An Industry Perspective on Geologic Storage & Sequestration

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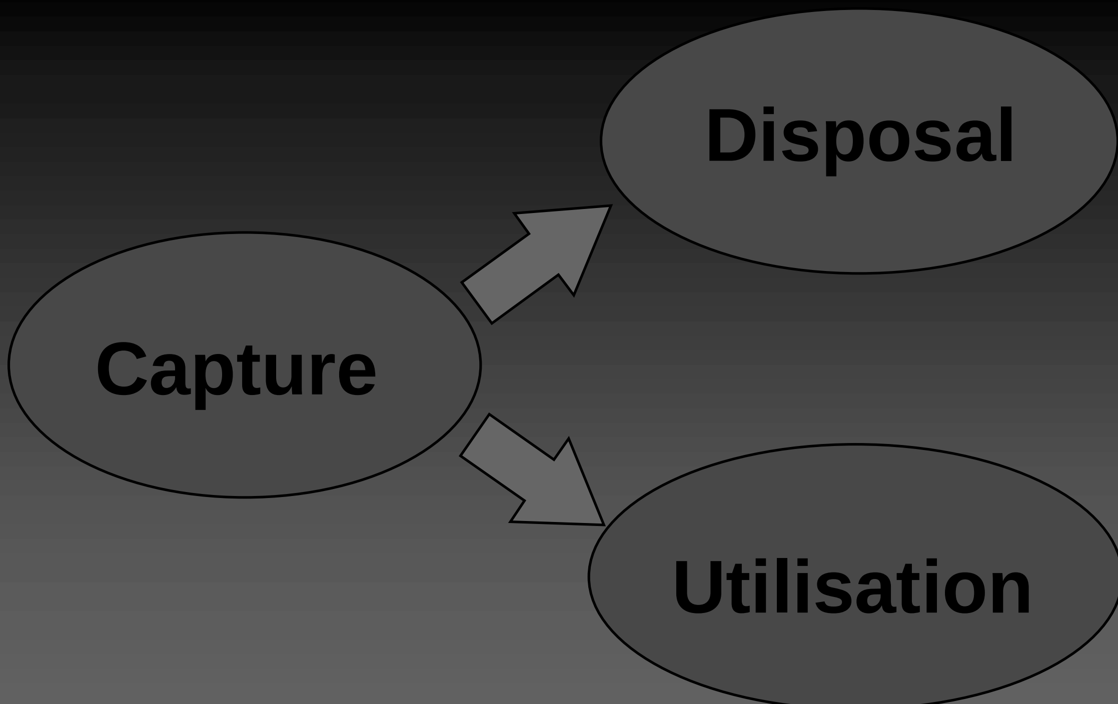
Disclaimer

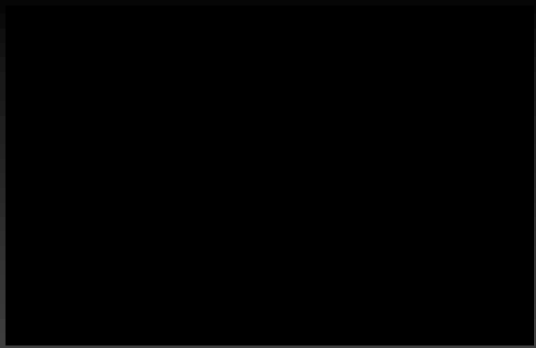
- The following may not be the only Industry Perspective on Storage & Sequestration
- It represents the opinions of BP and Chevron and some other energy companies that we have talked to

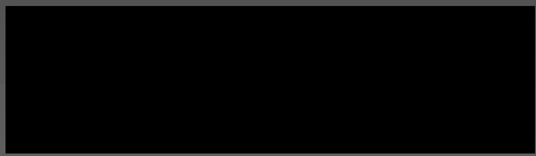
Overview

- Potential New Business Impact
- Business Drivers for R&D
- Technology Objectives
- Definitions of Storage & Sequestration
- Break-down of Geologic Storage R&D Categories
- Where We Think Industry (and others) are already strong
- Where We Think Additional R&D Gaps Still Exist
- Conclusions

Capture and Storage of CO_2







Potential New Business Impact

In order to reduce the atmospheric concentration of carbon dioxide to 550ppm we need to capture and store 200 - 300 GT Carbon (~1000GT CO_2) (Edmonds, Freund and Dooley Aug 2000 GHGT-5)

Potential Global Storage Capacity

	Global storage Capacity ($GtCO_2$)
Exhausted Oil & Gas Reservoirs[a]	920
Saline Formations[b]	3000

a, IEA report PH3/22 Feb 2000
b McMullan : Carbon Dioxide Collection & Disposal 1995

Potential Business Drivers

- Concern by the public and stakeholders
- Mandates or incentives, particularly overseas
- Potential future incentives in U.S.
- Jay Edmonds Study (PWNL) concluded Sequestration and Geologic Storage would be most important of options to achieve deep reductions through 2100
- E&P industry <u>already</u> has the downhole competencies to perform CO2 storage

Potential Business Drivers

- Separation of hydrogen from fossil fuels offers rapid availability of carbon free energy carrier
- Centralised capture and storage of CO_2 is viable option to minimise emissions
  - Potential storage capacity for 50 – 100% of global emissions to 2050
- Offers option to kick-start transition while providing breathing space for adaptation and development of long-term solutions
- Some R&D gaps still exist, however

Objective for R&D Gaps

- Industry has much of the core competencies
- Outside of EOR & Natural Analogs, storage experience is fairly time scale limited
- To store significant volumes of CO2 will require:

  -*"Convince governments, the public and the environmental NGOs this alternative is safe and effective"*

Definitions of Storage & Sequestration

- **3 trapping mechanisms**
  - Solubility Trapping - probably volume limited
  - Mineral Trapping - but time scales may be excessive - but most "permanent" of the options except in unique minerologies
  - Hydrodynamic Trapping - In many cases most of the CO2 volume, but potential for vertical and horizontal migration exist
- **Storage Definition**
  - Not necessarily permanent, may have some leakage risk, could be produced back if deemed necessary later
- **Sequestration Definition**
  - "Permanent" with very little chance of leaks

Geologic R&D Categories

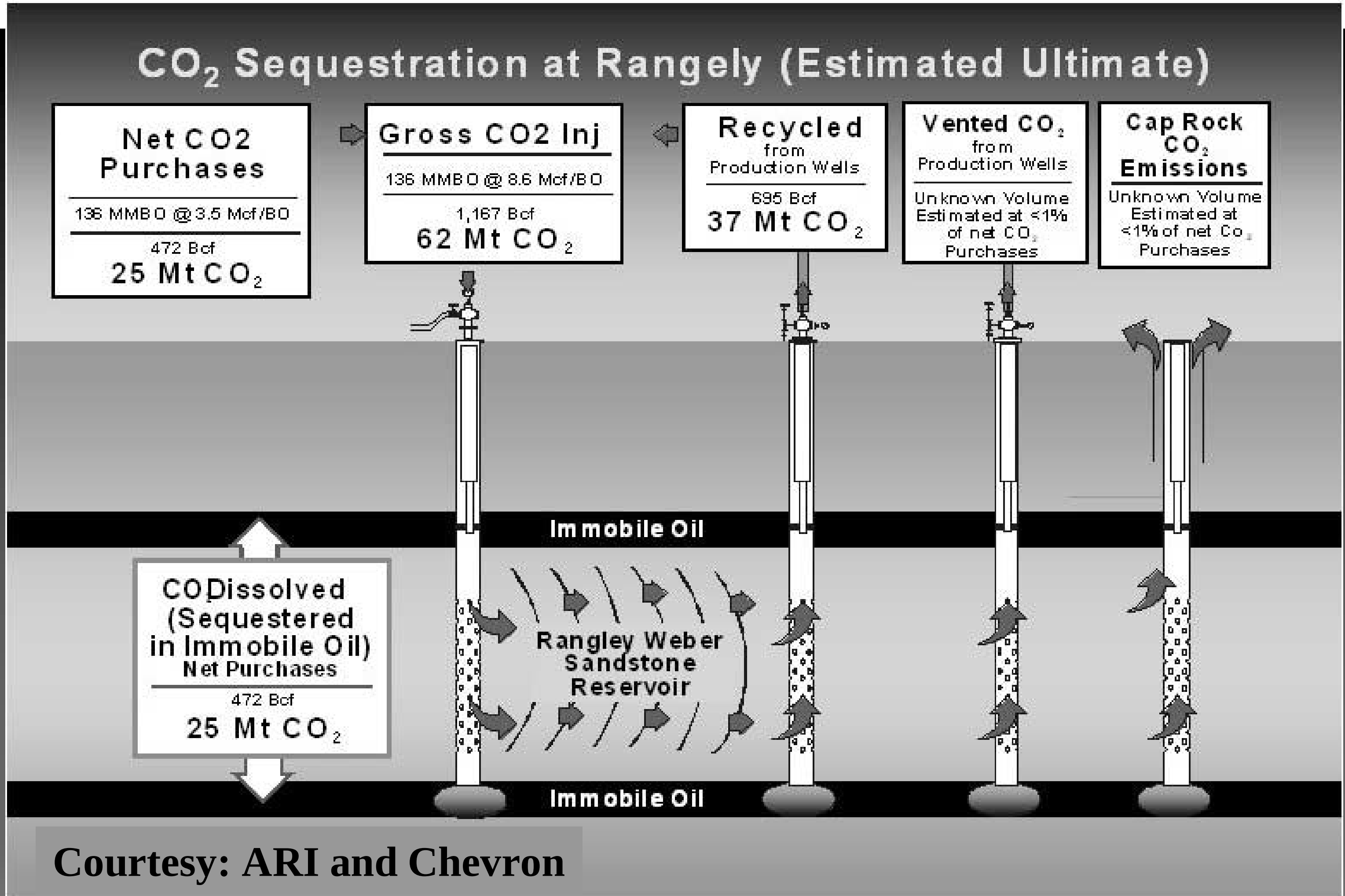
(& examples of what they mean)

- Understanding Geologic Storage
  - Types of trapping, seals & caprocks, etc.
- Maximizing Sequestration Potential
  - How to maximize sweep potential, minimize leakage, and maximize volume (e.g. EOR drivers different than CO2 storage)
- Short Term Monitoring & Verification
  - How to use existing tools such as seismic, tracers, etc.
- HSE Risk Assessment Methodology
  - How to assess risk, mitigate & remediate risk
- Long-Term Monitoring & Verification
  - What cheaper, wider use tools might be developed later

The Good News, & a few Examples

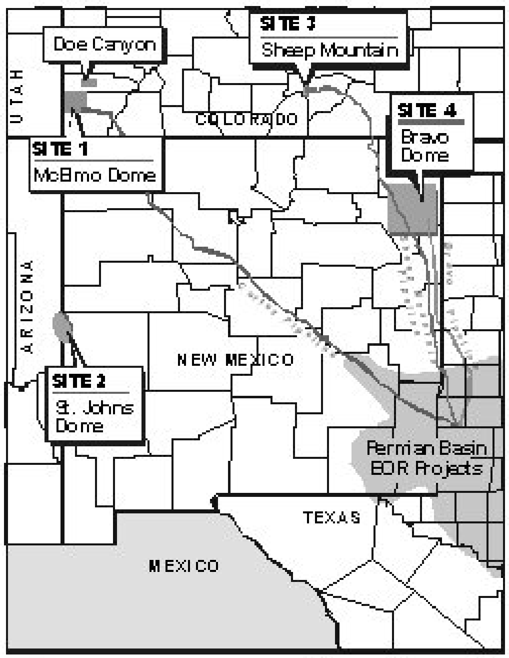
- Understanding Geologic Storage
  - Already being addressed by National Labs, JIPs, academia, etc.
- Maximizing Sequestration Potential
  - Already being addressed by National Labs, JIPs, academia, etc.
- Short Term Monitoring & Verification
  - Already being researched by world class efforts such as Weyburn, LBL's GEOSEQ, and others
- The E&P industry already knows about EOR, Natural Analogs, & is beginning to understand Pure CO2 Storage
  - Examples are SACS, Weyburn, etc.

Enhanced Oil Recovery - We Know A Lot Here



Natural CO_2 Analogs - A Lot Can Be Leveraged

Natural CO2 Reservoirs



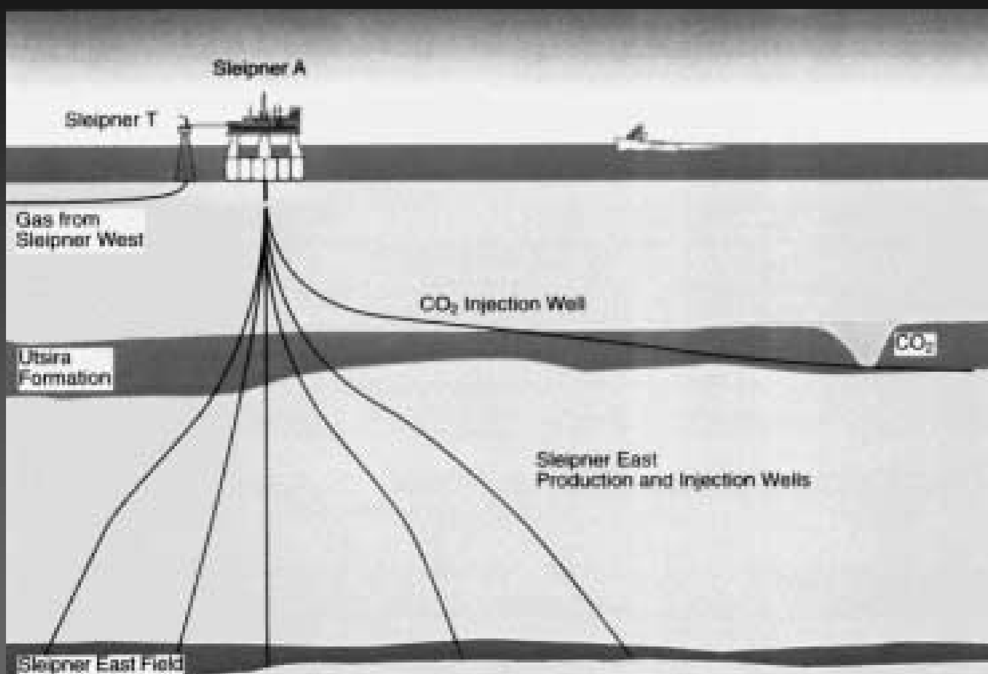
LOCATION OF NATURAL CO_2 FIELDS IN THE SOUTHWESTERN U.S.

	Original CO_2 in Place		1998 CO_2 Production		Reservoir Lithology	Depth (m)
	10 t	Tcf	10 t/yr	MMcfd		
McElmo Dome, CO	1,600	30	15.9	820	Carbonate	2,300
St Johns, AZ	830	16	0	0	Sandstone	500
Bravo Dome, NM	260	5	7.2	375	Sandstone	700
Sheep Mtn., CO	100	2	2.9	150	Sandstone	1,500

Advanced Resources International, Inc.

CO_2 Storage Offshore Norway
(courtesy of Statoil)

CO_2 Re-Injection at Sleipner, UKCS (courtesy of Statoil)



- SACS: 3 year JIP World's first commercial scale CO_2 storage project
- Evaluation of fate of CO_2
  - migration modelling
  - monitoring options

Conclusions

- The industry already knows a fair amount about EOR, Natural Analogs, etc.
- More R&D is necessary to overcome potential public perception problems
- Some Gaps already being addressed by world-class R&D organizations
  - Examples include understanding geologic storage, maximizing sequestration, short-term verification & monitoring (V&M)
- Some Gaps need additional significant work
  - HSE risk assessments; long-term V&M