

# Carbon Capture and CO<sub>2</sub> Enhanced Oil Recovery as Clean Development Mechanism Projects

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INTEGRATED ENVIRONMENTAL SOLUTIONS

# Agenda

- Kyoto Protocol / Clean Development Mechanism
- Carbon Capture and Sequestration
- Enhanced Oil Recovery / CO<sub>2</sub> EOR
- Captured Carbon (C<sub>2</sub>) Market

# Kyoto Protocol/CDM

# Kyoto Protocol

- Part of the United Nations Framework Convention on Climate Change (UNFCCC)
- Entered into Force 16 Feb 2005
  - 187 signators
- Commits to average CO<sub>2</sub> reductions of 5.2% from 1990 levels by the year 2012
- Assigns Annex B countries (industrialized countries and economies in transition that historically generated the most Carbon
- Establishes “Flexible Mechanisms” for emission reduction

# Flexible Mechanisms

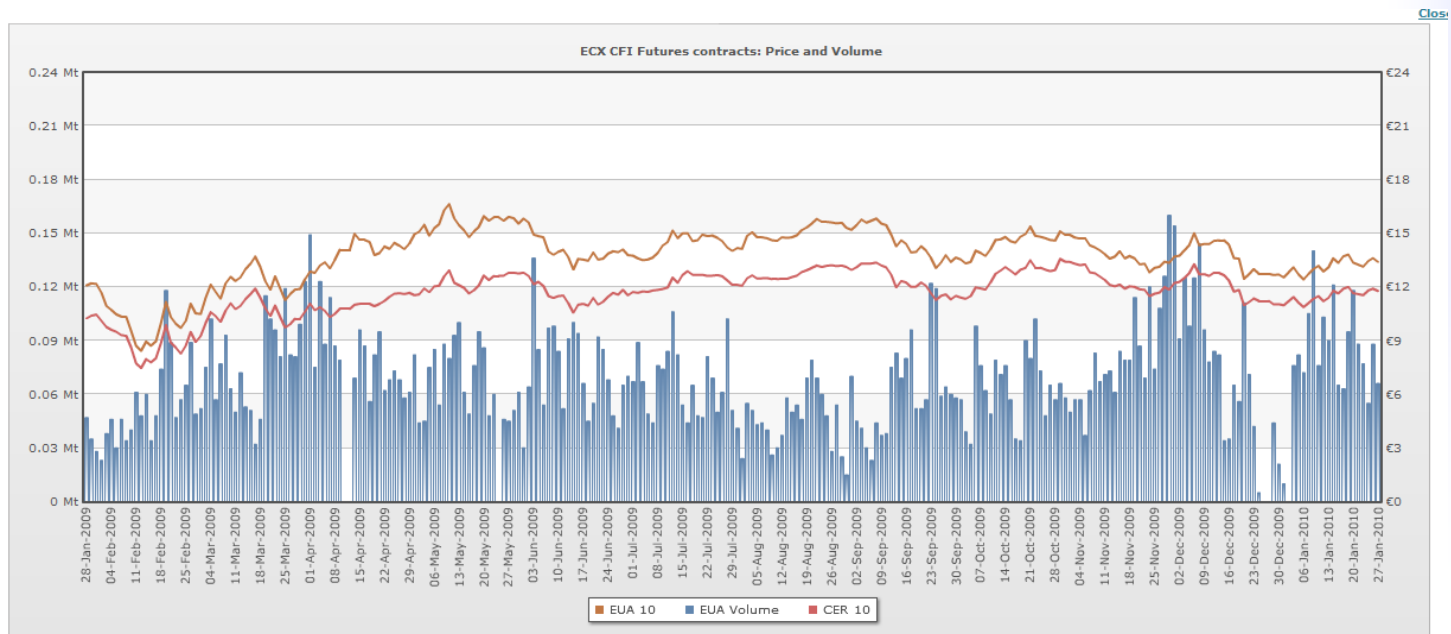
- Emission Trading Programs
  - Annex B countries can trade to meet emission commitments
  - Must be **supplemental** to national effort
- Clean Development Mechanism (CDM)
  - Allows credits from projects in **poorer** countries to be used by **rich** countries
- Joint Implementation (JI)
  - Enables countries with binding targets to get credit from projects carried out in other countries with binding targets

# CDM Projects

- Since 2006
  - 1800 projects registered
  - 3.6 Billion Metric Tonnes CO<sub>2</sub>eq
- Requires Annex B countries to sponsor projects in developing countries
- Projects must show “Additionality”
- Must have an approved “Methodology”
  - To date there are 82 approved Methodologies
- Designed to *offset* CO<sub>2</sub> – not manage it

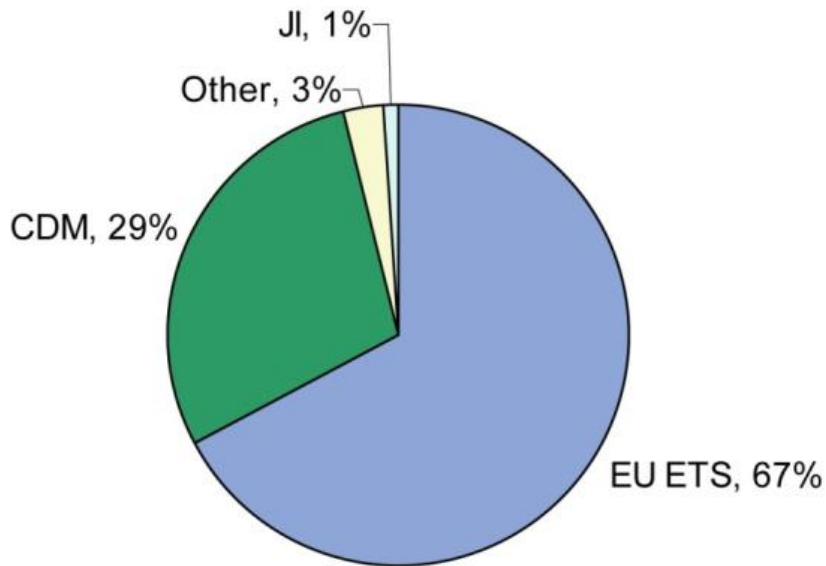
# CDM Investment

- Typical CDM return is around 10%
- Self-Sponsorship
- Stability of CER market

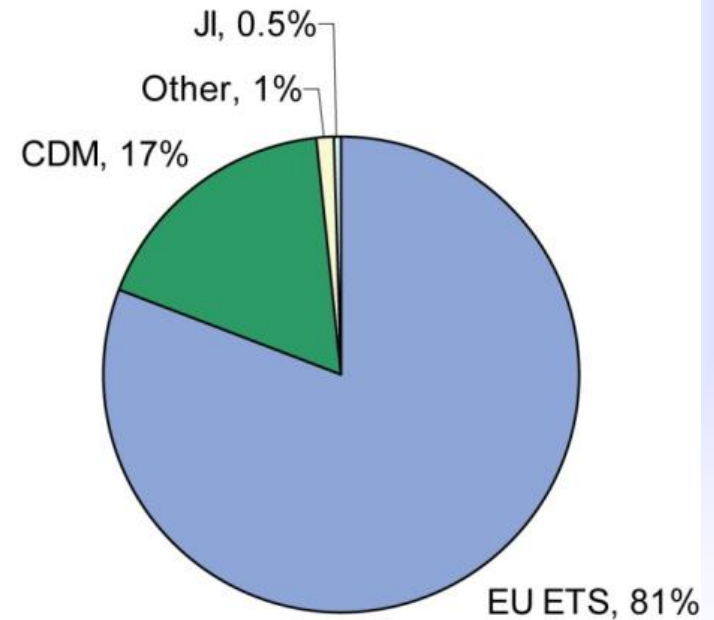



# Global Emissions Trading

**a** Physical volume (1,640 Mt CO<sub>2</sub>e)



**b** Financial value (\$30 billion)



 Hepburn C. 2007.  
Annu. Rev. Environ. Resour. 32:375–93



# CDM Challenges

- Funding/Global Recession
- Security
- Accountability
- Approvals/Additionality
- Renewal

# **EU halts emissions trading after hacking**

**The European Union on Wednesday suspended trading in carbon credits for a week after hackers broke into the national trading registries and stole and then sold millions of euros worth of credits.**

**'This transitional measure is taken in view of recurring security breaches in national registries over the last two months,' the European Commission said in a statement.**

**The European Union Emission Trading Scheme (or EU ETS) is the largest multi-national, greenhouse gas emissions trading scheme in the world. Limits are placed on the amount of carbon dioxide companies may emit, and those who pollute less are free to sell them to companies that need more.**

**This is not the first time criminals have targeted the ETS. Last year a series of emails sent to trick users into divulging their passwords, a type of attack known as 'phishing', sparked panic and forced a halt into trading in numerous countries.**

**The European police organisation Europol estimate a value added tax (VAT) scam on carbon credits in 2008 and 2009 netted criminals five million euros.**

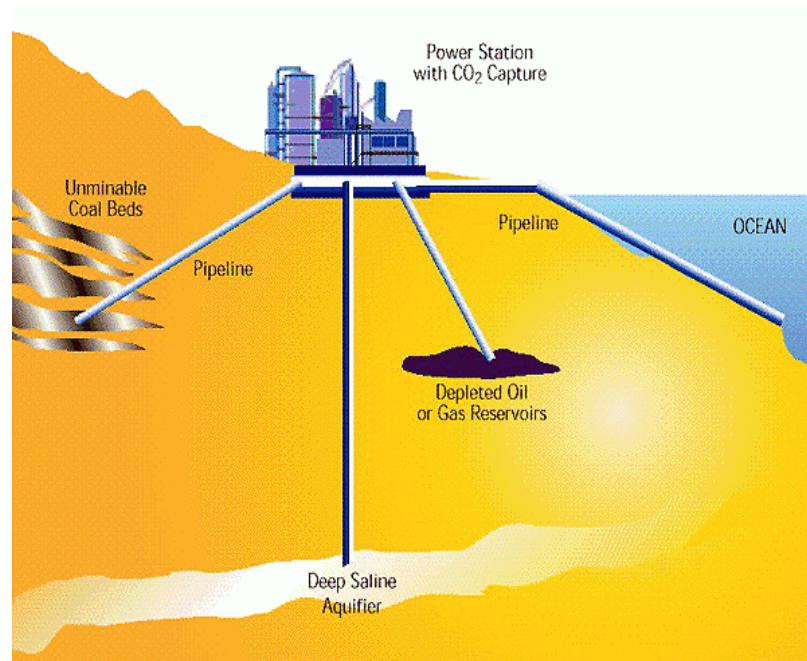
**Thursday January 20, 2011, Sky News**

# Carbon Capture and Sequestration

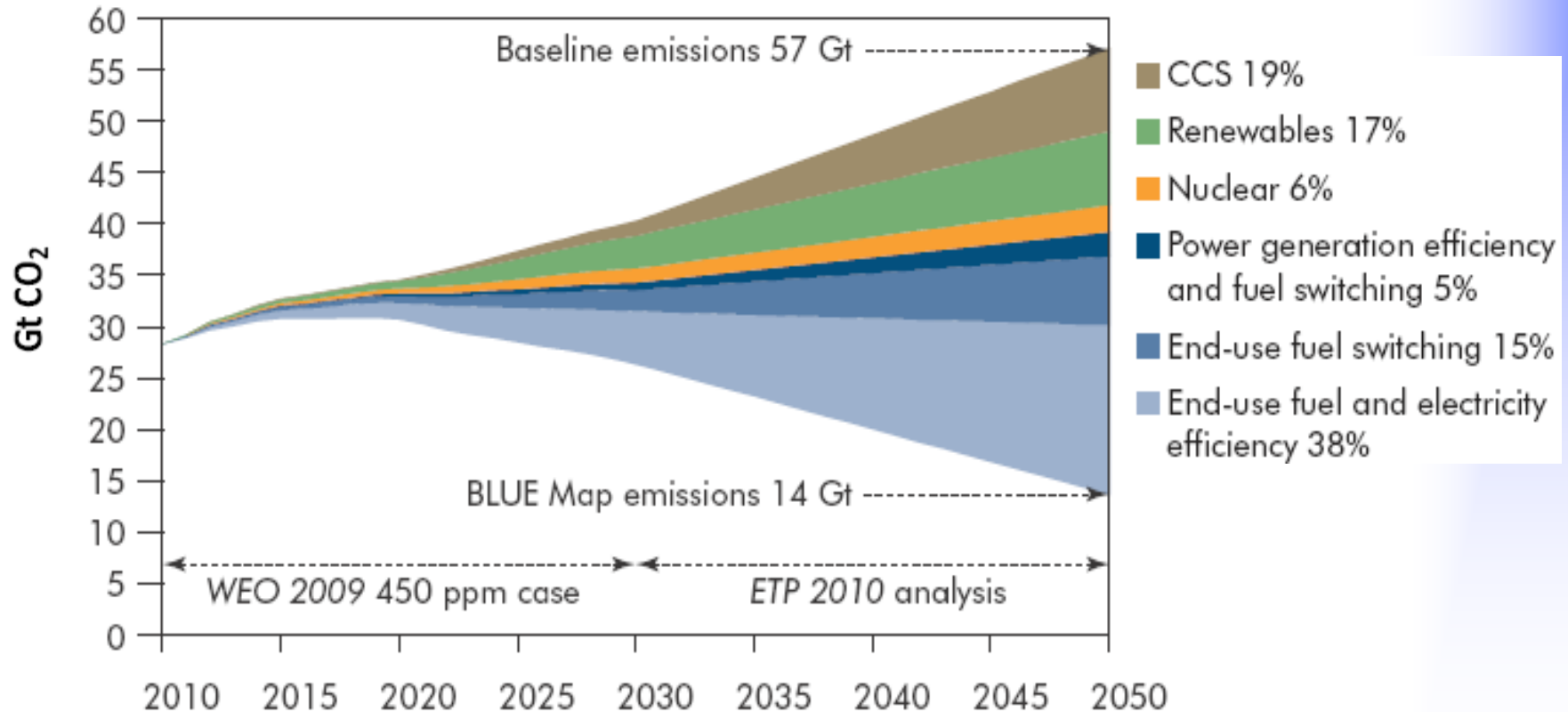


# Carbon Capture and Sequestration (CCS)

- Capture CO<sub>2</sub> from anthropogenic sources
- Inject into a geological or marine feature
  - Prevent generated CO<sub>2</sub> from entering the atmosphere



# Key CO<sub>2</sub> Control Technologies



Source: IEA ETP 2010

# CO<sub>2</sub> Capture

- Post-Combustion
  - Only Retro-fit available for existing facilities
  - Adds 20-35% additional power requirements
- Pre-Combustion
  - Converts fuel to H<sub>2</sub> for easier capture
- Oxy-Fuels
  - High efficiency burn with higher O<sub>2</sub>
- Industrial Processes



# CO<sub>2</sub> Transport

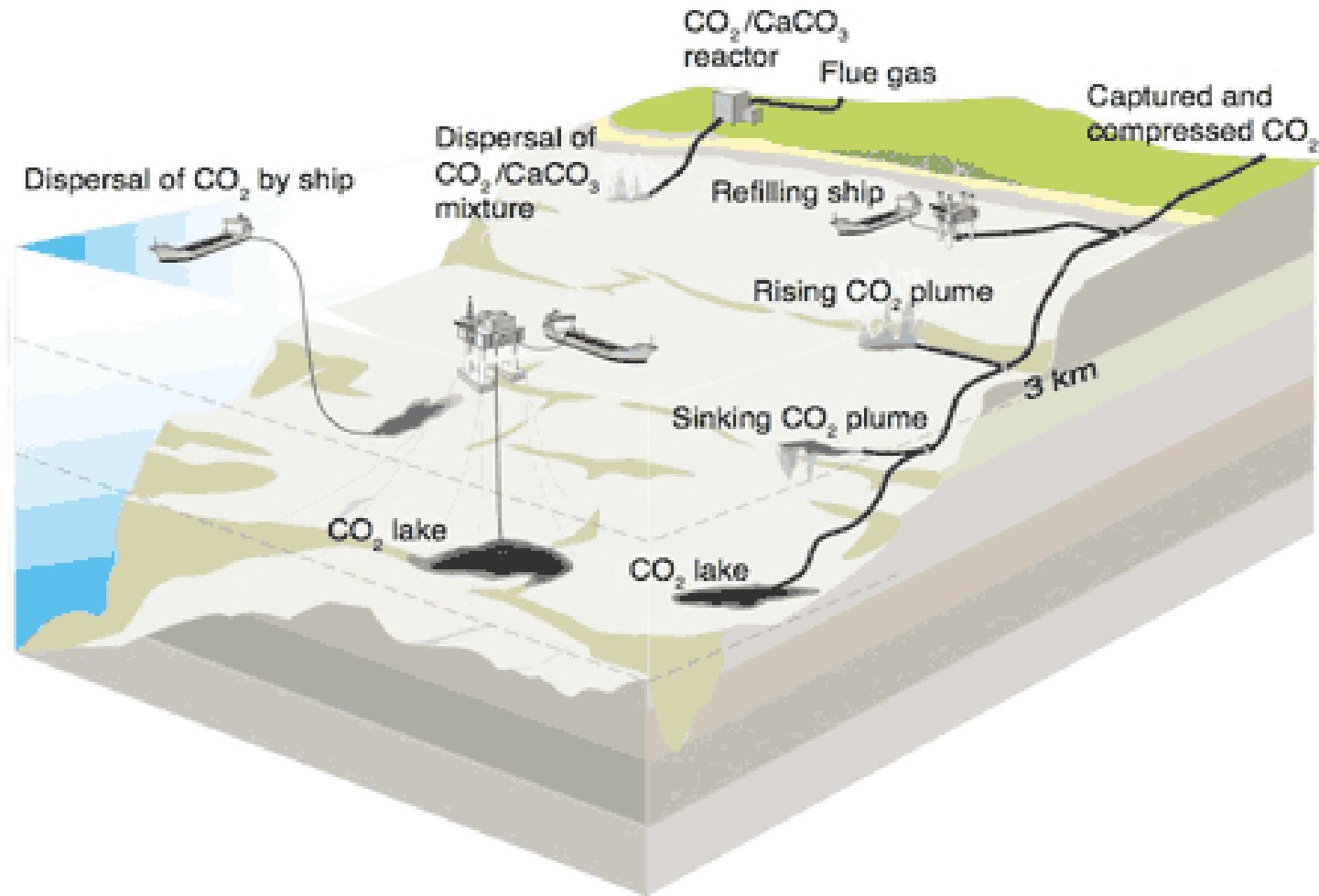
- **Shipping**

- Tankers aboard ships can be used to cover long distances or offshore storage.
- CO<sub>2</sub> is transported in a liquid phase under moderate pressure and low temperature.

- **Pipelines**

- CO<sub>2</sub> is maintained in a supercritical state under a pressure over 74 bar.
- Intermediate recompression depending on the distance of storage site

# CO<sub>2</sub> Storage





# CCS Issues

- Classification – Waste or Commodity?
- HSE Risks – Water and Local Air
- Costs – Development and Implementation
- Public Policy – NIMBY
- Planning – Storage Ownership and Liability

# Barendrecht, The Netherlands

Protest against a Shell project to store 11 million tons of CO<sub>2</sub> in depleted gas fields



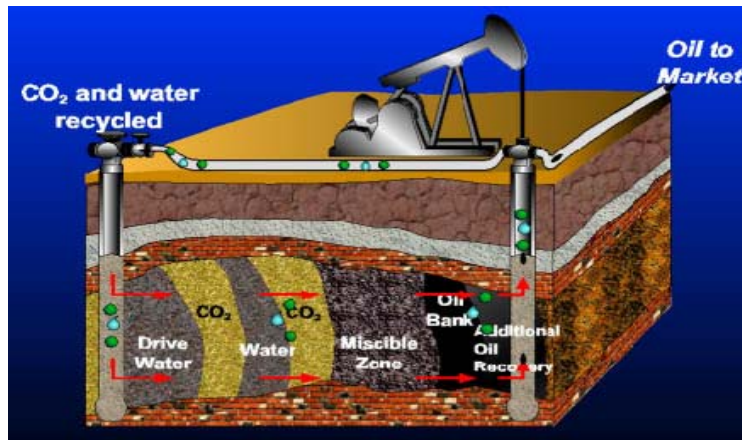
**Project dropped Dec 2010**

[www.headlines.nos.nl](http://www.headlines.nos.nl), and Scientific American

# CCS and CDM

- CCS was excluded from CDM Approved Methodology list until Dec 2010 (Cancun Conference)
  - CDM benefitting countries concerned over flood of CERs into market
- CCS different from all other Methodologies
  - CO<sub>2</sub> is generated, not offset or prevented
  - CO<sub>2</sub> treated as a waste product for disposal
- CDM offers some financial incentive for CCS development and implementation

# Enhanced Oil Recovery



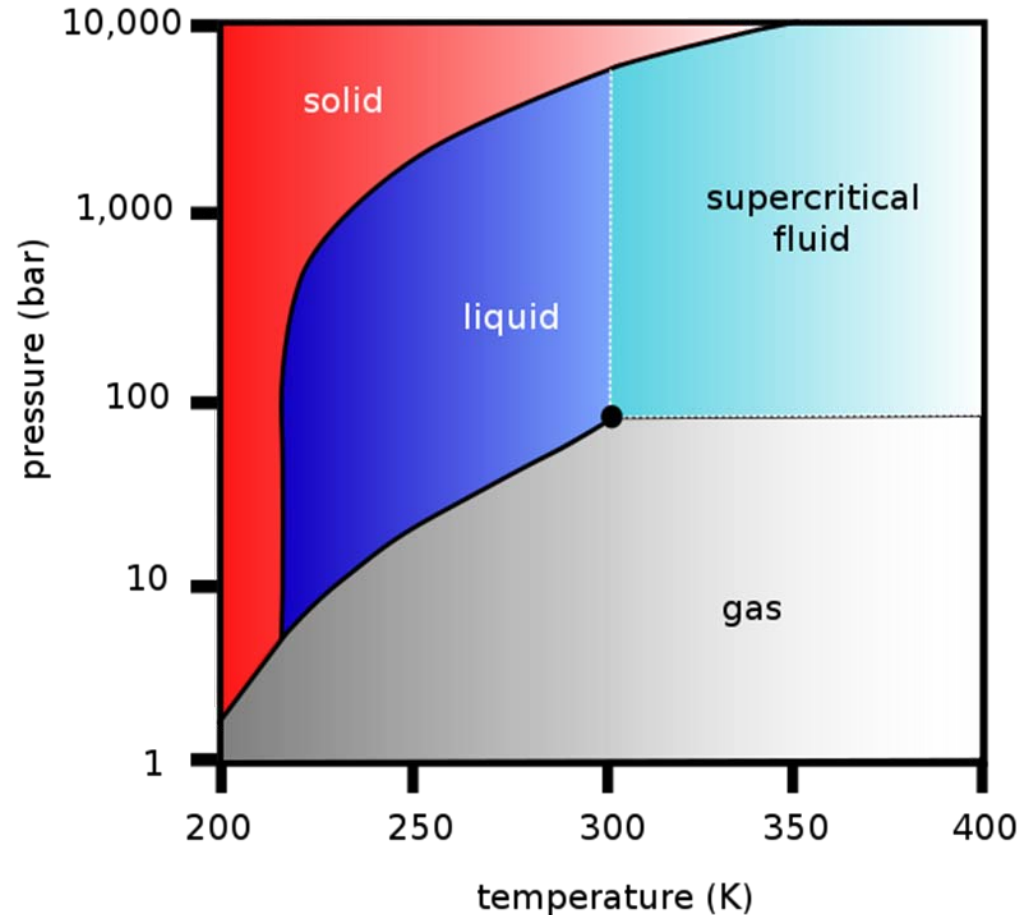
# What is EOR?

- Primary (Natural Uplift)
  - 5-15% of reserves recovered
- Secondary (Assisted pressure)
  - Pumps (ESP, Rod)
  - Water injection
  - 30-50% of reserves recovered (includes primary)
- Tertiary (EOR – improved mobility)
  - Additional 5-15% recovered
  - Viable at around \$20/bbl

# CO<sub>2</sub> EOR

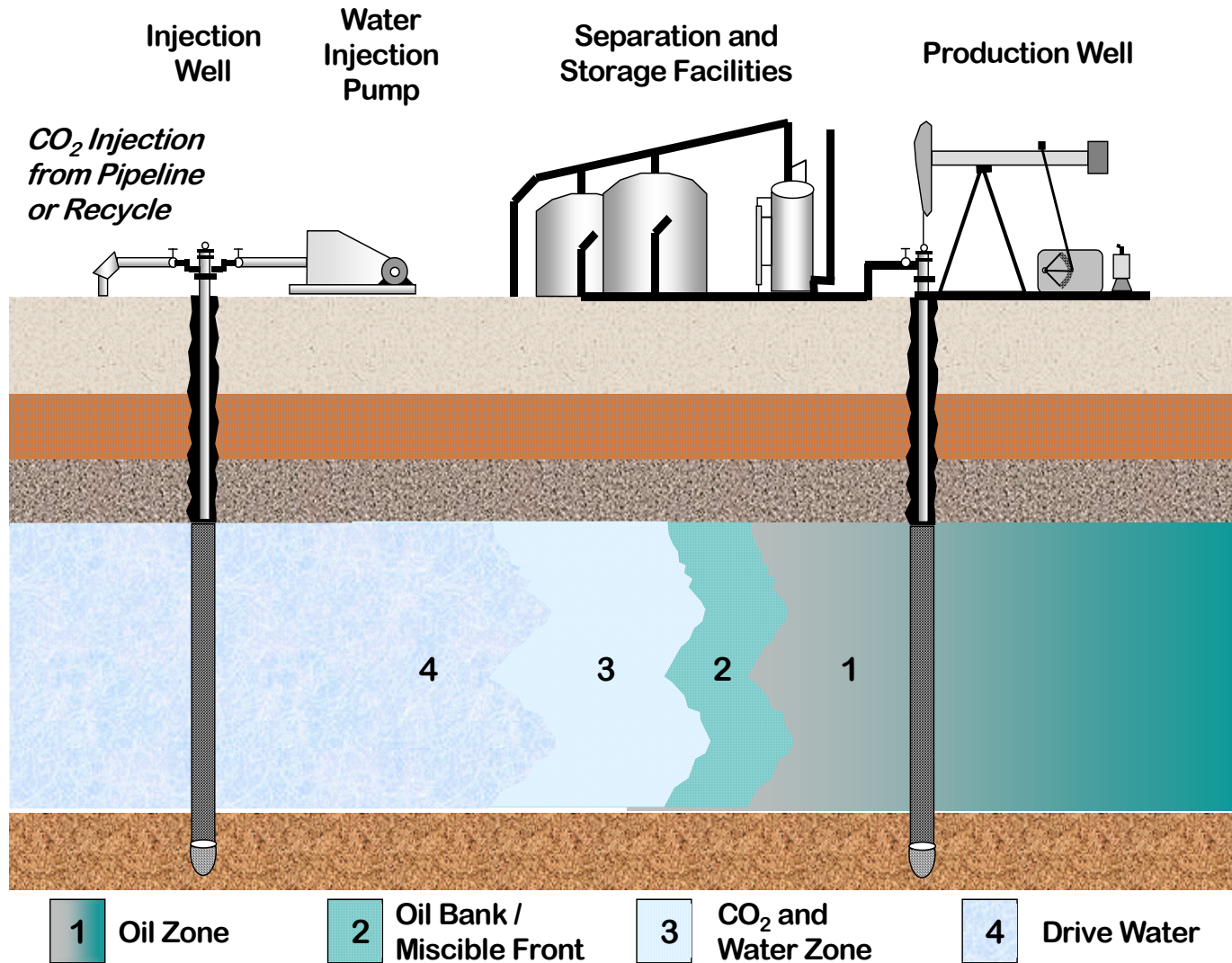
- CO<sub>2</sub> must be in a supercritical state
- Depth: 1,000 – 12,000ft
- API: 28 - 48
- Reservoir Porosity: 4-24%
- Reservoir Permeability: 2-200 mD
- CO<sub>2</sub> reduces the viscosity of the oil
  - From 500 cp (Centipoise) to 100 cp
    - Water = 0.9 cp
  - Easier to extract
- Operating fields use Water/CO<sub>2</sub> sweeps
- No waterflooding residuals
  - Brine, toxic metals

# CO<sub>2</sub> Properties



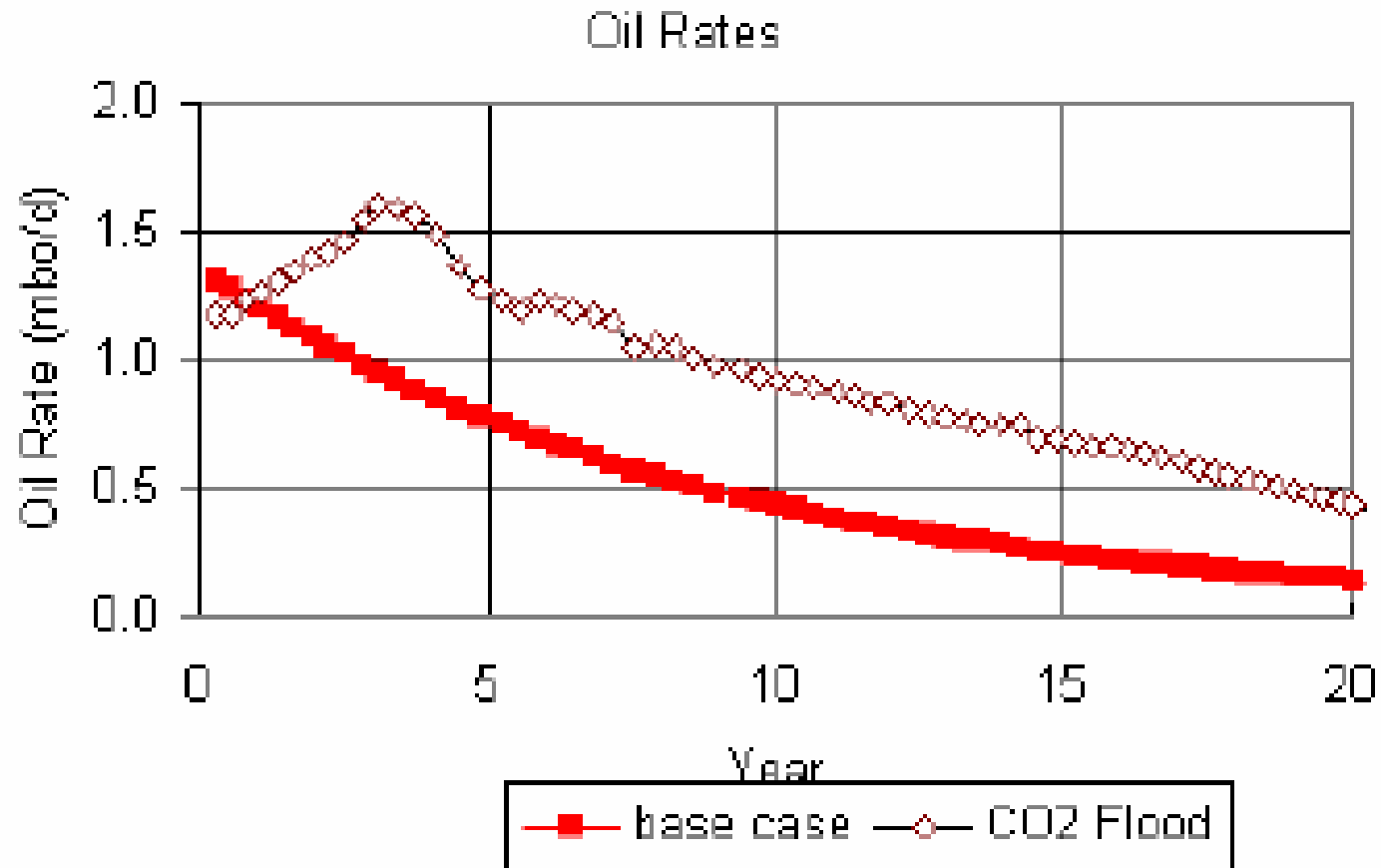
Constituent	Value	Units
CO <sub>2</sub>	95%	by volume
H <sub>2</sub> S	<10	ppmbw
Sulphur	<35	ppmbw
THC	<5%	by volume
N <sub>2</sub>	<4%	by volume
O <sub>2</sub>	<10	ppmbw
H <sub>2</sub> O	<25	#/mmcf

# CO<sub>2</sub> EOR Process





# Effectiveness



# CO<sub>2</sub> EOR Benefits for CCS

- Economic Incentive to Develop Technologies
  - CO<sub>2</sub> is purchased (commodity)
- Resolves mineral rights issues
  - Storing in a pre-defined field
- Long term liability
  - Risks already determined
- ***Recovered oil is 70% “Carbon Free”***
  - Accounting for C in oil and C required for extraction

# Carbon Free Fuel

- Typical barrel of oil contains 0.42 Mt CO<sub>2</sub>
  - Does not account for Carbon to Market
- 0.26 – 0.32 Mt CO<sub>2</sub>/bbl remains in the reservoir
  - 60%-70% Carbon sequestered
- Other Fuels
  - Non EOR oil is 0% Carbon Free
  - Bio Fuel is 10-15% Carbon Free

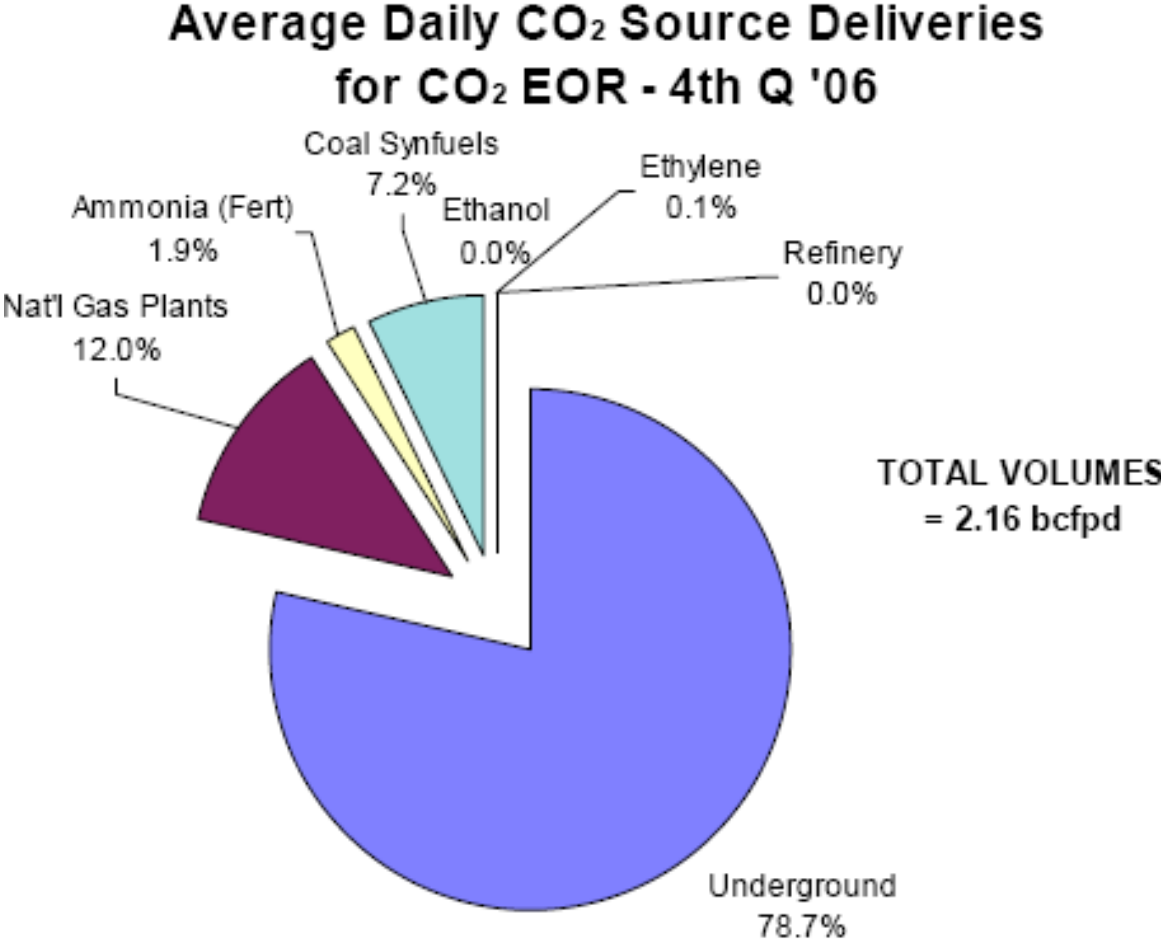
# CO<sub>2</sub> EOR History

- First demonstrations in 1960s (US Dept of Energy)
- Most CO<sub>2</sub> EOR projects in North America
- Countries with active CO<sub>2</sub> EOR projects include:
  - UAE, Thailand, Indonesia, Russia, Saudi Arabia and Turkey

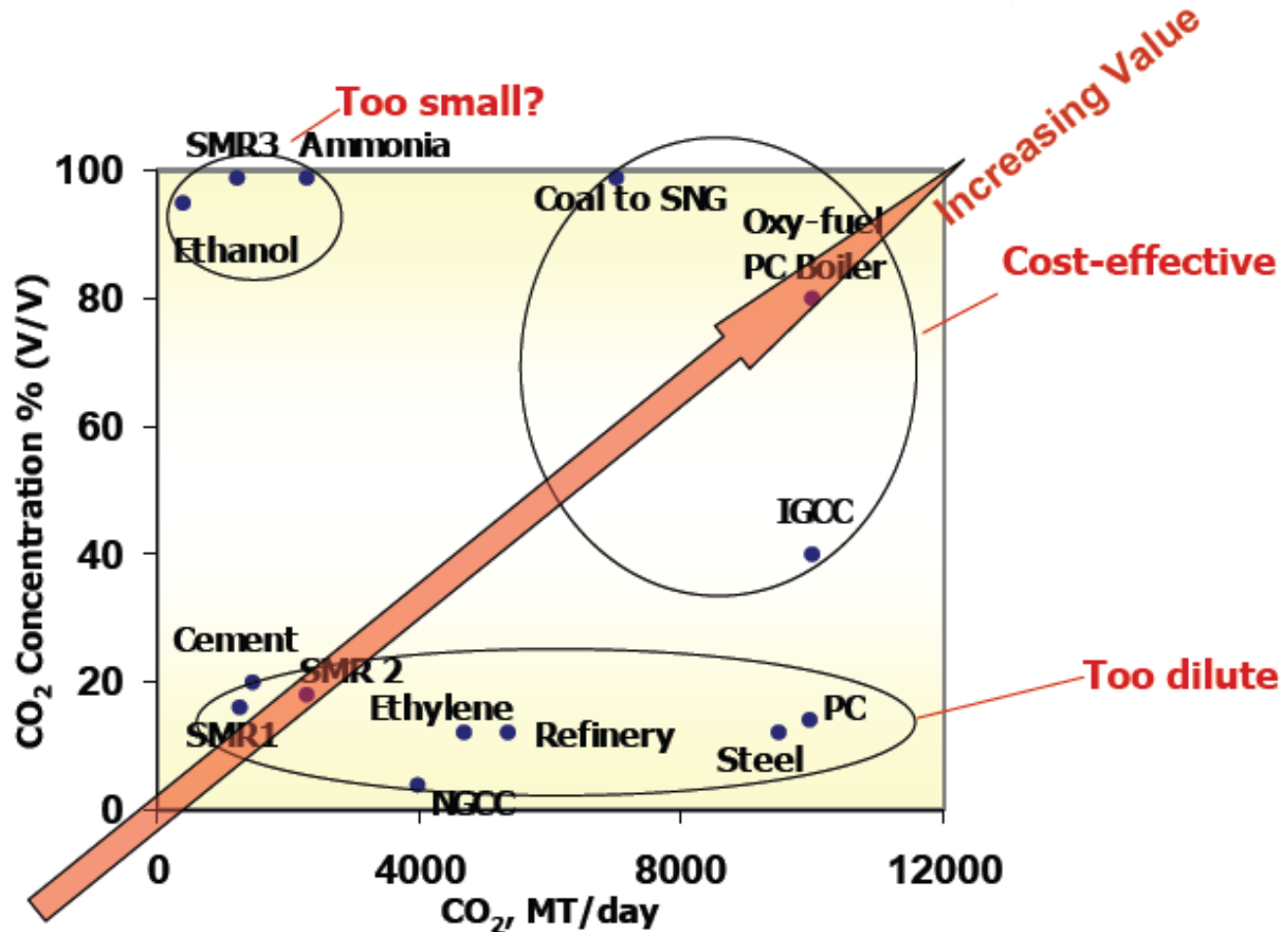
# CO<sub>2</sub> EOR Utilization

- Weyburn Oil Field (Canada)
    - 18 million ton CO<sub>2</sub> to recover an additional 130 million barrels (0.138 Mt of CO<sub>2</sub> / bbl)
    - Extends field life by 27 years
  - DOE study shows higher utilization
    - Mean = 0.698 Mt/STB (Short Tank Barrel)
    - STD = 0.301 Mt/STB
- US DOE (2006)

# Current CO<sub>2</sub> Sources for EOR



# Collecting CO<sub>2</sub> from CCS



SMR1 – SMR/PSA plant syngas; SMR2 – SMR/PSA plant flue gas  
 SMR3 – SMR/Amine plant CO<sub>2</sub>; PC – pulverized coal power plant  
 SMR – Steam Methane Reformers

# The Capture Carbon (C<sup>2</sup>) Market



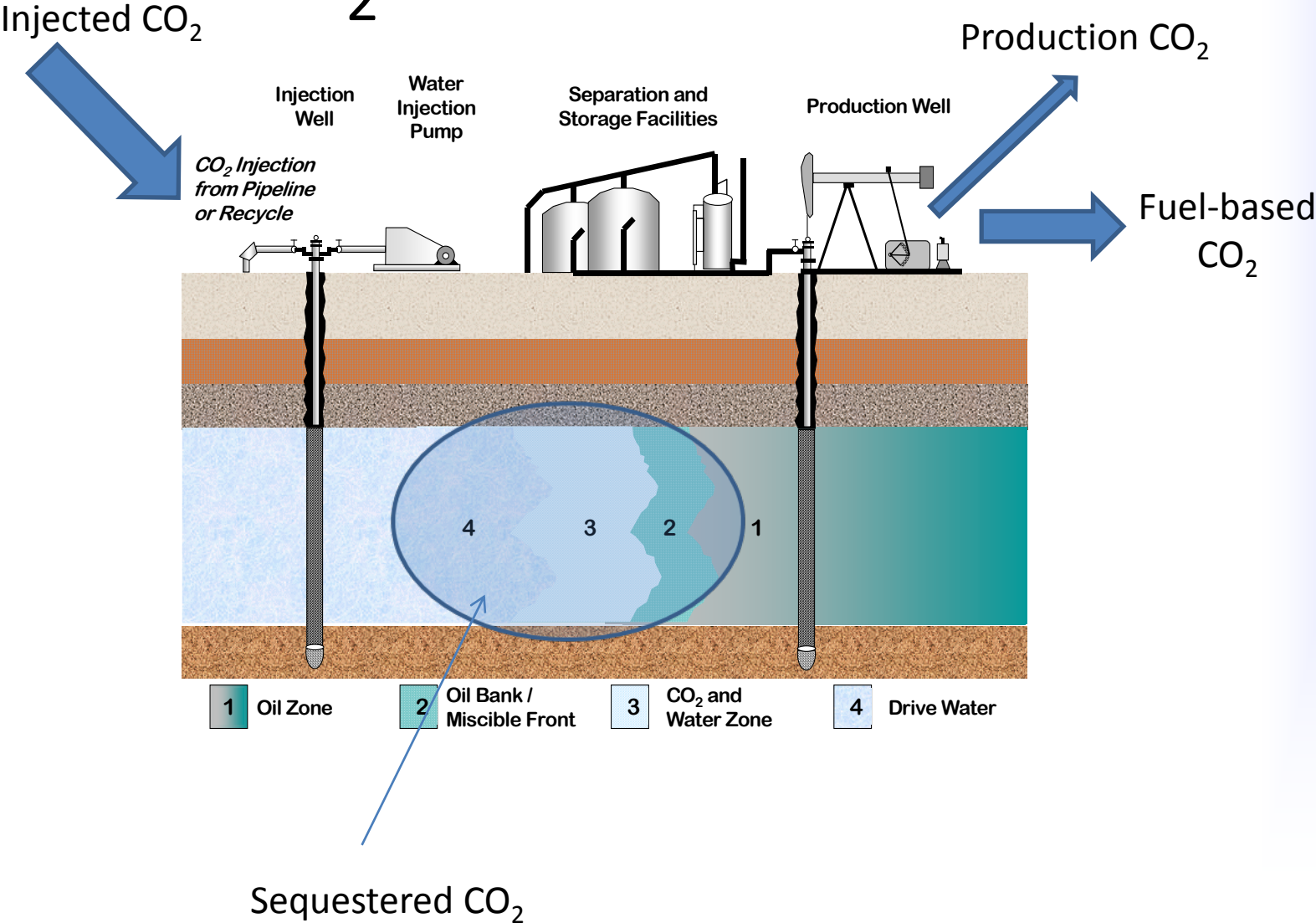
# Treat CO<sub>2</sub> as a Commodity

- Is CO<sub>2</sub> captured? – Commodity
- Is CO<sub>2</sub> reduced (or offset)? - CDM

# Captured CO<sub>2</sub> Market

- CO<sub>2</sub> EOR drives demand
- Not enough available for EOR production through CCS
- ETS based on CERs – CO<sub>2</sub> that does not exist
- New market needed to trade CO<sub>2</sub> as a commodity
- Credits for Sequestered portion

# CO<sub>2</sub> EOR Value Chain



# Demand Driven Markets

- Industrial countries (Annex B) capture CO<sub>2</sub>
- Transport CO<sub>2</sub> to oil fields for EOR
  - Pipelines
  - Ships
- Inject CO into fields
  - 40% escapes due to production
  - 60% remains in reservoir

Leverage that 60%!

- CDM/JI
- Carbon-free Fuel

# Summary

- CCS and CDM play a vital role in Carbon Management
- CDM financial incentives not enough to fund CCS projects
- CO<sub>2</sub> EOR provides a market for captured CO<sub>2</sub>
- Captured CO<sub>2</sub> should be considered a commodity not a waste

# BONUS SLIDE!

*Wireless Information System  
for Emergency Responders*



- Free application from National Library of Medicine
- Available online, PC, iPhone, and SmartPhones
- 5,236 known chemicals, response toolkits, and incident management tools
- Search “WISER”