

*Wyoming Oil & Gas Conservation Commission*

# Status of CO<sub>2</sub> Flooding & Future Options

Carbon Sequestration Work Group  
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# HOW TO AVOID EMISSIONS?

## *WHAT ARE THE U.S. MARKETS FOR CO<sub>2</sub>*

- Existing
  - CO<sub>2</sub> EOR (2.2 bcfpd)
  - Merchant CO<sub>2</sub>
    - Hydrofracturing services (60 mmcfpd)
    - Food Grade (550 mmcfpd)
      - Food, beverage, waste water treatment
- Potential
  - Enhanced Coal Bed Methane
  - Enhanced Gas Recovery

**IF: WITH CO<sub>2</sub> CAPTURE**

**THEN: NEW SOURCES OF CO<sub>2</sub> FOR EOR (1)**

**EXISTING SOURCES (BUT NOT CAPTURED)**

- EXISTING BUT NON-UTILIZED INDUSTRIAL CO<sub>2</sub> SOURCES
  - NATURAL GAS BYPRODUCT CO<sub>2</sub>
  - HYDROGEN PLANTS
  - ETHANOL
  - CEMENT
  - EXISTING FOSSIL FUEL POWER PLANTS
  - PETROLEUM COKE GASIFIERS
  - OTHERS

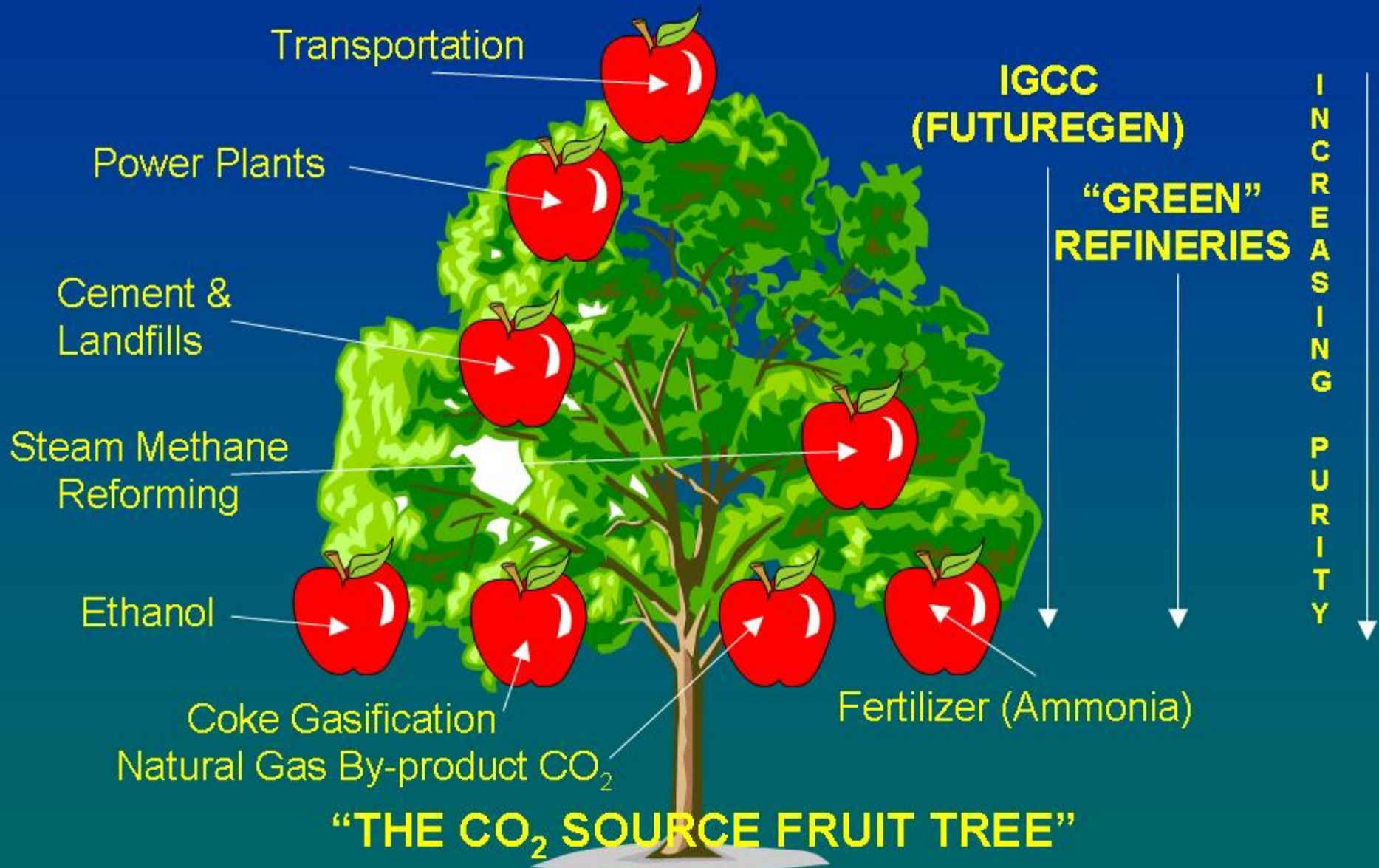
## *IF*: WITH CO<sub>2</sub> CAPTURE

### *THEN*: NEW SOURCES OF CO<sub>2</sub> FOR EOR (2)

#### COMING SOURCES

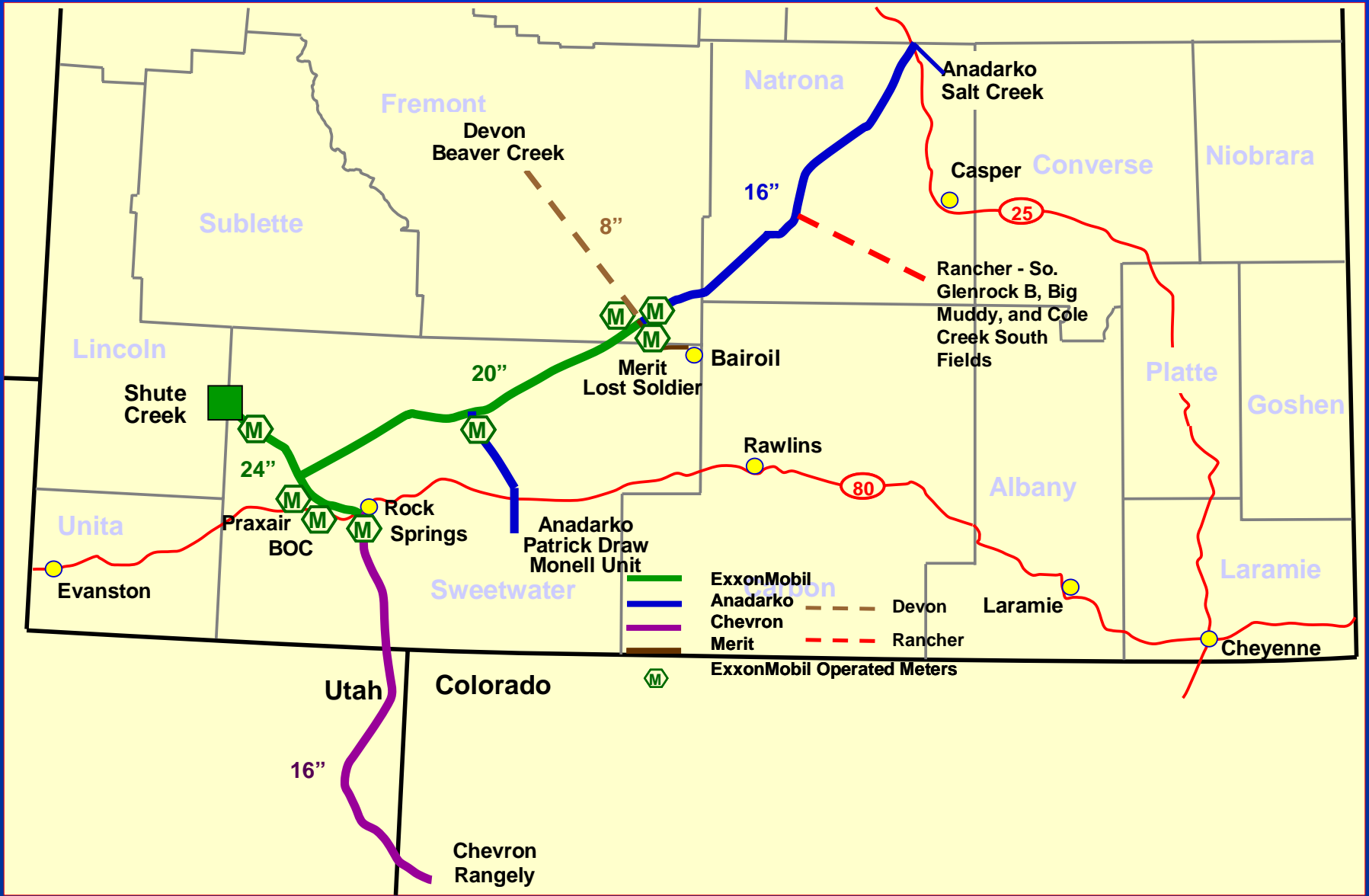
- NEWLY DEVELOPING INDUSTRIAL SOURCES
  - ELECTRIC POWER PLANTS
    - RETROFITS FOR CAPTURE
    - NEW POST COMBUSTION CAPTURE (e.g., TENASKA – SWEETWATER, TX)
    - COAL GASIFICATION (FUTUREGEN-LIKE (e.g., Duke @ Edwardsport)
  - SYNGAS AND POLYGEN GASIFICATION (e.g., DKRW in WY, Eastman in GC)
  - OIL SHALE AND IN-SITU GASIFICATION
  - OTHERS

# Industrial CO<sub>2</sub> Sources



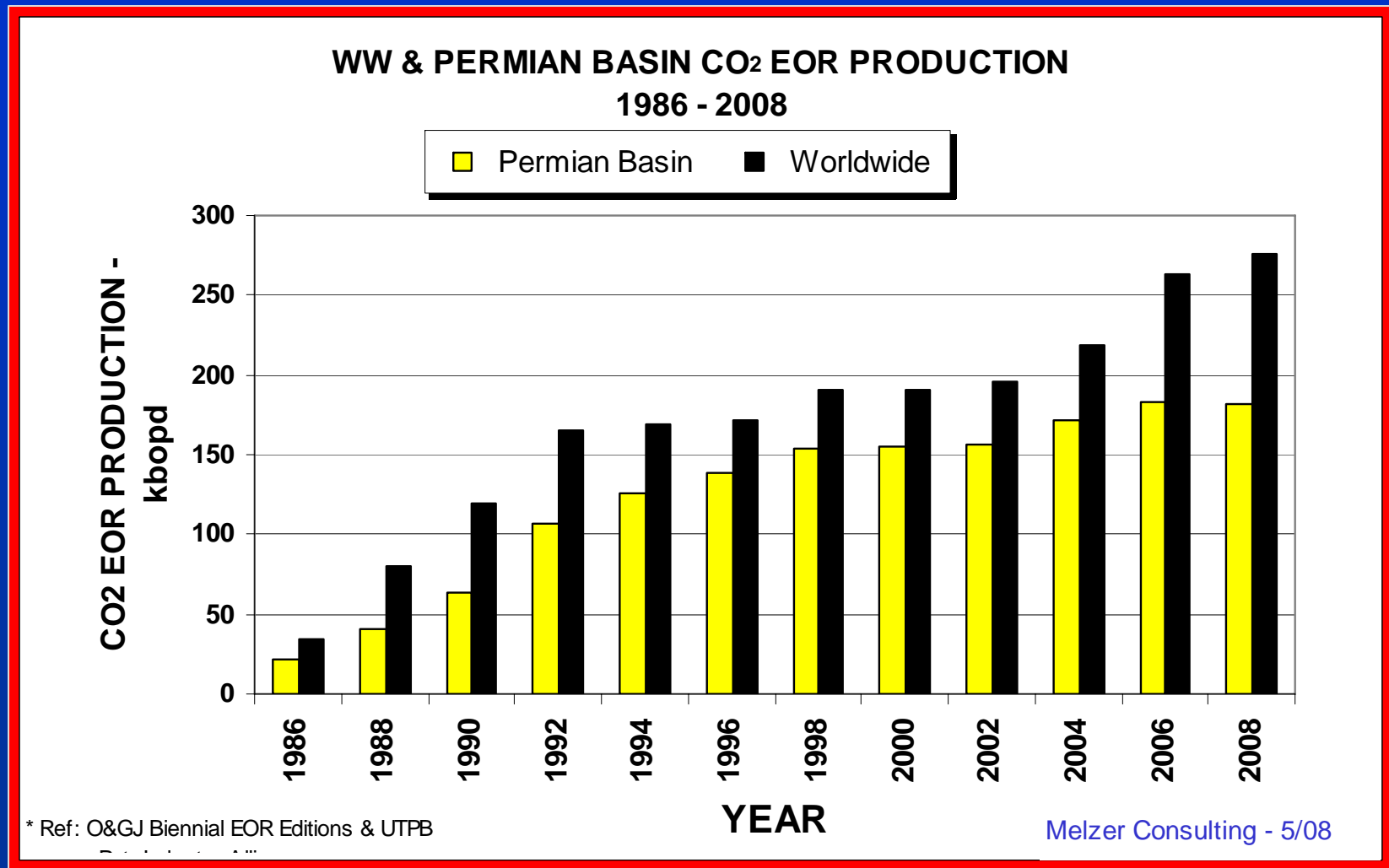


# Wyoming CO2 Pipelines



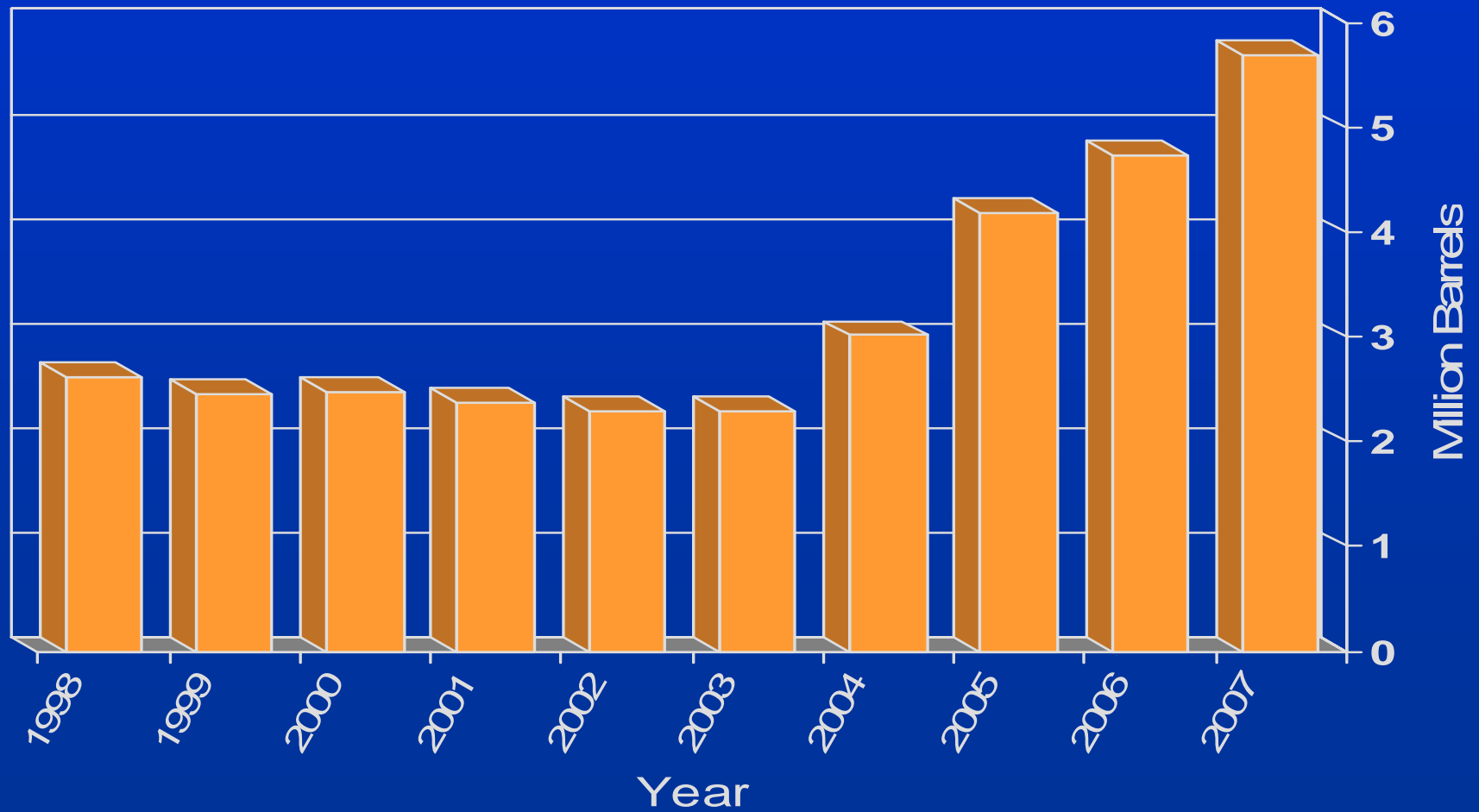
# BACKGROUND

## (OF CO<sub>2</sub> EOR PRODUCTION GROWTH\*)



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# CO<sub>2</sub> OIL PRODUCTION



# CO<sub>2</sub> Storage Conceptual Analogues

- CO<sub>2</sub> EOR (124,000 tons/per day of “new” CO<sub>2</sub>, = 2.16 bcfpd ~ 1.1 mmbpd)
- Natural Gas Storage (450 State Permitted NG Injection Sites)
- Strategic Petroleum Reserve (688 mmbo in Storage as of 10/6/06\*) – Current storage capacity - 727 mmbo

Conclusion: Industry is Doing This!

\*[http://www2.spr.doe.gov/DIR/SilverStream/Pages/pgDailyInventoryReportViewDOE\\_new.html](http://www2.spr.doe.gov/DIR/SilverStream/Pages/pgDailyInventoryReportViewDOE_new.html)

# **UIC Program**

4840 Class II Wells

223 CO<sub>2</sub> Injectors

11 Gas Disposal Wells

9 Gas Storage Fields

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# **2007 UIC Permits**

38 Hearings

203 New Wells

53 Permit Amendments

# Important New Paradigm

- ⇒ The major objection to CO<sub>2</sub> by oil producers is long pay out times not necessarily total reserves or NPV
  - initial oil response
  - large capital exposure

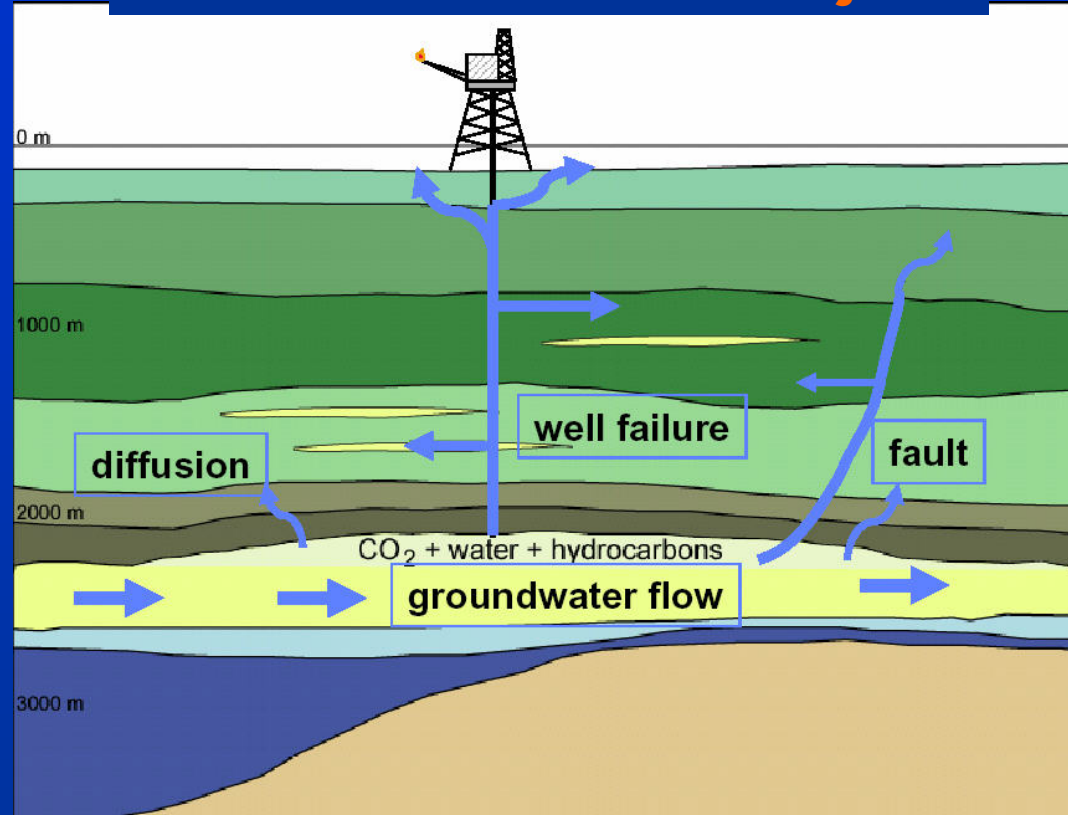
But what if reservoir storage space is valuable and injector is paid to store?

# CO<sub>2</sub> STORAGE

## Oil & Gas

- Known
  - Seismic
  - Core
  - Produced
  - Pressure
- Minimizes risk

← In which reservoir should I inject? →



## Deep Saline

- Unknowns
- Long term liability increased

"It's better to have the devil that you know than the one you don't."

# Disjoint between Government and Industry

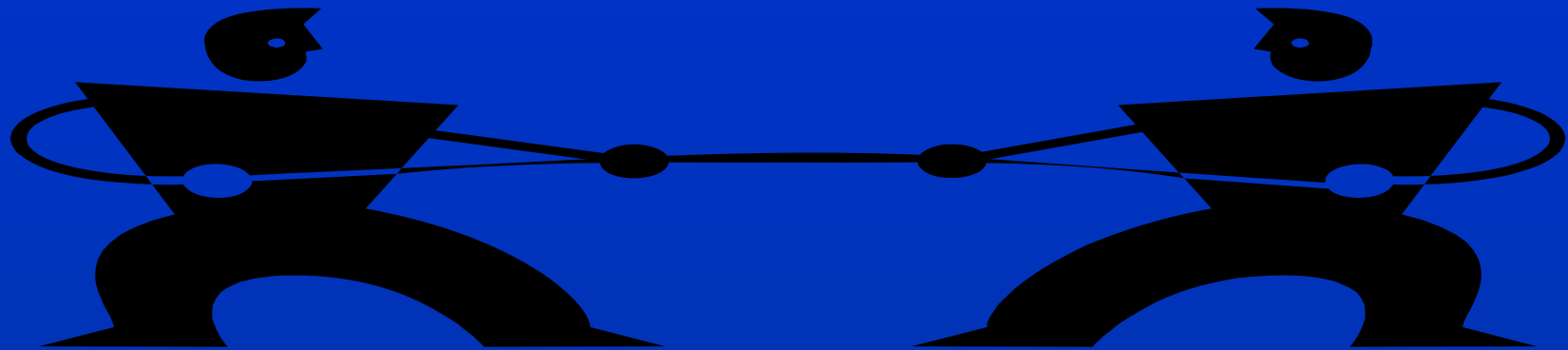
If CO<sub>2</sub> capture and geological storage is to play a significant role in mitigating global emissions, then the quantity of CO<sub>2</sub> placed in geological storage will need to approach 10 Gt/yr **worldwide** or roughly 300 times the current rate of CO<sub>2</sub> injection for EOR.

D. Keith and M. Wilson, Nov. 2002

*My number:*

*10 GT/yr = 520 bcfpd (~250 x current rate of new CO<sub>2</sub> utilization in the **U.S.**)*

# Government vs. Petroleum Industry



## Focused on:

- Long term
- Geological storage
- Regulatory Requirements
- Research

## Focus for Industry:

- Shorter term and dramatic deployment of new technologies
- Exploration
  - Resource plays: cost/payout
- Optimal Utilization of Assets
  - Experienced Personnel
  - Subsurface knowledge

# THE COMING CARBON REGULATED WORLD

## *THE FOUR COMPETING STANDARDS*

“QUALIFYING” CO<sub>2</sub> EMISSION REDUCTIONS ALLOW EFFICIENCIES, FUEL CONVERSIONS TO “RENEWABLES,” PLUS AGRICULTURAL AND FOREST SEQUESTRATION WITH

1. NO GEOLOGICAL SEQUESTRATION
2. GEOLOGICAL BUT NO CO<sub>2</sub> EOR
3. GEOLOGICAL INCLUDING CO<sub>2</sub> EOR WITH ‘ADDITIONALITY’
4. GEOLOGICAL INCLUDING CO<sub>2</sub> EOR WITH OR WITHOUT ‘ADDITIONALITY’

# THE COMING CARBON REGULATED WORLD

STANDARD #1 – “KYOTO-LIKE”

UNQUALIFIABLE  
EMISSION REDUCTIONS

QUALIFIABLE  
EMISSION REDUCTIONS

GEOLOGICAL SEQUESTRATION



EFFICIENCIES  
FUEL CONVERSIONS  
RENEWABLES  
AGRI SEQUESTRATION  
TERRESTRIAL SEQ

# THE COMING CARBON REGULATED WORLD

STANDARD #2 – “GEOLOGICAL BUT w/COMMERICAL EXCLUSION”

UNQUALIFIABLE  
EMISSION REDUCTIONS

CO<sub>2</sub> ENHANCED OIL RECOVERY



QUALIFIABLE  
EMISSION REDUCTIONS

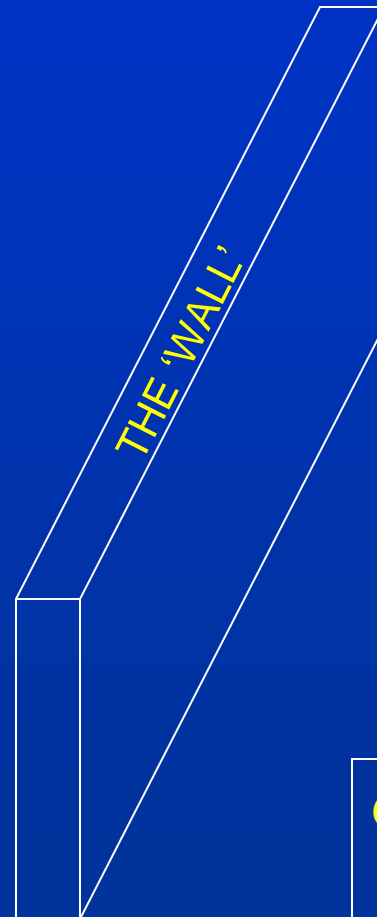
- EFFICIENCIES
- FUEL CONVERSIONS
- RENEWABLES
- AGRI SEQUESTRATION
- TERRESTRIAL SEQ
- GEOLOGICAL SEQ**
- IN UNPROVEN TRAPS,  
CONSIDERABLE RESEARCH REQ'D

# THE COMING CARBON REGULATED WORLD

## STANDARD #3 – “IMMEDIACY OF ACTION”

UNQUALIFIABLE  
EMISSION REDUCTIONS

CO<sub>2</sub> ENHANCED OIL RECOVERY  
Without “Additionality”



QUALIFIABLE  
EMISSION REDUCTIONS

EFFICIENCIES  
FUEL CONVERSIONS  
RENEWABLES  
AGRI SEQUESTRATION  
TERRESTRIAL SEQ  
GEOLOGICAL SEQ INCLUDING  
SOME EOR (additionality)

# THE COMING CARBON REGULATED WORLD

## STANDARD #4 – “INFRASTRUCTURE BUILDOUTS”

UNQUALIFIABLE  
EMISSION REDUCTIONS

INCENTIVE ‘GAMING’



QUALIFIABLE  
EMISSION REDUCTIONS

EFFICIENCIES  
FUEL CONVERSIONS  
RENEWABLES  
AGRI SEQUESTRATION  
TERRESTRIAL SEQ  
GEOLOGICAL SEQ INCLUDING  
EOR (w/ or w/o additionality)

# CO<sub>2</sub> Storage

## Future Under Standards 3 or 4

- Potentially Huge CO<sub>2</sub> Volumes (>1 mm tons/day by 2016)
- Grows from Known Subsurface Traps (Stage 1) then (Potentially) into Non-Hydrocarbon Bearing & Saline Aquifer Formations (Stage 2) - but probably not until 2016 or later
- Injected as a Commodity (Stage 1) then as a Waste Stream (Stage 2)
- Stage 2 Requires Significant PR and a large number of Demo Projects to Convince the Public (if it is a Waste Stream)
- Potentially Regulated by the Federal Government (EPA)
- Existing State Organizations Currently Regulating Underground Injection (SOGRA) are Regulating CO<sub>2</sub> EOR only – would continue during Stage 1

2006

2010

2015

2020

STAGE 1

STAGE 2

# THE CASE FOR CO<sub>2</sub> EOR JUMPSTARTING CCS

- I. Expansion of the Existing and Experienced Industry
- II. Established Subsurface Conditions: Proven Traps and Seals
- III. Potential for Value-Added Products with Commercial Subsidizing of CCS
- IV. Co-Use and Expansion of Existing CO<sub>2</sub> Infrastructure
- V. Well Explored Local and Regional Geologic Settings
- VI. Embedded Compensation to Mineral/Surface Owners
- VII. The Superposition of Oil Production and CCS Provides a Solution to the Most Difficult of Propositions: Convincing Site Owners of the Need for Waste Injection on Their Property

# ANTICIPATED PHASES OF CCS

REGULATORY OVERSIGHT

STATE (SOGRAs)

EPA (Ground Water)

STATES

PERMITTING

INJECTION

CLOSURE

POST-CLOSURE

Industry Operations

**Categorization of Sites to Consider the Following:**  
Geological Attributes of Site,  
Seals, Adequate Unit Size,  
Bonding (Operator's  
Record/History), etc.

**Will Determine Level of  
Monitoring Required**

Interstate Oil & Gas  
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