CO_2 ENHANCED OIL RECOVERY (CO_2 EOR) AND WHAT IT TEACHES US ABOUT GEOLOGIC SEQUESTRATION

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OVERVIEW

I. THE CO_2 EOR PROCESS
II. WHERE CURRENT CO_2 COMES FROM
III. MOVING IT AROUND
IV. INJECTING IT
V. HOW IT BEHAVES IN THE RESERVOIR
VI. PROCESSING AND PURIFICATION
VII. PUBLIC POLICY; HEALTH AND SAFETY; REGULATORY OVERSIGHT; BARRIERS

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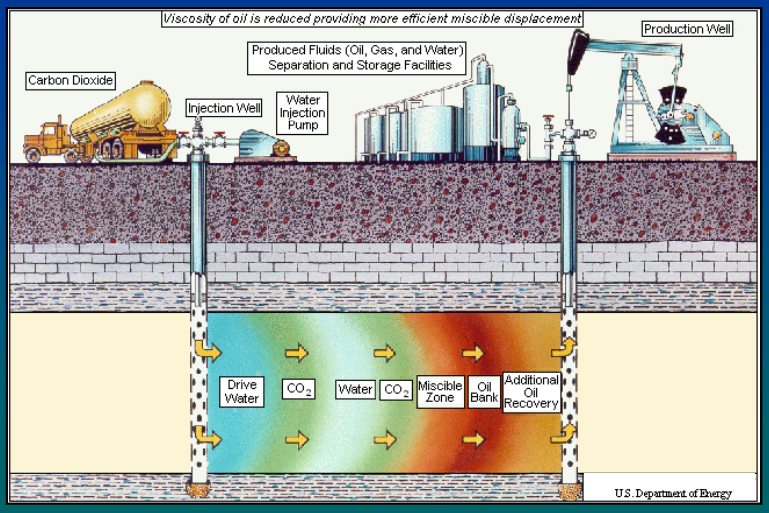
I. THE CO_2 EOR PROCESS



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IMPORTANT CO_2 TERMS

- DENSE PHASE OF CO_2
- MISCIBLE & IMMISCIBLE PROJECTS
- HORIZONTAL & VERTICAL FLOODING
- MOBILITY AND SOLUBILITY
- MMV(A) – MONITORING, MEASUREMENT AND VERIFICATION (ACCOUNTING)

HANDY CONVERSION FACTORS

- 17.5 THOUSAND CUBIC FT (MCF) = 1 TON OF CO_2
- 50 MILLION CUBIC FT (MMCF) / DAY ~ 1 MMTONS / YR
- 'FUTUREGEN SIZE' (275 MW) = 125 MMCFPD OR ~ 2.5 MMTONS / YR

II. SOURCING

CO_2 SOURCES AND TRANSPORTATION NETWORKS

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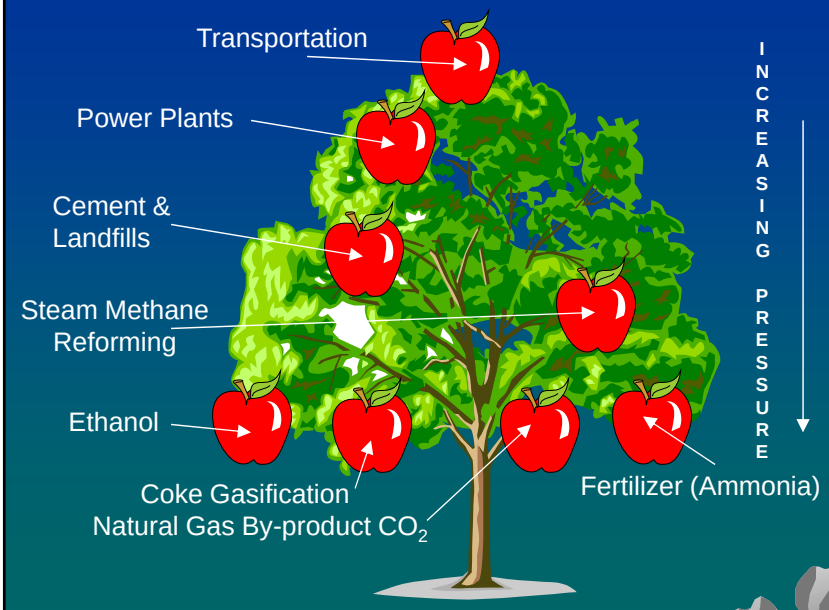
Industrial CO_2 Sources



"THE CO_2 SOURCE FRUIT TREE"

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CO_2 Sources

EXISTING

NATURAL, UNDERGROUND

McElmo, Bravo, Sheep Mountain, Jackson, Turkey

INDUSTRIAL, SURFACE

LaBarge Nat'l Gas, Red Deer Ethylene, DGS (Beulah, ND) Syngas, Val Verde Nat'l Gas, Kansas Ethanol, Trinidad Nat'l Gas, Michigan Nat'l Gas, Zama Nat'l Gas, Refineries (inactive for EOR at present but active for food grade)

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III. MOVING CO_2 AROUND

- ALL PIPELINES OPERATE AT PRESSURES EXCEEDING DENSE PHASE STATE (~1200 PSI)
- NOW 3100+ MILES OF MAJOR CO_2 PIPELINES
- CANYON REEF CARRIERS (W. Tx) 140 MILE 16" PIPELINE IN SERVICE NOW FOR 36 YEARS; PRESSURE (HYDRO) TESTED IN 2003; RECERTIFIED FOR ORIGINAL OPERATING PRESSURE OF 2200 PSI
- SPECS REQUIRE 95% CO_2 (BY VOL) AND WATER <20-30# / MMCF

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North American CO_2 Pipelines

PIPELINE	Owner/Operator	Length (mi)	Diameter - in	Estimated Capacity (mmcfpd)	Location
Anadarko Powder River Basin CO2 PL	Anadarko	125	16	195	WY
Anton Irish	Oxy	40	8	82	TX
Bravo	Oxy Permian	218	20	312	NM,TX
Canyon Reef Carriers	Kinder Morgan	139	16	195	TX
Centerline	Kinder Morgan	113	16	195	TX
Central Basin	Kinder Morgan	143	26-16	195	TX
Chaparral	Chaparral Energy	23	6	61	OK
Choctaw	Denbury Resources	183	20	312	MS,LA
Cordona Lake	ExxonMobil	7	6	61	TX
Cortez	Kinder Morgan	502	30	1175	TX
Dakota Gasification	Dakota Gasification	204	12	129	ND/Sask
Dollarhide	Pure Energy	23	8	82	TX
El Mar	Kinder Morgan	35	6	61	TX
Enid-Purdy (Central Oklahoma)	Anadarko	117	8	82	OK
Este I - to Welch, Tx	ExxonMobil, et al	40	14	169	TX
Este II - to Salt Crk Field	ExxonMobil	45	12	129	TX
Ford	Kinder Morgan	12	4	45	TX
Joffre Viking	Penn West Petroleum Ltd.	8	6	61	Alberta
Llano	Trinity CO2	53	12-8	82	NM
Pecos County	Kinder Morgan	26	8	82	TX
Raven Ridge	ChevronTexaco	160	16	195	WY/Co
Sheep Mtn	British Petroleum	408	24	563	TX
Shute Creek	ExxonMobil	30	30	1175	WY
Slaughter	Oxy Permian	35	12	129	TX
Transpetco	TransPetco	110	8	82	TX,OK
Val Verde	PetroSource	83	10	93	TX
W. Texas	Trinity CO2	60	12-8	82	TX,NM
Wellman	Wiser	25	6	61	TX
White Frost	Core Energy, LLC	11	6	61	MI
Wyoming CO2	ExxonMobil	112	20-16	195	WY

Aggregate Length Equivalent: Boston to Los Angeles

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IV. INJECTION

- CURRENT TEXAS (1st Q '09) VOLUMES OF "NEW" CO_2 INJECTION ARE:
  - 103,000 TONS PER DAY OR 37 MILLION TONS PER YEAR
  - EQUIVALENT TO 14 FUTUREGEN-SCALE PROJECT OFFTAKES
- INJECTION MARKET HAS BEEN ENTIRELY DEFINED BY ECONOMICS OF CO_2 EOR INCLUDING COST AND AVAILABILITY OF CO_2
- HUGE POTENTIAL TO GROW THAT MARKET WITH PROPER INCENTIVES IN PLACE (re: ARI BASIN STUDIES REPORTS (USDOE)

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V. RESERVOIR BEHAVIOR

- CO_2 DENSITY CLOSELY MATCHES OIL, LIGHTER THAN WATER
- CO_2 VISCOSITY LIKE THAT OF GAS; READILY MOVES THROUGH FORMATION (MOBILITY)
- STRIPS HYDROCARBONS TO FORM MISCIBLE (MIXED CO_2 + OIL) PRESSURE FRONT
- DISSOLVES INTO OIL AND WATER GIVEN TIME
- RESERVOIR RETAINS SIGNIFICANT VOLUMES OF CO_2 (e.g., DEAD END PORES) IN SPITE OF PRODUCTION OF FORMATION AND INJECTED FLUIDS

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VI. SURFACE CO_2 PROCESSING

- CO_2 PROCESSING OCCURS BOTH AT THE SOURCE AND AT THE FIELD DURING PRODUCTION AND FOR CO_2 RECYCLING (THE CO_2 PRODUCED WITH OIL)
- PROCESSING TECHNIQUES ARE BOTH CHEMICAL AND MECHANICAL AND WAS PIONEERED BY THE NAT'L GAS AND CO_2 EOR INDUSTRY

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VII. PUBLIC POLICY, HEALTH AND SAFETY, REGULATORY OVERSIGHT, BARRIERS

- EOR REGULATED BY RCT, STORAGE CURRENTLY A POLICY VOID
- HISTORY: NO LOSS OF LIFE ACCIDENT DUE TO CO_2 EXPOSURE
- BASIC FRAMEWORK FOR REGULATION OF CO_2 STORAGE HAS BEEN DEVELOPED WITHIN STATES THAT DO EOR &/or GAS STORAGE
  - State Oil & Gas Regulatory Agencies (SOGRAs) for CO_2 operations
  - DOT's Office of Pipeline Safety for LD CO_2 transport to lease boundary
- SOGRAs METHODOLOGY INCLUDES MEASURES (UNITIZATION) FOR AGGREGATION OF NECESSARY RIGHTS (MINERAL, SURFACE)
- STATES (w/ POSSIBLE HELP FROM FEDS?) WILL DEVELOP STANDARDS FOR STORAGE PROJECT LICENSING
- REGULATORY NEEDS: NEW OVERLAYS FOR
  - Reservoir Monitoring Requirements and Duration
  - Long Term Responsibility and Liability Provisions
  - Statutory Assistance for Aggregating Surface and/or Mineral Rights

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CO_2 Storage
Conceptual Analogues

- CO_2 EOR (103,000 tons/per day of "new" CO_2, = 1.8 bcfpd ≅ 1 mmbwpd)
- Natural Gas Storage (450 U.S. and 64 Tx State {TRRC} Permitted NG Injection Sites*)

RCT

- Strategic Petroleum Reserve (706 mmbo in Storage as of 3/1/09**) – Current storage capacity - 727 mmbo

* http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/undrgrnd_storage.html

** http://www.spr.doe.gov/dir/dir.html

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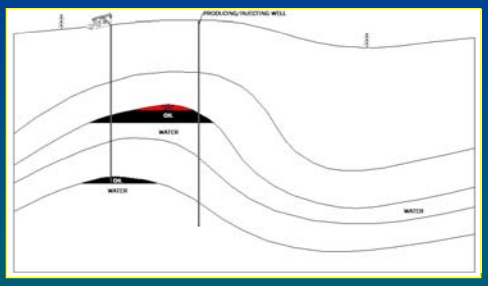
OIL AND GAS FIELD STORAGE

- Continue Regulatory Jurisdiction of RCT
- Stacked Opportunities In Texas Abound
- Some Opportunities are Mixed Oil & Gas Targets and Deep Saline Formations in Same Wellbores
- RRC Jurisdiction From Inception through Closure



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CO_2 CAPTURE PROJECTS: THE DILEMMA

- COMPANIES* ARE READY TO IMPLEMENT CO_2 CAPTURE PROJECTS FOR NAT'L GAS SEPARATION, ELECTRICITY GENERATION (IGCC), FERTILIZERS & SPECIALTY CHEMICALS (POLYGEN) COAL TO SYNTHETIC NATURAL GAS AND LIQUIDS (SYNGAS & CTL),

but

- CONSIDERING THE PENDING LIABILITY FOR CO_2 EMISSIONS (e.g. California), WILL THE COMPANIES MOVE FORWARD WITHOUT ASSURANCES THAT CCS WILL BE A QUALIFIED OFFSET?

* JUST FOUR OF THE ($B) EXAMPLES: TENASKA, SANDRIDGE/OXY, SUMMITT ENERGY, EASTMAN PROJECTS

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THANK YOU

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