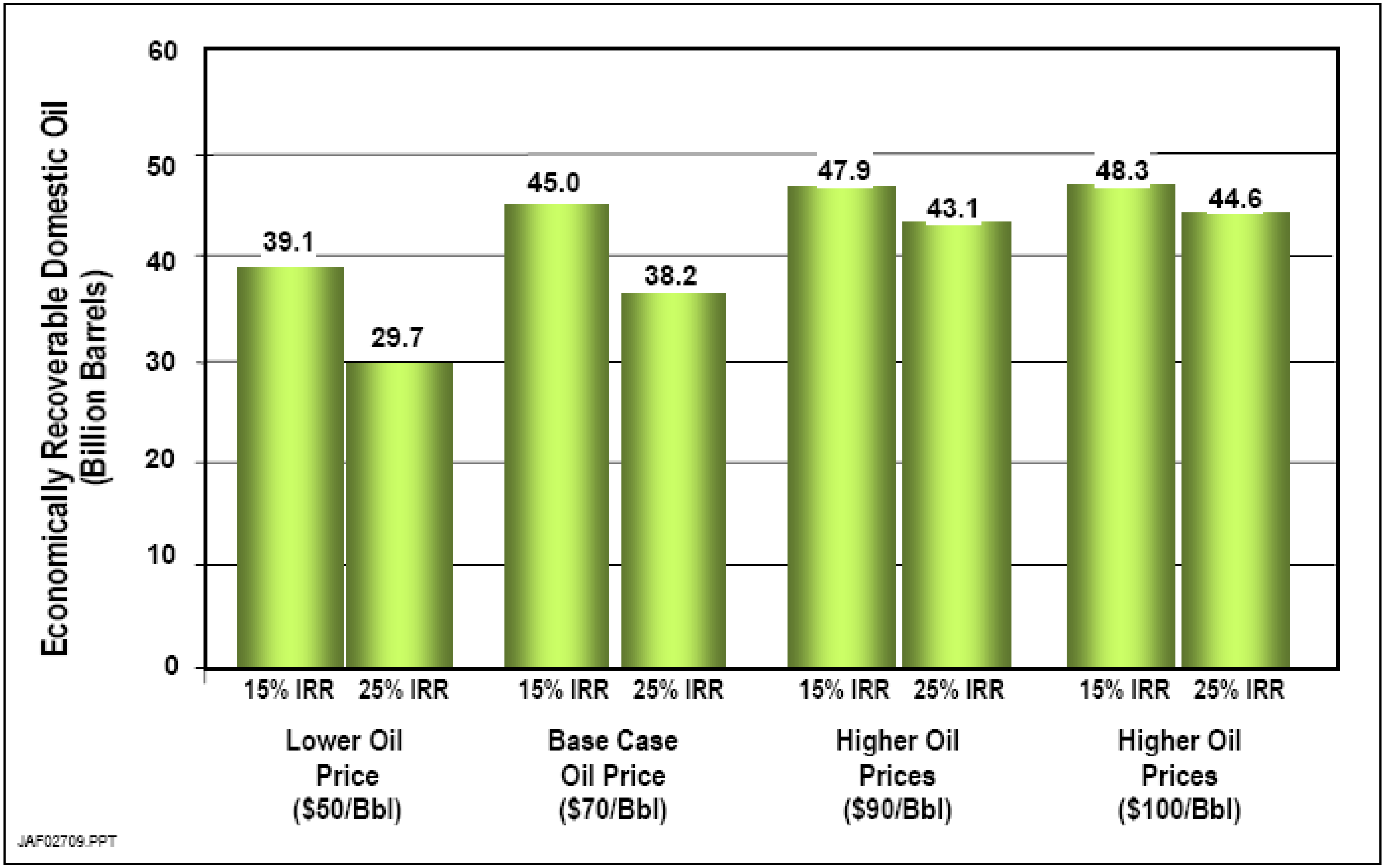

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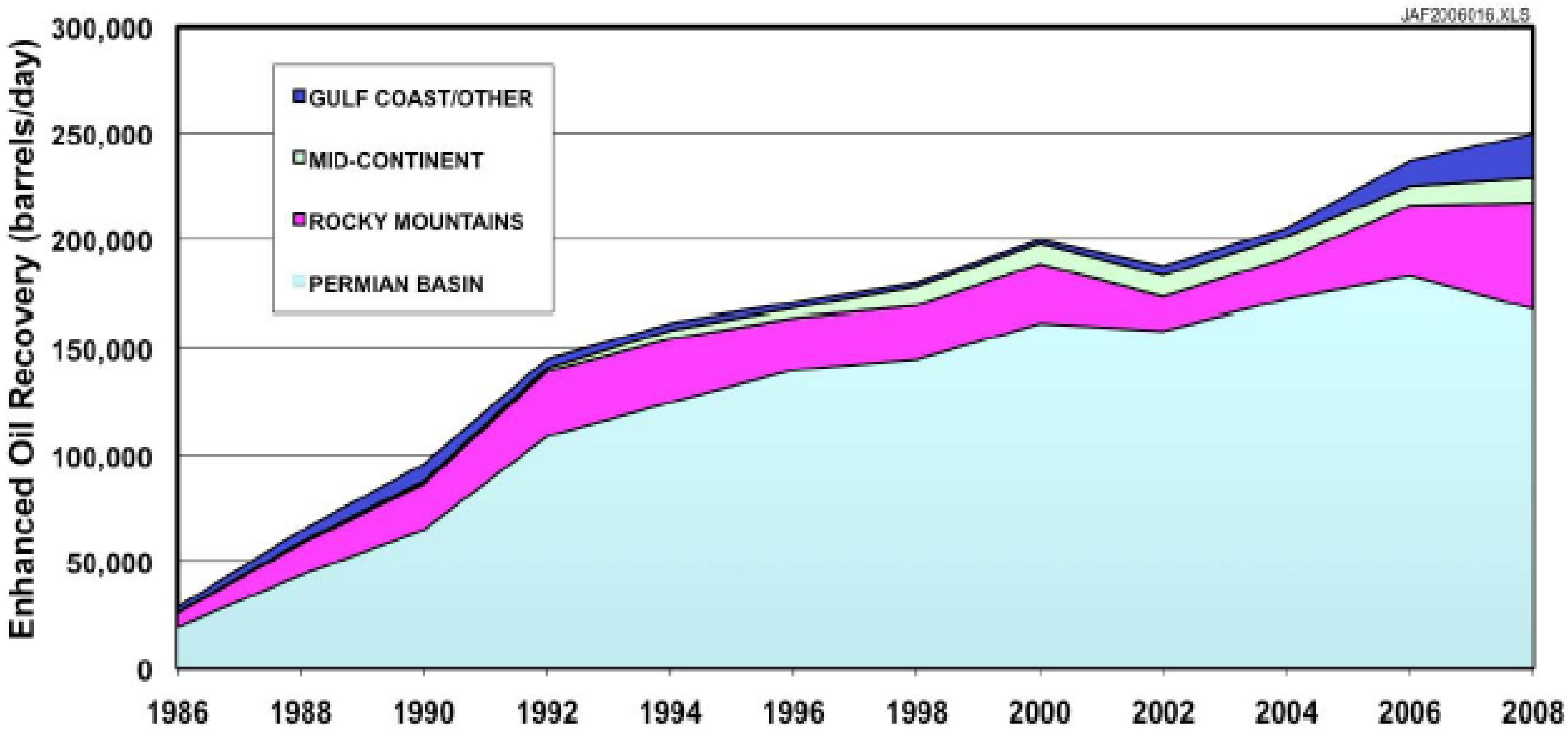
Growth of CO_2-EOR Production in the U.S.



Oil and Gas Journal, 2008.

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ALTERNATIVE ENERGY DEVELOPMENTS

Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)

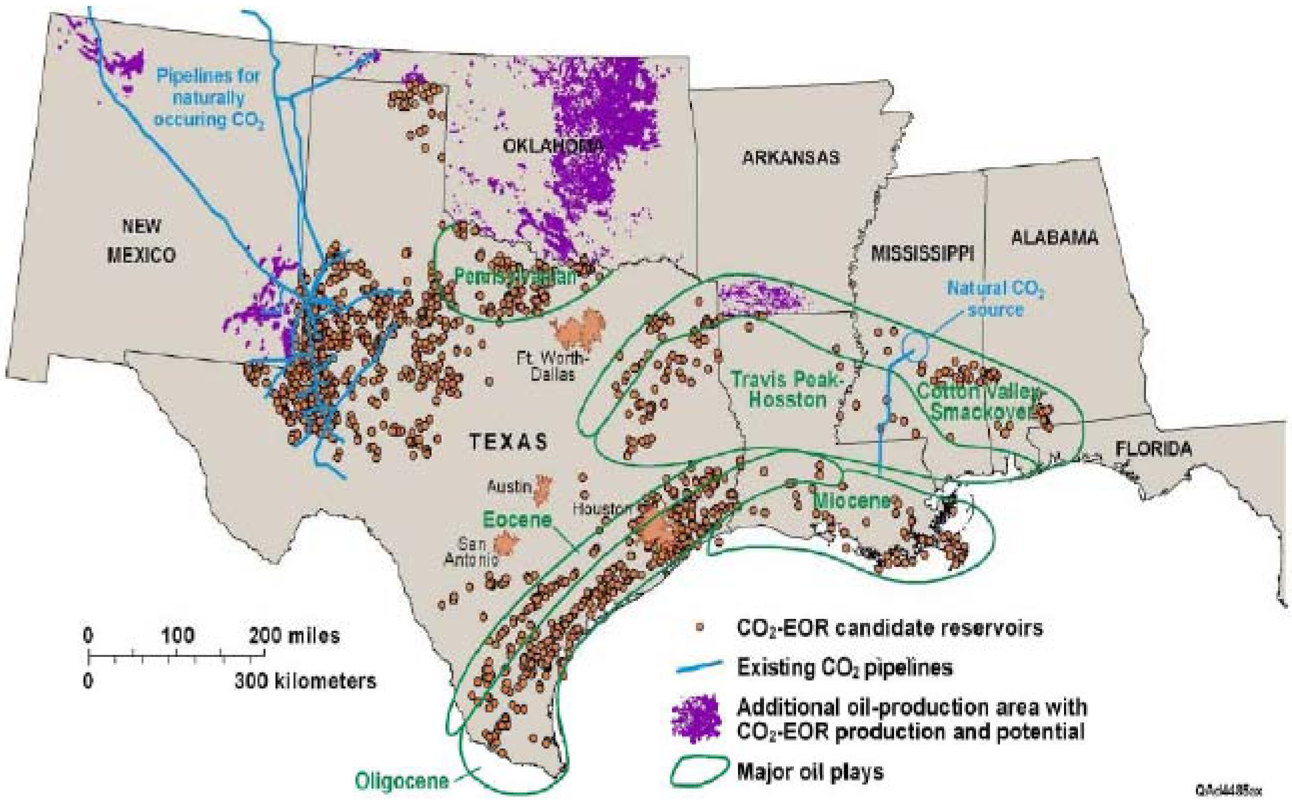

Figure 21 Areas with miscible CO_2 –EOR Potential [[8]]

Source: Pone & Kim (2006)

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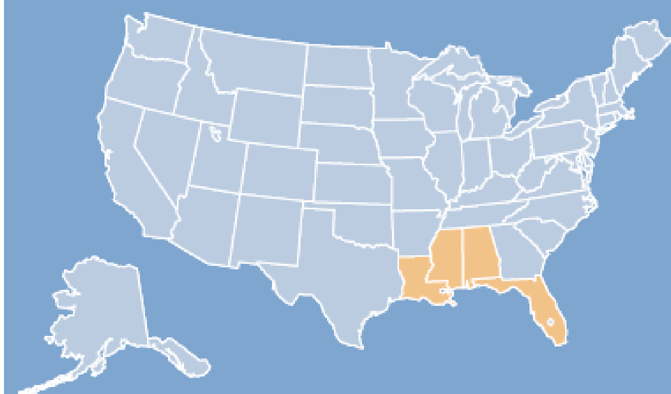
ALTERNATIVE ENERGY DEVELOPMENTS

Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)

BASIN ORIENTED STRATEGIES FOR CO_2 ENHANCED OIL RECOVERY:

ONSHORE GULF COAST



Prepared for
U.S. Department of Energy
Office of Fossil Energy – Office of Oil and Natural Gas

Prepared by
Advanced Resources International

February 2006

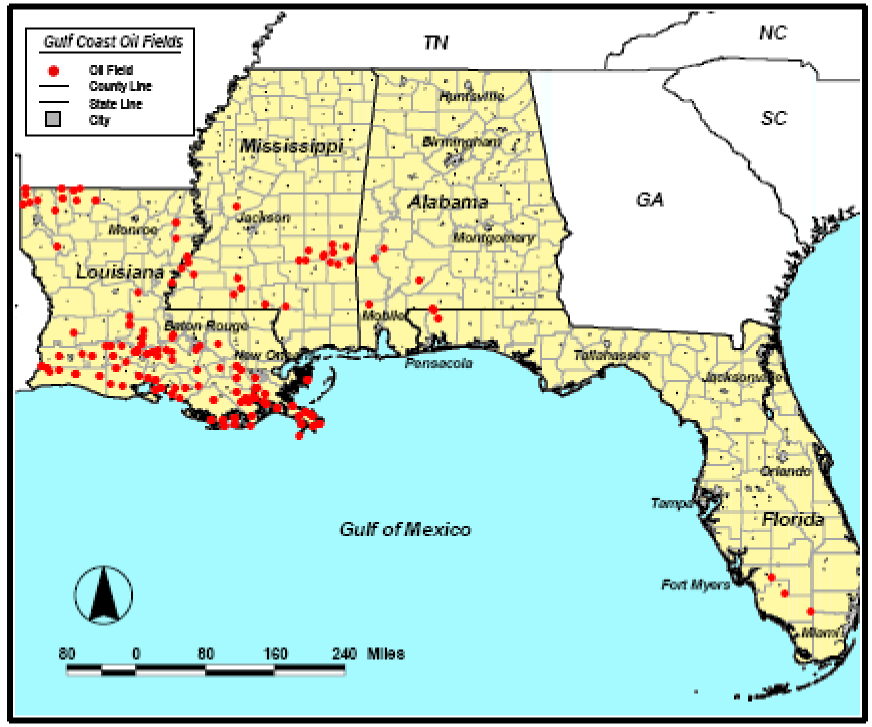


Table 2. The Gulf Coast Region's "Stranded Oil" Amenable to CO_2-EOR

Region	No. of Reservoirs	OOIP (Billion Bbls)	Cumulative Recovery/ Reserves (Billion Bbls)	ROIP (Billion Bbls)
Louisiana	128	16.1	6.7	9.4
Mississippi	20	1.9	0.7	1.2
Alabama	5	0.8	0.3	0.5
Florida	5	1.3	0.5	0.8
TOTAL	158	20.1	8.2	11.9

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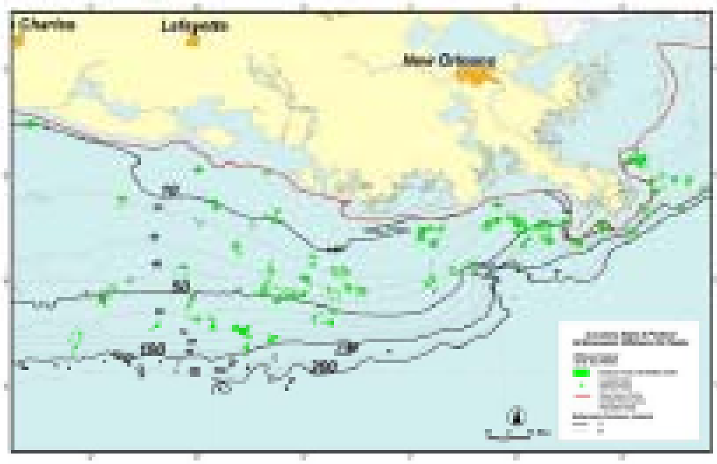
ALTERNATIVE ENERGY DEVELOPMENTS

Unconventional Energy : CO_2-Enhanced Oil Recovery (CO_2-EOR)



Offshore Louisiana Fields with Future Incremental Oil Recovery Potential

Estimates of Technical Recoverable Oil Resources in the Louisiana Offshore

	No. of Fields	OOIP (MM Bbls)	Technically Recoverable (MM Bbls)
State Offshore	12	1,100	237
Federal Offshore	87	20,960	4,213
Total	99	22,060	4,450

Economic Benefits of Producing Incremental Oil from CO_2-EOR

Assuming that 3.6 billion barrels are developed over a 40-year time frame, by 2025 this would amount to:

- Incremental crude oil production of 200,000 to 250,000 barrels per day
- Over 6,000 jobs retained by the Louisiana oil and gas industry
- Increased economic activity in Louisiana amounting to over $500 million per year
- Increased state and federal revenues of over $250 million per year.

BASIN ORIENTED STRATEGIES FOR CO_2 ENHANCED OIL RECOVERY:

OFFSHORE LOUISIANA

Prepared for:
U.S. Department of Energy
Office of Fossil Energy – Office of Oil and Natural Gas

Prepared by:
Advanced Resources International, Inc.

March 2005

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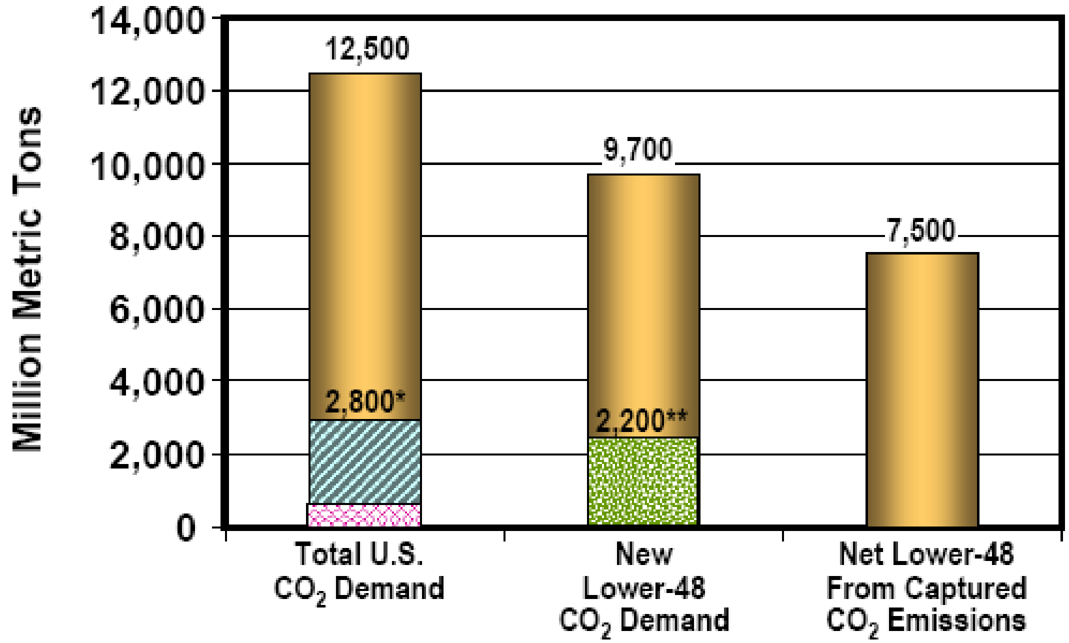
Market Demand for CO_2 by the Enhanced Oil Recovery Industry[(1)]



*CO_2 demand being met by on-going CO_2-EOR projects and CO_2 demand in Alaska.
**CO_2 demand that can be met by natural CO_2 and already being captured CO_2 emissions.
(1) Economic CO_2 market demand for EOR at oil price of $70/B (real), CO_2 cost of $45/mt, and ROR of 15% (real).

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CLIMATE LEGISLATION UPDATE

Administration

Obama and congressional leaders have goal to pass a new climate law before the Climate Conference in Copenhagen in December.

U.S. House

- Last year the primary climate legislation bill (Lieberman-Warner, S. 2191) failed in the Senate
- This year climate legislation originated in the House (H.R. 2454, Waxman-Markey, ACESA)
- After considerable horse-trading, ~1500 page Waxman-Markey passed out of the House on a 219-212 vote.

U.S. Senate

- Boxer, Chair of Senate Environment and Public Works Committee initially announced her desire to start with Waxman-Markey and produce a bill in August.
- Reid, Senate Majority Leader has said that the Senate climate plan envisions all committee action being completed by the end of September, with an eye toward October for the floor debate.
- Latest count: 35 yes; 9 probably yes; 21 fence sitters; 13 probably no; 22 no.

Note: If climate legislation fails, EPA could regulate GHG under the "endangerment finding". EPA has already proposed rules for GHG emissions reporting and carbon sequestration.

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WAXMAN-MARKEY
THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009
(ACESA)
SUMMARY

Title I – Clean Energy
- Renewable Energy
- Carbon Capture and Sequestration
- Clean Fuels and Vehicles
- Smart Grid and Electricity Transmission
- Partnering with the States
- Federal Purchases of Renewable Electricity

Title II – Energy Efficiency
- Building Energy Efficiency
- Manufactured Homes
- Appliance Energy Efficiency
- Transportation Efficiency
- Utilities Energy Efficiency
- Industrial Energy Efficiency
- Public and Federal Energy Efficiency

Title III – Reducing Global Warming Pollution
- *Global Warming Pollution Reduction Program*
- Supplemental Pollution Reductions
- Offsets
- Banking and Borrowing
- Strategic Reserve
- Carbon Market Assurances and Oversight
- Additional Greenhouse Gas Standards
- Clean Air Exemptions

Title IV – Transitioning to a Clean Energy Economy
- Ensuring Domestic Competitiveness
- Green Jobs and Worker Transition
- Consumer Assistance
- Exporting Clean Technology
- Adapting to Global Warming

Title V – Agriculture and Forestry Related Offsets

WAXMAN-MARKEY
THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009

Overview of the proposed greenhouse gas (GHG) cap-and-trade program contained in Titles III and V

Coverage

large stationary sources emitting more than 25,000 tons/yr of GHGs, producers and importers of all petroleum fuels, distributers of natural gas to residential, commercial and small industrial users, producers of "F-gases", and other specified sources.

Emissions Reduction Targets

Emission caps that would reduce aggregate GHG emissions for all covered entities from 2005 levels by 3% in 2012; 17% in 2020; 42% in 2030; and 83% in 2050. Bill also establishes economy-wide goals for all sources, including but not limited to those covered by the cap-and-trade program.

Distribution of Allowances

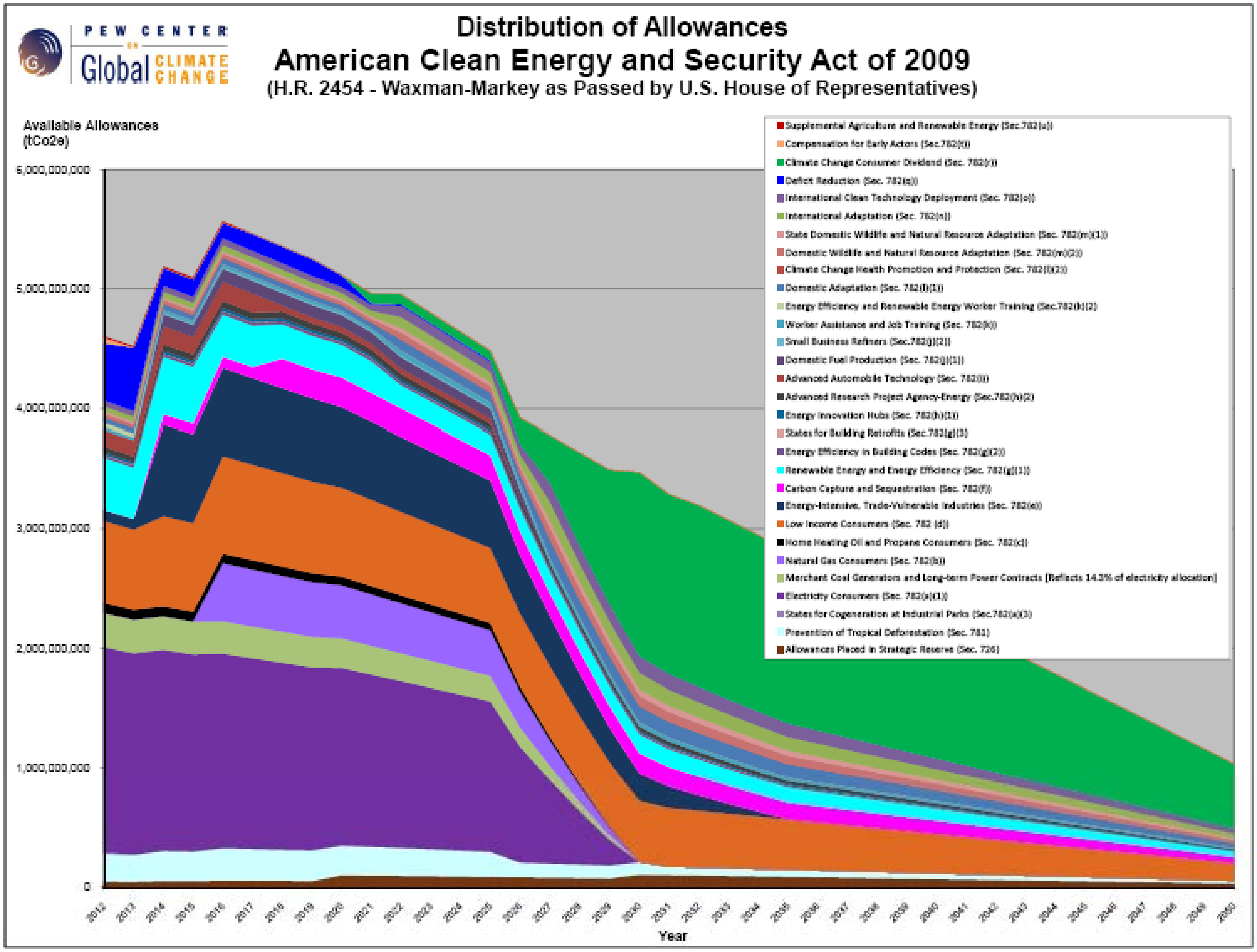
[See following chart] Approximately 20% of allowances are auctioned in the initial years of the cap-and-trade program. This percentage increases over time to about 70% by 2030 and beyond.

Offsets and Other Cost Containment Measures

Bill allows up to 2 billion tons of offsets (1 billion from domestic sources, 1 billion from international sources) to be used for compliance system wide.

Carbon Market Oversight

Bill requires FERC to regulate the cash market in allowances and offsets, and assigns the Commodity Futures Trading Commission the responsibility for regulation and oversight of any derivatives markets (unless the President decides otherwise).



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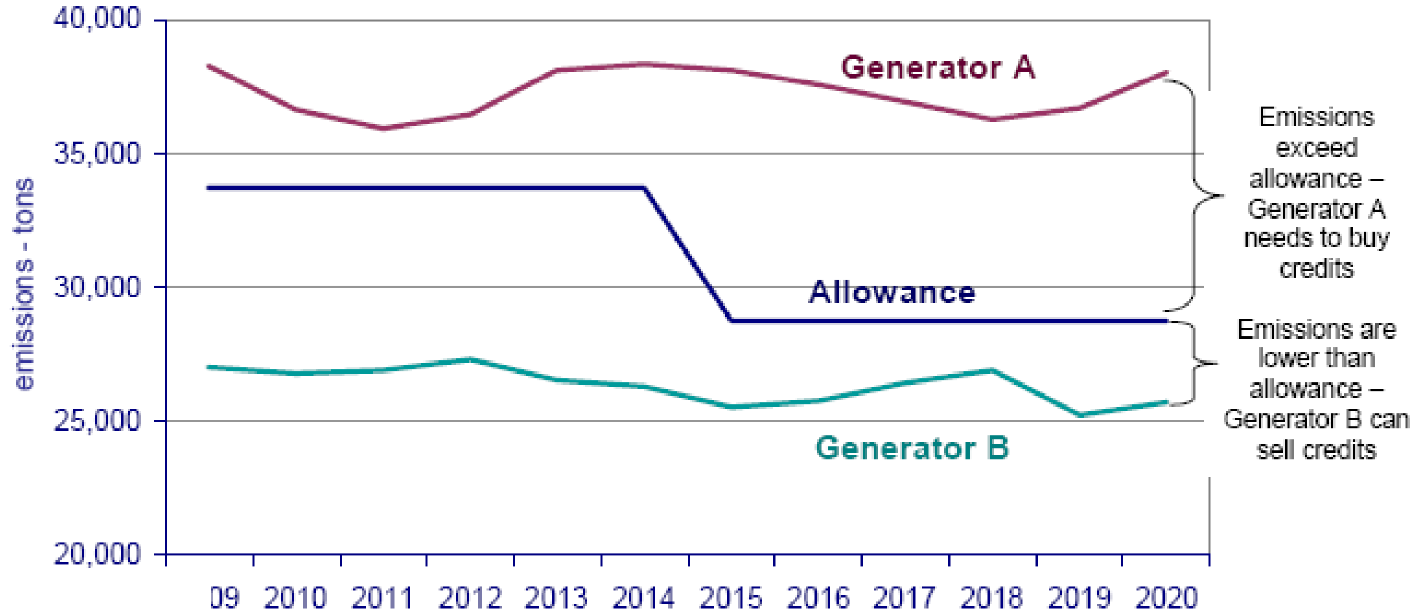
ENVIRONMENTAL IMPLICATIONS OF CARBON CAP-AND-TRADE

Background

Cap–and–Trade Basics



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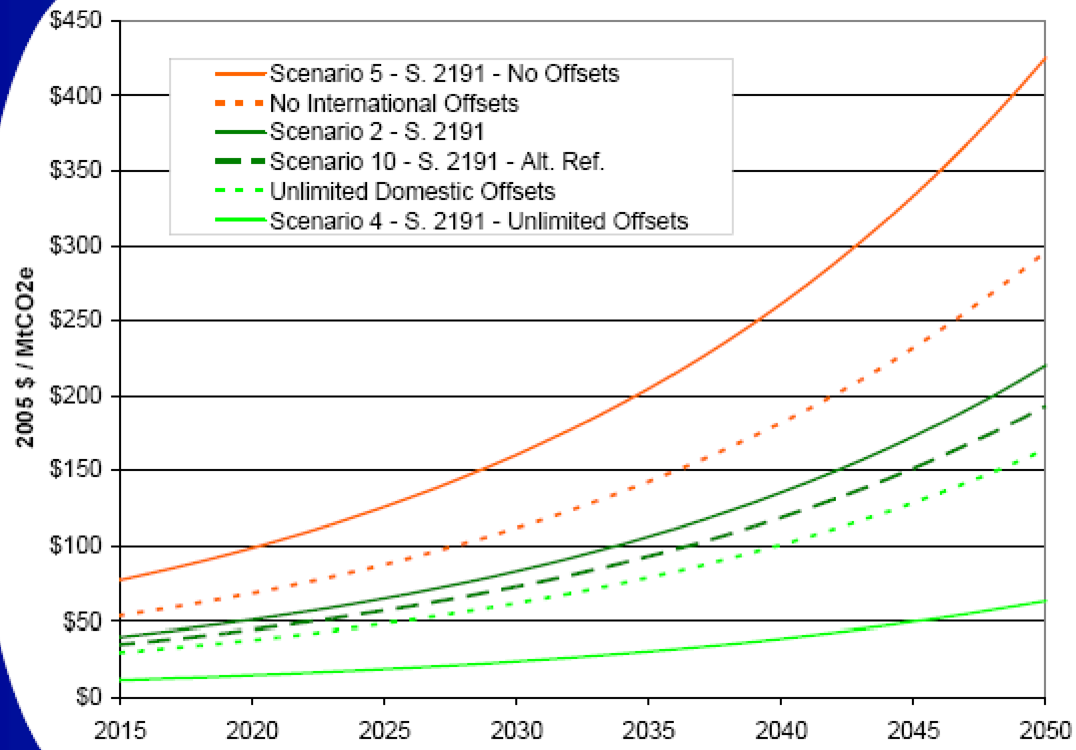
Scenario Comparison

GHG Allowance Prices (IGEM)



- Compared to the variation in allowance prices between the various alternative technology scenarios, there is a greater variation in allowance prices amongst the alternative offset and international credit scenarios.
- Allowing the unlimited use of domestic offsets and international credits can reduce allowance prices by 71% compared to scenario 2.
- Allowing the unlimited use of just domestic offsets can reduce allowance prices by 26% compared to scenario 2.
- If international credits are not allowed, allowance prices increase by 34% compared to scenario 2.
- If both international credits and domestic offsets are not allowed, allowance prices increase by 93% compared to scenario 2.
- Allowance prices are 12% lower under the alternative reference case compared to scenario 2.

EPA Analysis of S. 2191

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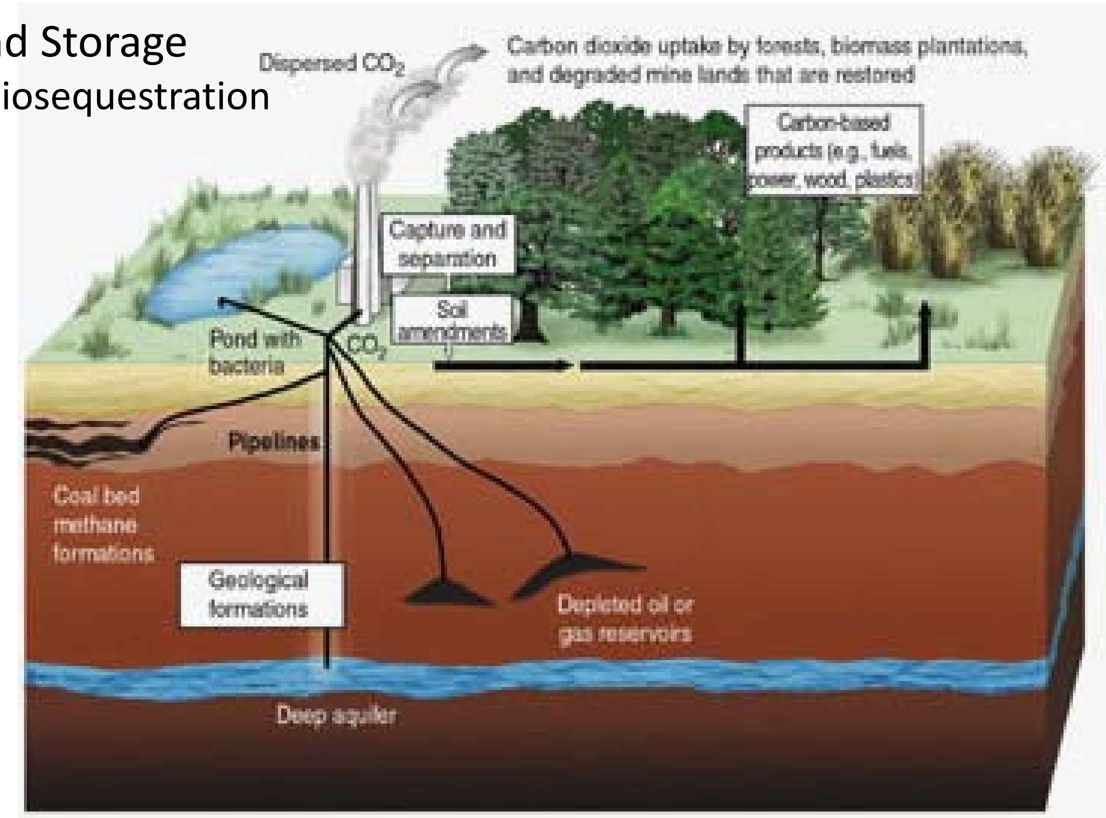
To Comply with GHG Emissions Reduction Requirements, Affected Sources Can:

1. Reduce emissions
2. Purchase allowances
3. Produce or purchase offset credits

Carbon Capture and Storage

Geosequestration - Biosequestration



Source: www.123eng.com/projects/carbon.doc

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Storing CO2 with Enhanced Oil Recovery

DOE/NETL-402/1312/02-07-08

February 7, 2008

NETL

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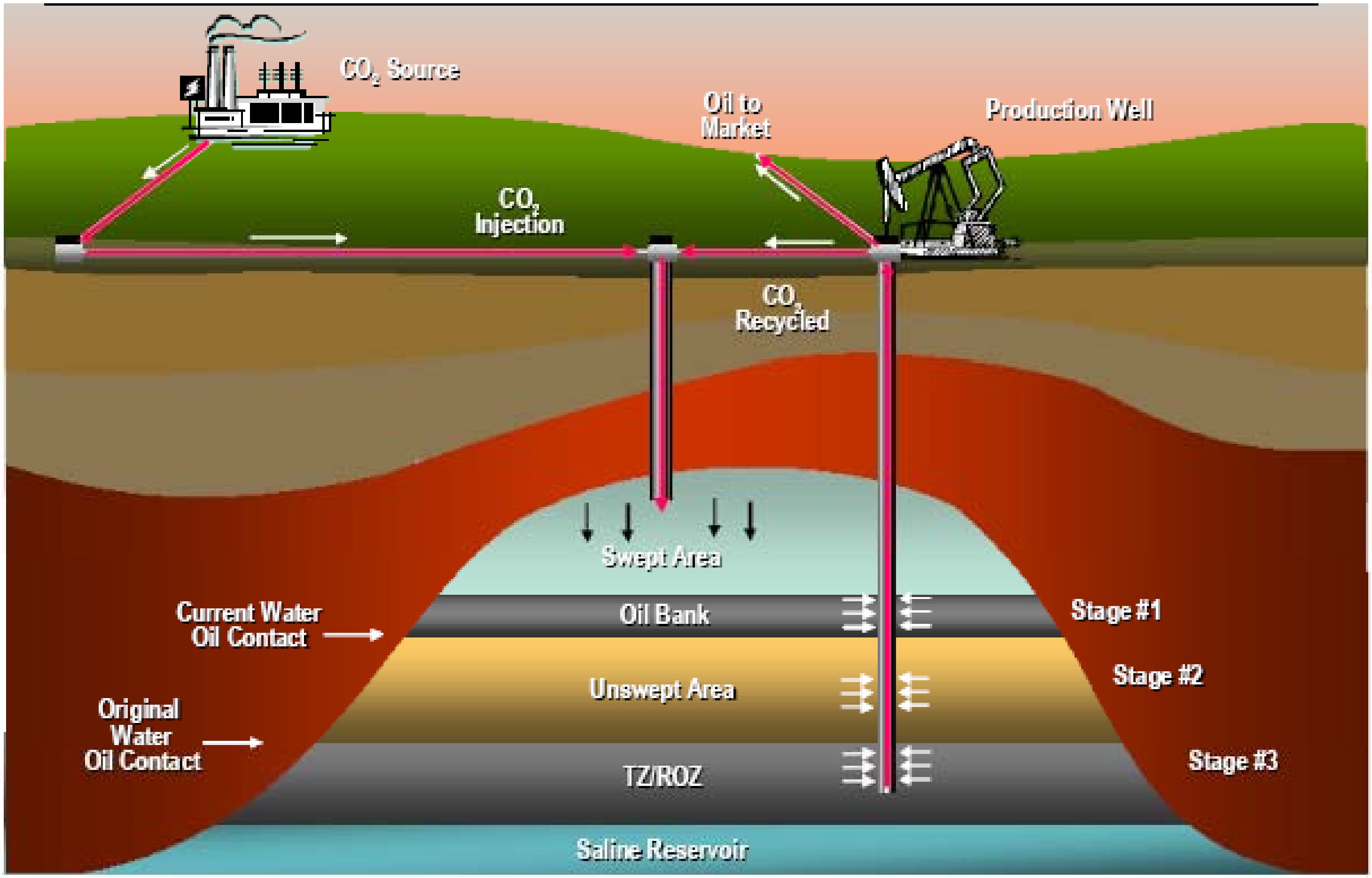
Illustration of Next Generation Integration of CO_2 Storage and EOR



Source: DOE, 2008

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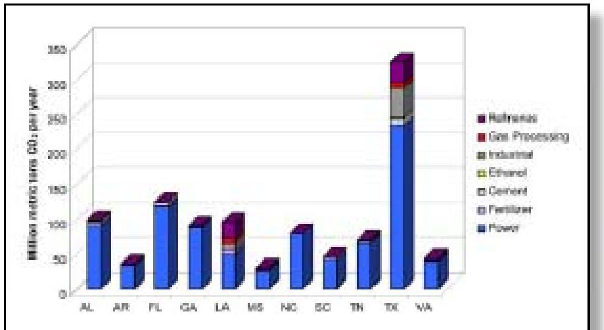
SECARB CO_2 Sources

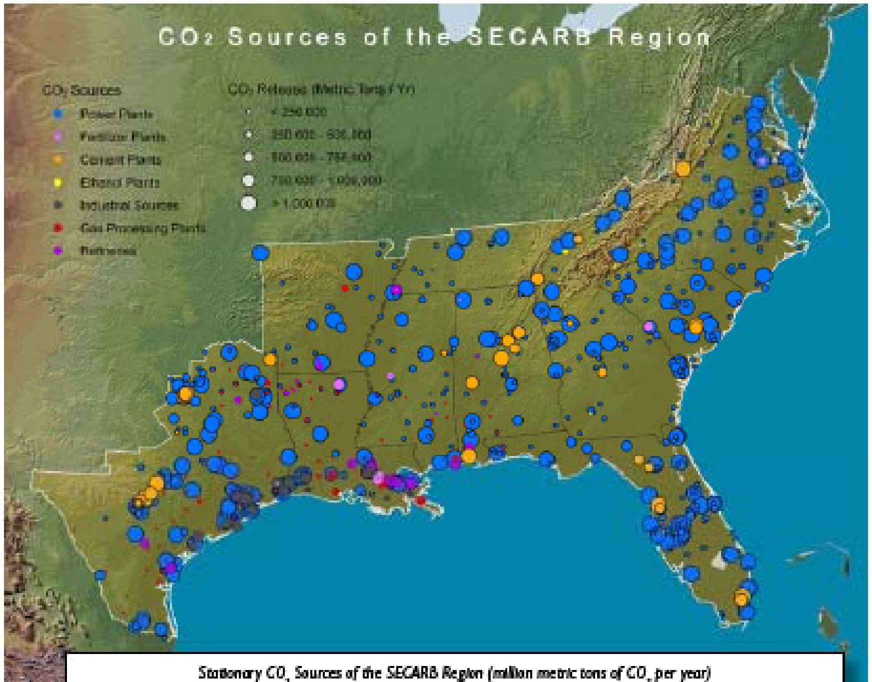
There are more than 900 large, stationary sources of CO_2 in the SECARB Region which are potential targets for carbon sequestration. Their total annual emissions are estimated at just over 1 billion metric tons (1.2 billion tons) of CO_2. Fossil-fuel (coal, oil, and gas) power plants are the largest contributors, accounting for approximately 83 percent of the total CO_2 emissions (see graph).

The SECARB Region is also host to a number of non-power related stationary sources of CO_2. These include, in descending order of contribution of CO_2: refineries, ethylene plants, cement plants, gas processing plants, iron and steel plants, and ethylene oxide plants.



CO_2 emissions for the SECARB Region are displayed in the chart (right) and map (above) by location, source type, and quantity.

Scherer Coal fired power plant in Juliet, Georgia produces over 25.6 million tons of CO_2 per year. (Source: Georgia Power)



Stationary CO_2 Sources of the SECARB Region (million metric tons of CO_2 per year)

State	Electric Generation*	Fertilizer*	Cement Plants *	Ethanol*	Industrial*	Petroleum/ Natural Gas*	Refineries/ Chemical*	Total*
AL	71.1	0.2	5.4	—	0.5	0.3	1.3	78.8
AR	32.9	—	0.9	—	0.3	0.5	0.8	35.4
FL	137.0	—	5.5	—	0.1	0.1	—	142.7
GA	88.0	0.9	1.0	—	0.1	—	—	90.0
LA	52.6	4.6	0.8	—	9.6	5.9	28.3	101.8
MS	28.3	0.6	0.5	—	0.1	0.8	3.6	33.9
NC	76.7	—	—	—	0.1	—	—	76.8
SC	36.1	—	3.8	—	0.4	—	—	40.3
TN	61.8	—	1.5	0.4	0.2	—	1.8	65.7
TX**	237.6	—	11.1	—	42.5	4.8	37.2	333.2
VA	44.6	0.7	1.1	—	0.2	—	—	46.6
TOTAL	866.7	7.0	31.6	0.4	54.1	12.4	73.0	1045.2

* Units are all in million metric tons
** Eastern Texas: TRRC Districts 1-6

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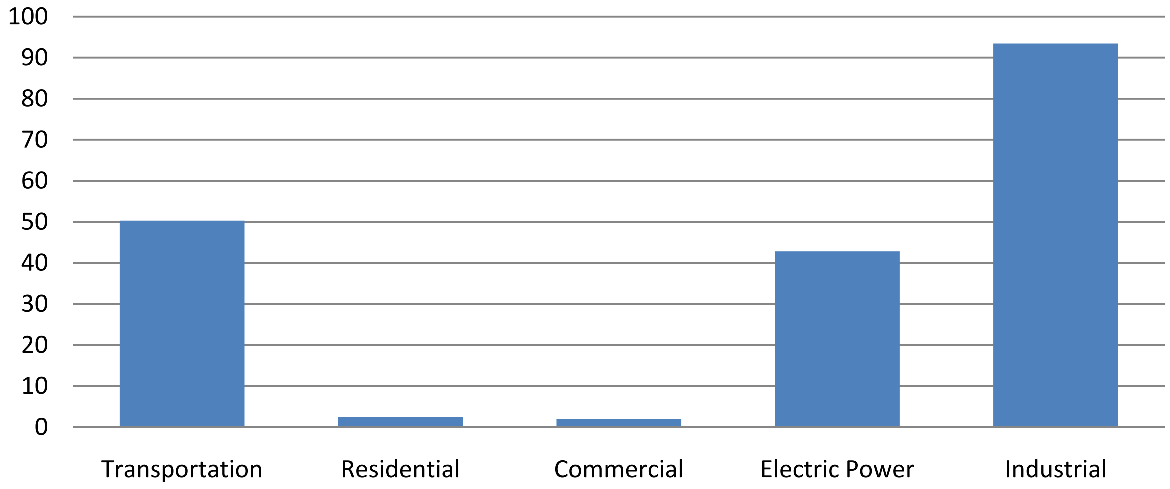
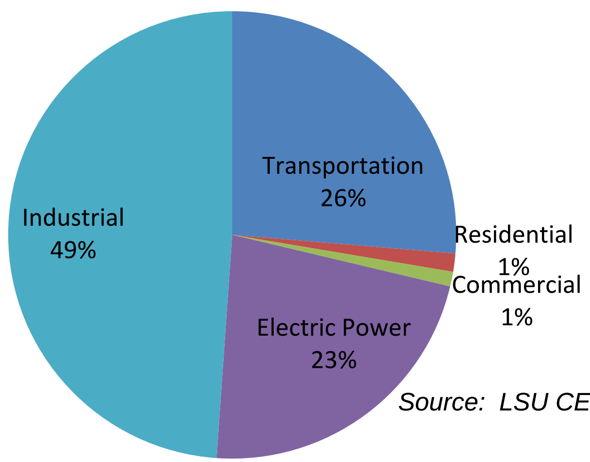
Louisiana 2005 Fossil Fuel Combustion Emissions by Sector (MMTCO_2E)



Louisiana 2005 Fossil Fuel Combustion Emissions by Sector



Source: LSU CES Greenhouse Gas Inventory, preliminary data, 2009.

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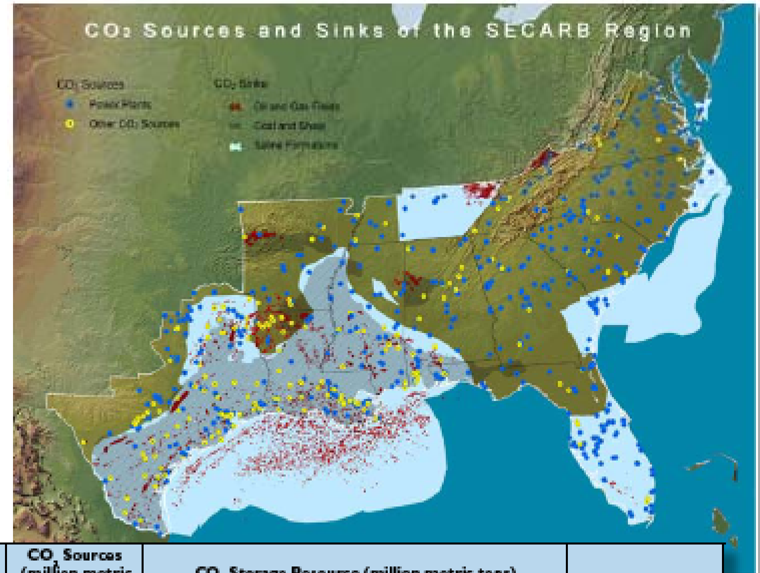
SECARB: Composite Map of CO_2 Sources and Geologic Storage Formations



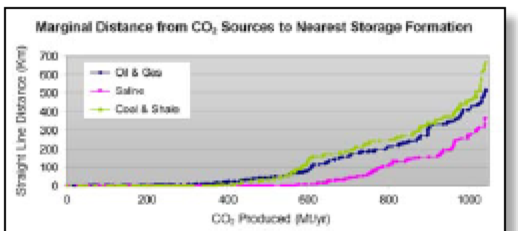
The distance between a CO_2 stationary source and a geologic storage formation is calculated as the shortest straight-line distance from each source to the nearest geologic storage site. While these results do not give a complete picture of the transportation and infrastructure requirements, they do give a first-order interpretation of the magnitude of the requirements.

The sources in SECARB match up well with the potential storage reservoirs. For example, more than 70 percent of all sources (by volume) in the SECARB Region are located within 50 km (31 mi) of a storage formation. Approximately 40 percent of the sources are actually co-located with an appropriate storage formation. This especially occurs in the Gulf Coast region where many of the sources overlie saline formations, coal beds, or both.

The table below identifies how many years storage is possible given the current annual emissions and the known CO_2 storage resource.

Formation Type	Straight-Line Distance to Nearest Formation		
	< 50 km	50 -100 km	> 100 km
Oil and Gas Fields	50%	9%	42%
Saline Formations	71%	5%	25%
Coal and Shale	52%	4%	44%
All Reservoirs	76%	5%	19%

Note: The total annual CO_2 storage rate used was 938 million metric tons, which was estimated based on current emissions and assuming 90% capture efficiency.



Above: Marginal distance from all CO_2 sources to their nearest storage formation.

State	CO_2 Sources (million metric tons per year)	CO_2 Storage Resource (million metric tons)				Number of Years Storage **
	Total	Oil and Gas	Coal and Shale*	Saline*	Total	
AL	79	390	2,592	32,250	35,232	446
AR	35	372	16,200	23,623	40,195	1,148
FL	143	183	1,700	28,950	30,833	216
GA	90	—	—	3,068	3,068	34
LA	102	7,960	11,100	348,744	367,804	3,606
MS	34	579	7,200	116,068	123,847	3,643
NC	77	—	—	3,380	3,380	44
SC	40	—	—	1,247	1,247	31
TN	66	—	—	1,250	1,250	19
TX****	333	6,332	18,700	513,870	538,902	1,618
VA	47	10	308	398	716	15
Federal Offshore	—	18,860	—	1,201,741	1,220,741	N/A
TOTAL	1,045	34,686	57,800	2,274,589	2,367,215	2,263***

* Low estimates used
** Years of CO_2 Storage at the current emission rates (State CO_2 storage resource/ state annual emissions)
*** Average years storage for whole of SECARB area (Total CO_2 storage resource/ total annual emissions)
**** Eastern Texas: TRRC Districts 1-6

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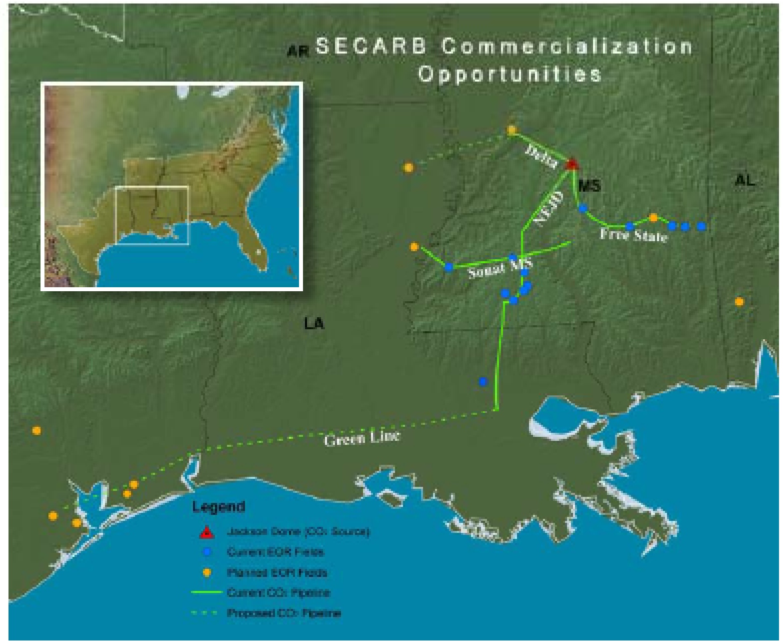
Southeast Regional Carbon Sequestration Partnership (SECARB)

SECARB Commercialization Opportunities

Early opportunities for commercialization in the Southeast Region most likely will be associated with an ability to offset the cost of capturing and storing CO_2. Utilizing CO_2 for EOR is the primary candidate for offsetting costs in several SECARB states. Work conducted by SECARB in Gulf Coast formations will assist in expanding CO_2 EOR opportunities. Another candidate is ECBM recovery utilizing CO_2. Field tests conducted by SECARB in Central Appalachia and in the Black Warrior Basin of Alabama will assist in determining the technical and economic feasibility of ECBM.

Within the SECARB Region, EOR is in place in Mississippi. Currently, the CO_2 that is used for EOR is coming from the Jackson Dome, a natural source of CO_2 located near Jackson, Mississippi. Denbury Resources operates a pipeline network that transports Jackson Dome CO_2 to oil fields in the Southeast. The Cranfield unit, near Natchez, Mississippi, is one EOR field operated by Denbury Resources, and it is host to a SECARB Validation Phase small-scale injection as well as a Development Phase large-scale injection in the brine formation down-dip of the EOR field.

Denbury Resources is developing and expanding a CO_2 pipeline network from the Jackson Dome to potential EOR sites in Mississippi, Louisiana, Texas Gulf Coast, and Alabama. Denbury Resources also is establishing agreements with sources of CO_2 that can supplement the volumes of CO_2 produced at Jackson Dome. As a result, the Denbury Resources pipeline system has the potential for becoming the regional backbone of an integrated network for CO_2.



Regional Incentives

Two initiatives in the SECARB region will help advance carbon capture and sequestration deployment:

- As part of SECARB Validation Phase field investigation, Virginia Tech, Marshall Miller & Associates (MM&A), and the Geological Survey of Alabama are evaluating the feasibility of capturing CO_2 from an industrial source and storing it in unmineable coal seams and associated brine formations in Central Appalachia and the Black Warrior Basin.
- As part of SECARB Development Phase field investigation, the Electric Power Research Institute (EPRI) and Southern Company (with operating units in Mississippi, Alabama, Georgia, and Florida) currently are evaluating CO_2 capture and separation technologies. SECARB plans to inject 100,000–250,000 metric tons (110,000–280,000 tons) per year of anthropogenic (power plant) CO_2 from 2011 to 2014.

Pipeline (Source: Denbury Resources).

Current EOR Fields	Location	Proposed EOR Fields	Location
Lockhart Crossing	LA	Tinsley Field	MS
Little Creek	MS	Lake St. John Field	LA
Mallalieu	MS	Heidelberg Field	MS
McComb	MS	Delhi Field	LA
Brookhaven	MS	Citronelle Field	AL
Eucutta	MS	Oyster Bayou	TX
Soso	MS	Fig Ridge	TX
Martinville	MS	Gillock Fields	TX
Yellow Creek	MS	Hastings Field	TX
Cyprus Creek	MS	Conroe Oil Field	TX
Smithdale	MS		
Lazy Creek	MS		
Cranfield Field	MS		

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Summary Remarks

- There are significant petroleum resources (stranded oil) in the U.S. amenable to recovery with CO_2-EOR
  - Total of 400 billion barrels in the U.S., of which about 87 billion barrels are technically recoverable
  - Total of around 14 billion barrels onshore and offshore Louisiana, of which about 7.7 billion barrels are technically recoverable

- CO_2-EOR offers a large "value added" market for captured CO_2 emissions

- Storing CO_2 with EOR helps with three of today's concerns about geological storage of CO_2
  - Regulatory/public acceptance
  - Mineral (pore space) rights, and
  - Long-term liability

- Oil produced today with CO_2-EOR is 70% "carbon free" and can become 100+% "carbon free" with the "next generation" technology (i.e. "green oil")

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Questions/Discussion

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