Geologic Sequestration of CO_2:
Policy and Regulatory Issues

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Outline of Presentation

- Background
- Current Status
- Important Considerations
- Next Steps
- Conclusions

Why Does a Regulatory and Verification Framework Need to be Established?

- Ensure public that geologic sequestration is safe and environmentally acceptable
- Obtain public acceptance of sequestration as viable option to reduce GHG emissions
- Establish accepted, verifiable methods for characterizing volumes of CO_2 sequestered
- **While ensuring that geologic CO_2 sequestration is an economically viable GHG emission reduction alternative**

Who Cares?
Stakeholders in Framework

- CO_2 providers
- CO_2 emitters
- Oil & gas producers
- CO_2 transporters
- CO_2 "storers"
- Royalty holders
- Landowners
- Environmental groups
- Local communities
- Financial institutions
- Emissions traders

Current Regulatory Framework for CO_2 Sequestration -- Overview

- Little or no existing policy, but some are/can be extended to apply to CO_2 sequestration
  - Protection of aquifers
  - Development of oil and gas E&P facilities
- Several proposed bills in U.S. Senate address measurement and verification
- Key: Classification of CO_2 as "storage" or "waste"
- In early stages, likely to "learn by doing"
  - Policy extension in response to specific project proposals

Current Regulatory Framework for CO_2 Sequestration -- International

- London Dumping and OSPAR Conventions are key
  - Possible perception under London Convention of injection of CO_2 as dumping of "industrial waste"
  - Consensus does not currently exist
  - "Wait and see" approach seems to prevail at present
- A number of countries are pursing limited initiatives
  - Primarily involving preliminary directives and/or convening multi-stakeholder consultation groups
  - Canada appears to be country doing the most

Current Regulatory Framework for CO_2 Sequestration – United States

- Several proposed bills in U.S. Senate address geologic sequestration and/or measurement and verification, but as part of larger considerations
  - Lieberman/McCain – Climate Stewardship Act
  - Corzine, Lieberman/Jeffords – National Greenhouse Gas Emissions Inventory and Registry Act
  - Daschle – Global Climate Security Act
- Primary issue may be resolving state vs. federal jurisdictional issues

Regulatory/Verification Framework and Financial Mechanisms are Related

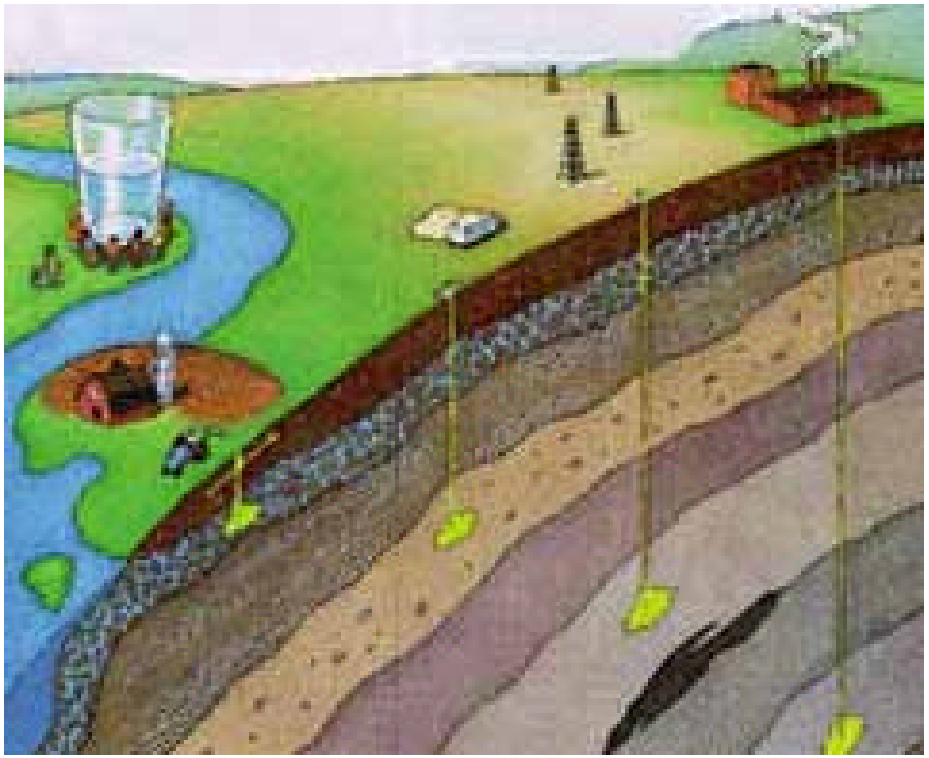
- No guidelines established on how financial mechanisms will address CO_2 sequestration
- Sequestration has been basis for some GHG emission reduction credit transactions
- Key aspect is confidence associated with verification of CO_2 sequestered
  - Possible leakage in the future
  - Clear assignment of title to CO_2 sequestered

Regulation of CO_2 Injection in Oil & Gas Fields Well Established in U.S.

- Environmental performance of CO_2-based EOR demonstrated in 80 fields globally
- For example, in Texas:
  - 52,000 permitted injection wells
  - 10,000 permitted to inject CO_2
  - 8,000 inject CO_2 exclusively
  - 1 Bcf/day of CO_2 is injected today
- Since the early 80's, this has resulted in
  - Over 380 million tonnes purchased CO_2 injected
  - Over 620 million barrels of incremental oil produced

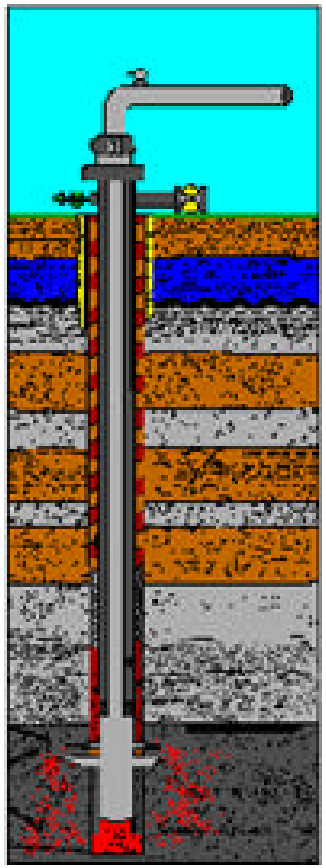
CO_2 Injection Similar to Water or Gas Injection

- Applied to:
  - Enhanced oil and gas production
  - Natural gas storage
- CO_2 supercritical at > ~ 800 meters
- CO_2 emissions volumes comparable to current produced water injection



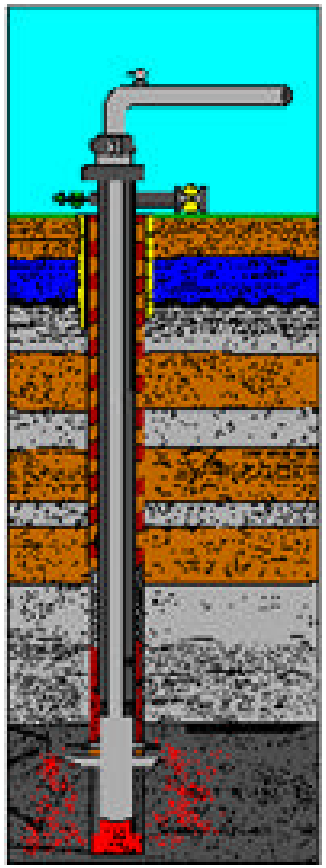
Source: Ground Water Protection Council

CO_2 Injection in Oil & Gas Fields is a Well Understood Process



- CO_2 is injected into natural traps
  - More is known about the geology of oil & gas fields than any of the other CO_2 storage options under consideration
- Less is known about storage in coal seams
- Key issue: Will the CO_2 remain "permanently" sequestered?
  - Oil & gas have been there for millions of years
  - How will "permanence" be defined?

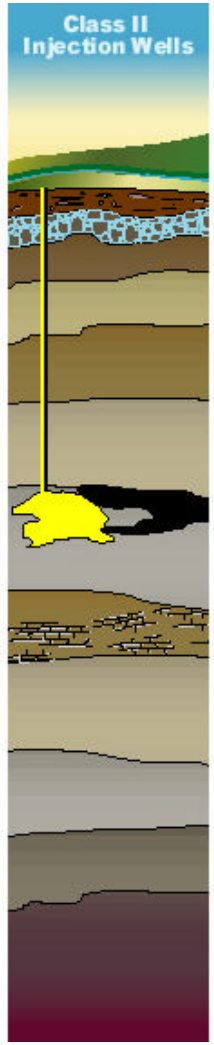
Regulation of CO_2 Sequestration Similar to Injection in Oil & Gas Fields



- State Underground Injection Control (UIC) programs could provide foundation
  - **Surface release is major risk, rather than groundwater contamination**
  - **Fluids and quantities similar to CO_2 over long term**
  - **Appropriate experience in place**
- Which existing programs best apply?
  - **Class I -- Municipal & industrial waste (inc. hazardous)**
  - **Class II -- Oil and gas production**

Class II Wells –Most Appropriate Regulatory Foundation

- Class II wells currently used for EOR
- CO_2 leakage not environmental hazard, if leakage in fact occurs
- Class II approach can take advantage of existing knowledge, tools
  - Monitoring, modeling, etc.
  - Will probably require some modification to address issues associated with long-term storage

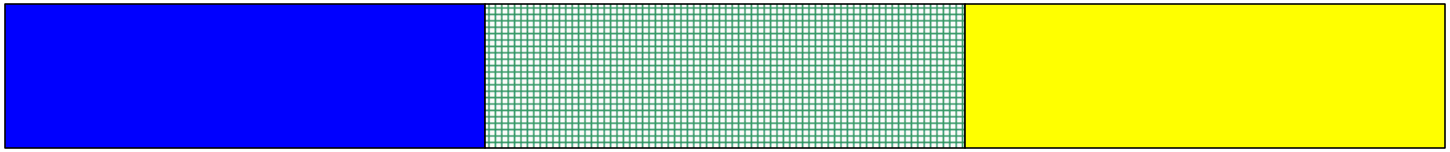


Interstate Oil and Gas Compact Commission Efforts

- IOGCC workshop, conducted in July 2002, established a need for four key actions initiated by the states
  - Encourage the IOGCC to take a policy position on CO_2 sequestration
  - Mobilize IOGCC resources develop regulatory guidelines.
  - Recommend DOE characterize options for long-term CO_2 storage,
  - Recommend DOE continue and expand CO_2 sequestration RD&D
- Passed official resolution at December 2002 meeting
  - Facilitate coordination among member states and other relevant organizations, including DOE
  - Develop recommended regulatory guidelines to assist member states

CO_2 Injection/Sequestration:
Addressing Several Phases of Activity

Active Injection/ Flooding Phase	Soaking Phase	Long-Term Storage Phase

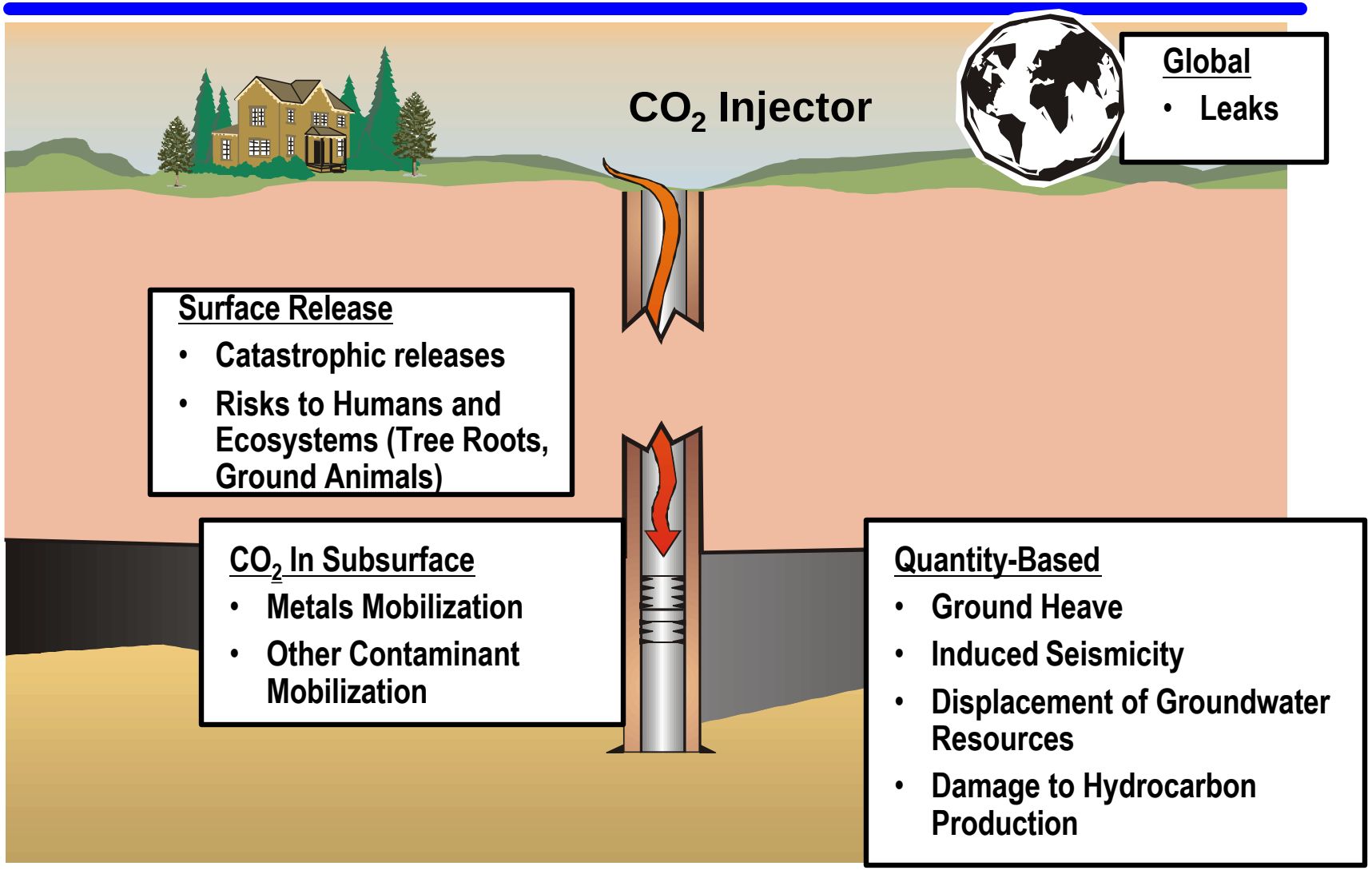


CO_2 Flooding Companies	"New" Hybrid Environmental/Flooding Companies	Long Term Containment Monitoring
10 - 30 Years	20 - 60 Years	> 50 Years

Converting CO_2 Injection to Long-Term Storage

- **Need to distinguish two categories of risks**:
  - Global Risks -- Local Risks
- **Risks relate to unique features of long-term storage**
  - Assessing and configuring reservoirs for long-term (~1,000 year) storage of CO_2.
  - Maintaining CO_2 in reservoir (at pressure) rather than "blow down" reservoir and reuse the CO_2.
  - Establishing cost-effective long-term monitoring and verification systems
- **Better understanding of risks needed**

Potential Risks from CO_2 Sequestration



Uncertainties That Research Can Help Address

- Realistic assessment of potential risks posed
- Characteristics of suitable formations
  - Right properties to provide CO_2 traps?
- Determination of the length of time CO_2 remains stored
  - Seal/gas cap interaction, impact of drilling on containment
  - Basin hydraulics and diffusion rates
  - Reactivity with underground minerals and solutions
  - Impact of potential seismic activity

Research Requirements Related to Monitoring and Verification

- Characterize storage integrity
  - CO_2 injectivity on subsurface dynamics
  - Potential subsurface confinement
  - Surface leaks
- Verify stored volumes
  - To establish emission reductions
- Optimize storage during “filling” process
- Calibrate predictive models

Good Science is not Enough: Public Perceptions Are Also Key

- **Public perception issues will need to be confronted early**
  - Determined and organized local opposition could derail progress despite larger global benefits
  - Public will need to be involved early in process
  - Proactive information dissemination critical
- **Public concerns**
  - Technology performance
  - Risks/benefits of alternatives
  - Effectiveness of risk management mechanisms and institutional oversight
- **Geologic sequestration likely to be divisive issue among environmentalists**

Establishing an Effective Framework:
A Role for R&D

- Multiple technology efforts underway globally to respond to the technical challenges
- DOE's programs have established technology targets for monitoring and verification:
  - Affordable, acceptable indirect monitoring by 2006
  - Low-cost, acceptable direct CO_2 monitoring technology by 2008
  - Forthcoming regional partnerships to address regional policy/perception issues and barriers
- Technology developments could both define and be defined by evolving regulatory framework

Regulatory Framework - Success Factors

- Public acceptance of sequestration
  - Based on realistic appraisals of risks, using best science
  - To ensure appropriate responses to these risks
- Demonstrated techniques for cost-effective measurement, monitoring, and verification
  - To determine quantities stored accurately
- Establishment of a level, predictable playing field
  - To verify credit-eligible emission reductions
- **Application of geologic sequestration to reduce GHG emissions**

Opportunities for Economic CO_2 Sequestration: Options

Opt. 1: Efficient, Cost Effective Regulations

- Class II style requirements
- Efficient permitting and oversight
- Appropriate risk-based management

Result: Significant cost-effective CO_2 sequestration with incremental oil and gas production

Opt. 2: Cumbersome, Costly Regulations

- Class I style requirements
- Slow, costly, cumbersome permitting and oversight
- Excessive monitoring and verification

Result: Limited CO_2 sequestration and no additional oil and gas recovery due to high costs

Conclusions

- Early characterization of policy direction critical to ensure sequestration is viable GHG management option
  - **Gain public acceptance for CO_2 sequestration**
  - **Enhance R&D effectiveness**
- An effective regulatory framework will need to be transparent, adaptable, and flexible, but stable
  - **To ensure efforts to pursue sequestration projects are not stymied**
- Best to build upon established regulatory foundation
  - **Addresses comparable issues and concerns**
  - **To be modified to address long-term storage considerations**
  - **Regulatory expertise already exists within state agencies**