# Onshore Lower 48 Oil and Gas Supply Submodule:

# Miscible $CO_2$ EOR Cost Tables and Price Supply Curve

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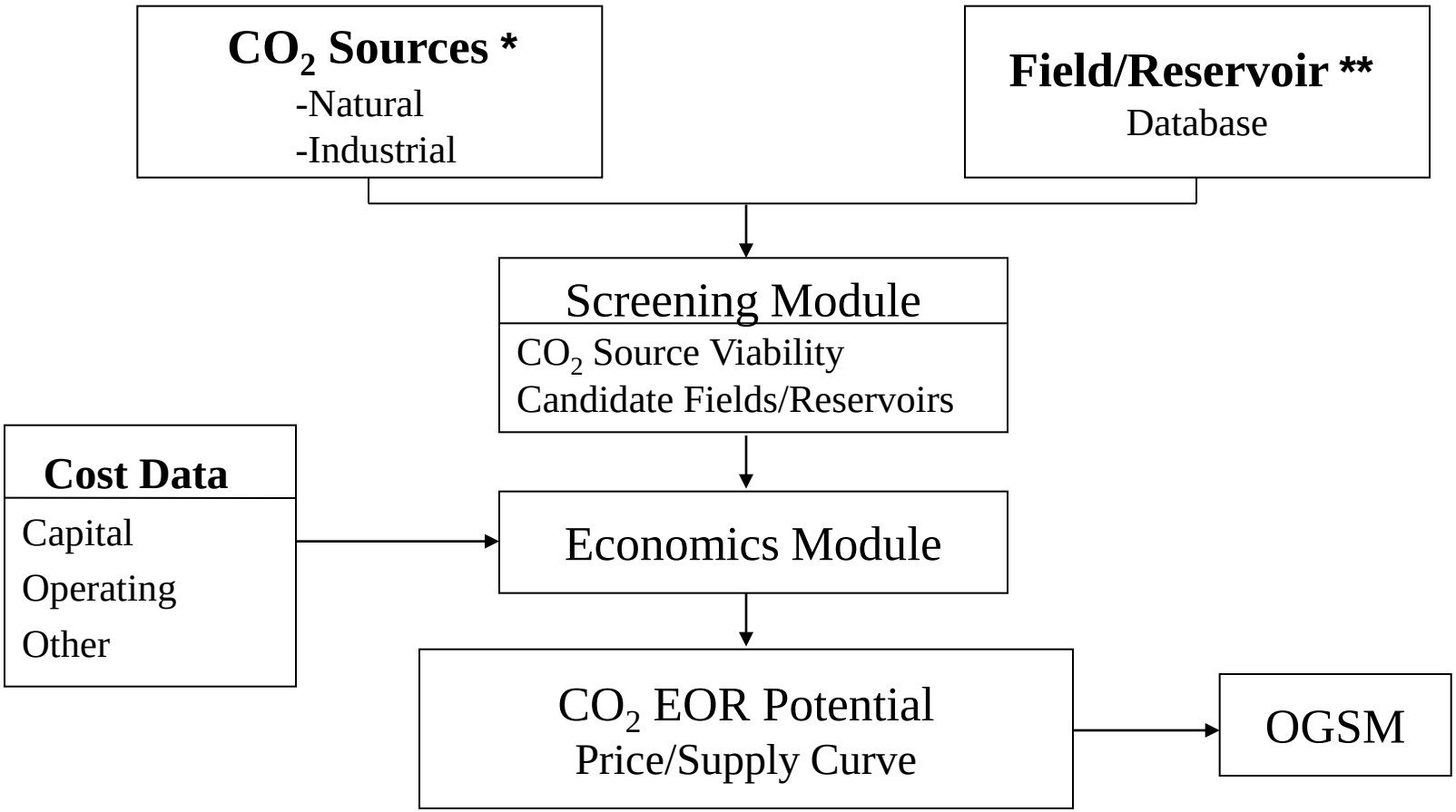
# Objective

- **Determine technical and economical recoverable resource due to $CO_2$ miscible flooding**
- **$CO_2$ sources to include**
  - Natural sources
  - Industrial sources

# Methodology Overview




* National Carbon Sequestration Database

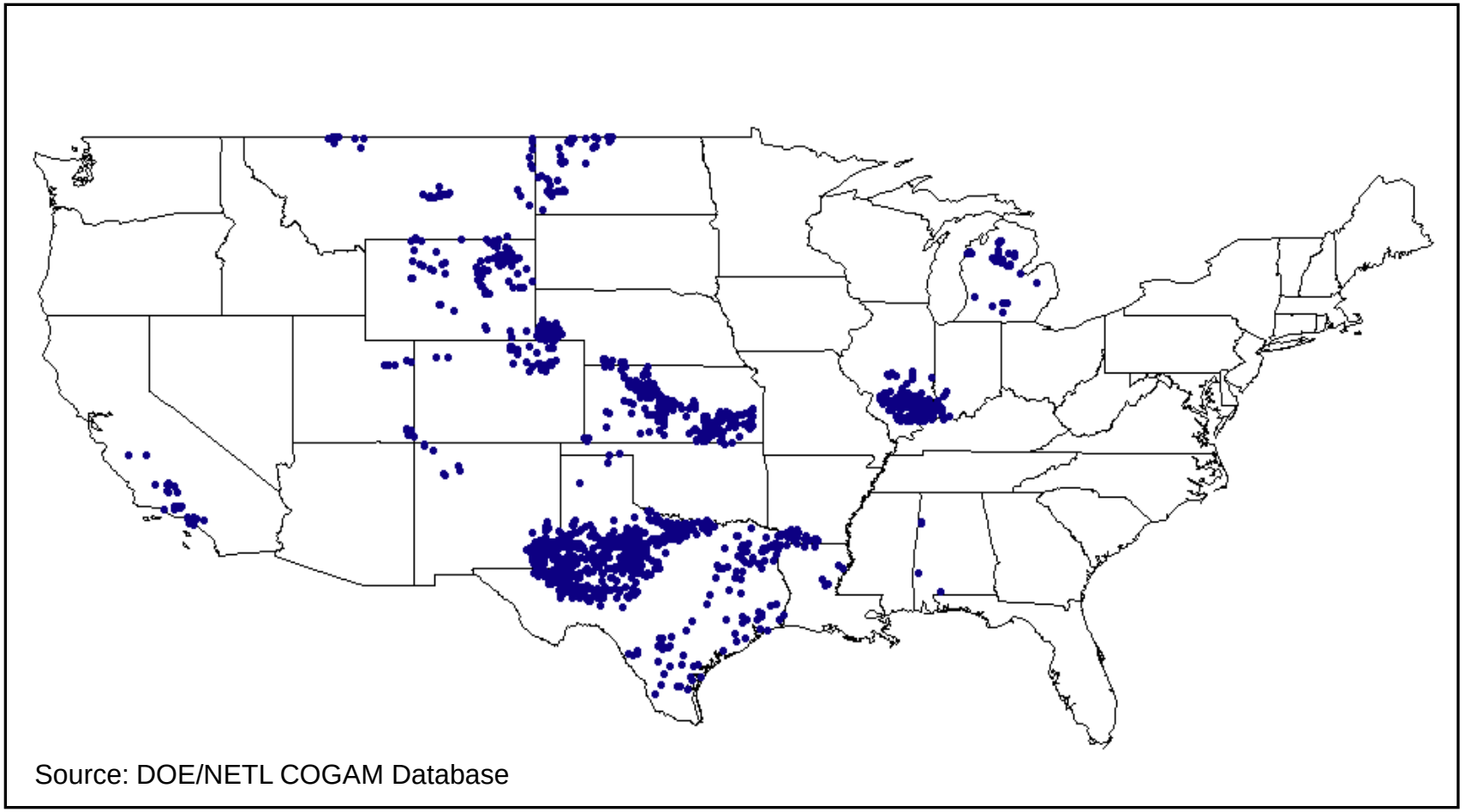
** For *AEO2008*-COGAM Database
For *AEO2009*-New NRG Database

# Screening Criteria

- **API gravity > 22**
- **Reservoir pressure > minimum miscibility pressure**
- **Depth > 2500 feet**
- **Oil viscosity < 10cp**
- **Oil saturation > 20% pore volume**
- **Sandstone vs. carbonate**

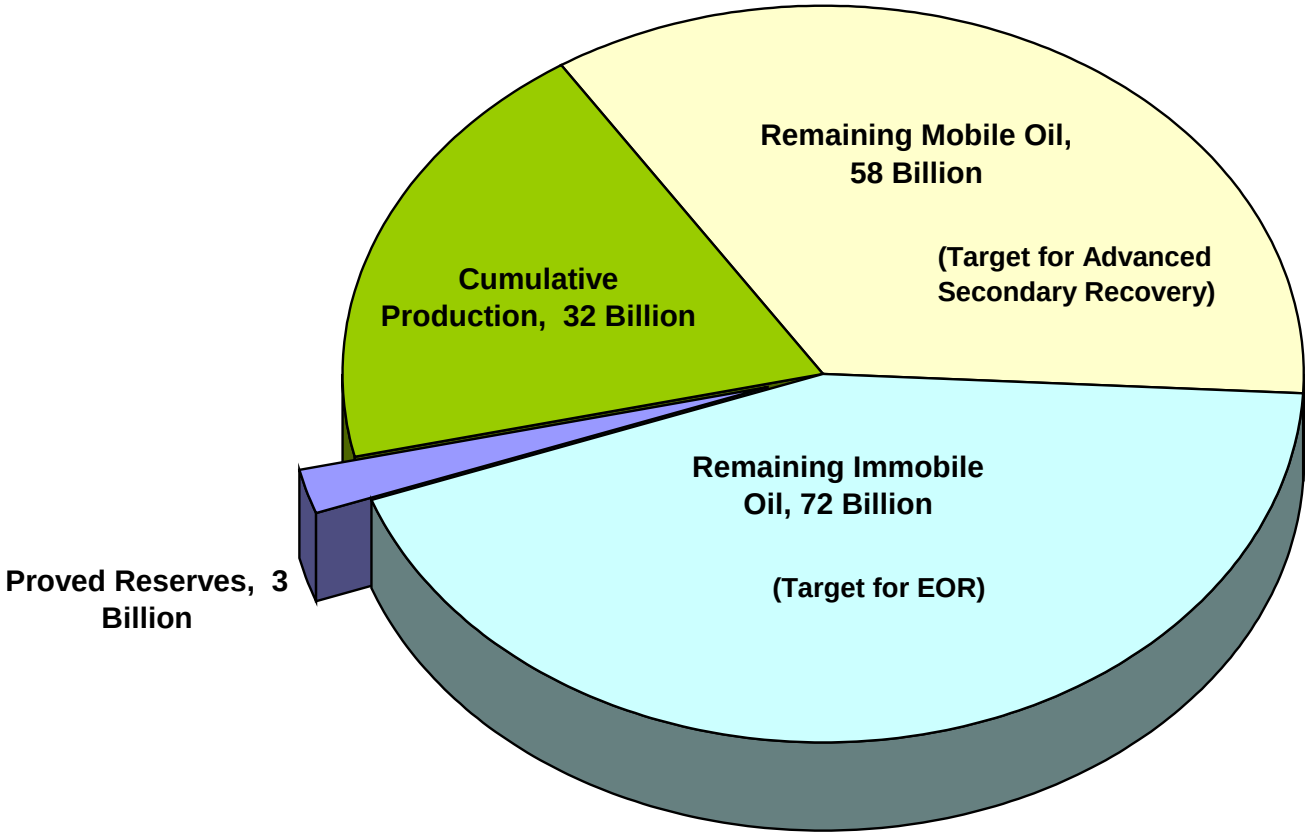
# Potential Targets for $CO_2$ EOR

## 2,235 Candidate Reservoirs and Fields



Source: DOE/NETL COGAM Database

# Total Oil In Place – 165 Billion Barrels
## For Screened $CO_2$ EOR Candidate Reservoirs




**Source: OLOGSS Model (2009)**
**NRG & Associates Database (2006)**

# Target for Enhanced Oil Recovery

- **"Target resource" is the remaining oil in place to which current and future production technologies can be applied.**

- **"Technical recovery" is the oil which can be <u>produced over 40 years</u> using the existing technology. This does not include:**
  - Economics
  - Availability of $CO_2$
  - Infrastructure or other development constraints

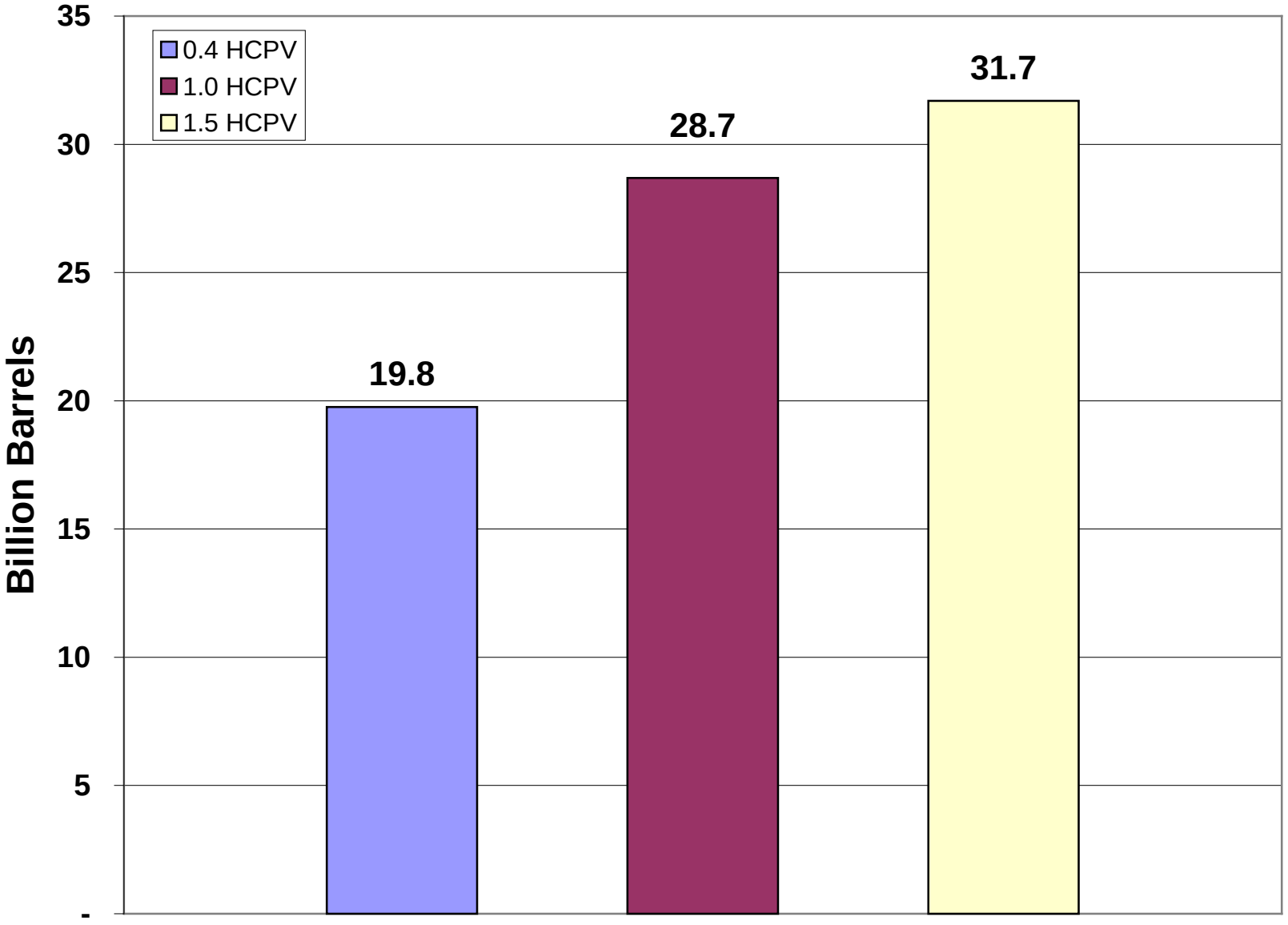
# Technical Recovery

- **Uses $CO_2$ PM model to estimate the $CO_2$ EOR production for each candidate reservoir based upon**
  - Oil Saturation
  - API gravity
  - Reservoir Pressure
  - Hydrocarbon Pore Volume
  - Other Key Parameters

- **Technical Recovery is based upon a 40 year project lifespan**

# Technical Recovery

## Life-cycle Production for 40 Years

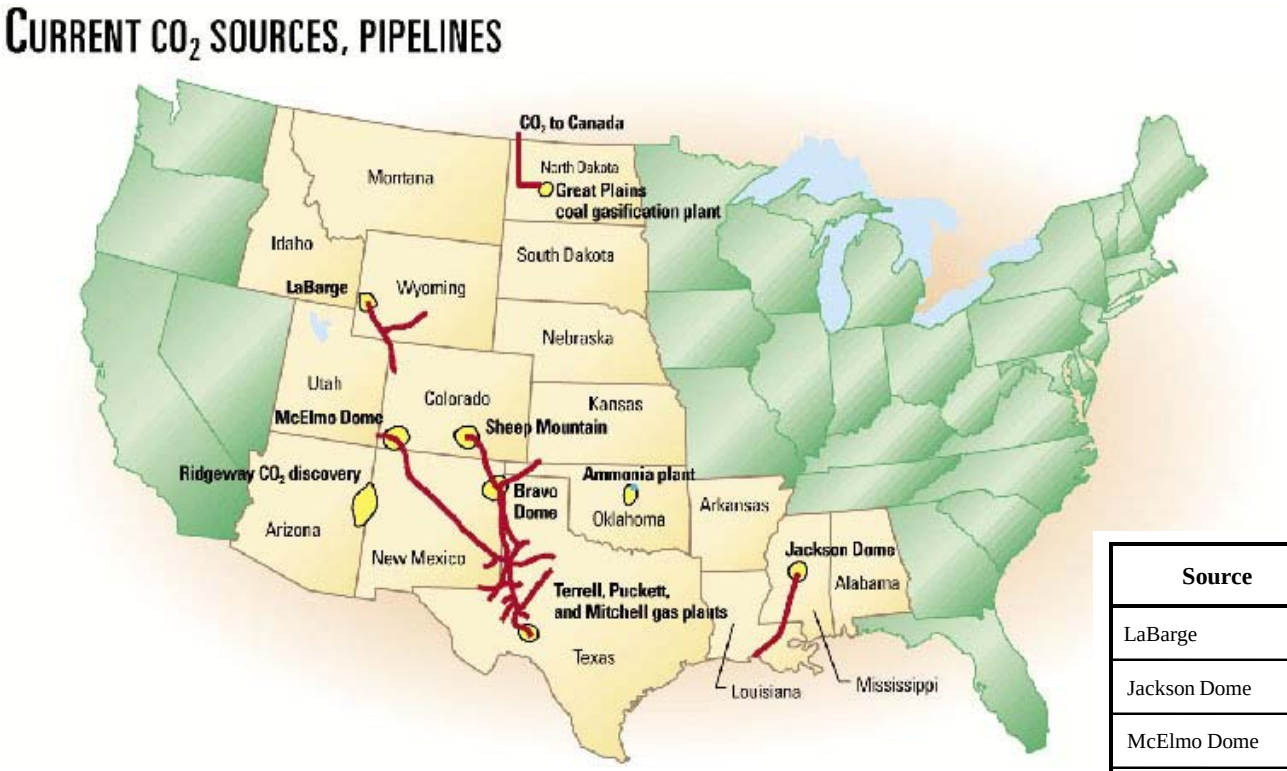


# Types of $CO_2$ Considered

- **Natural Sources ~** 1 TCF/yr (55.6)
- **Industrial Sources** ~ 24 TCF/yr (1,334.2)
  - Fossil Fuel Plants
  - Refineries
  - Hydrogen Plants
  - Cement Plants
  - Ammonia Plants
  - Others to be determined

**Note :Values in ( ) are in Million Tons (MMtn) per year**

# Natural Sources of $CO_2$

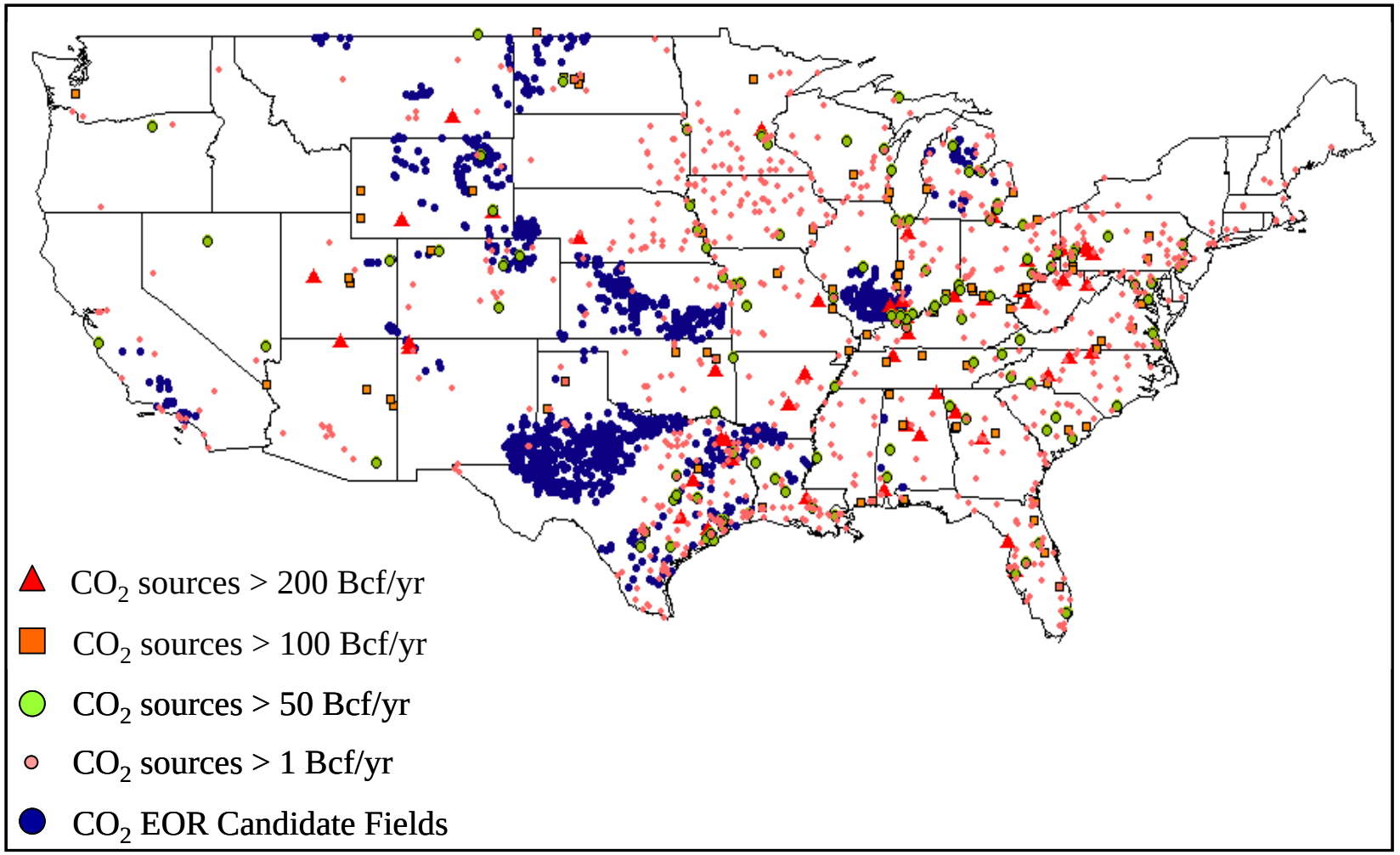



**<u>Annual $CO_2$ Produced</u>:**

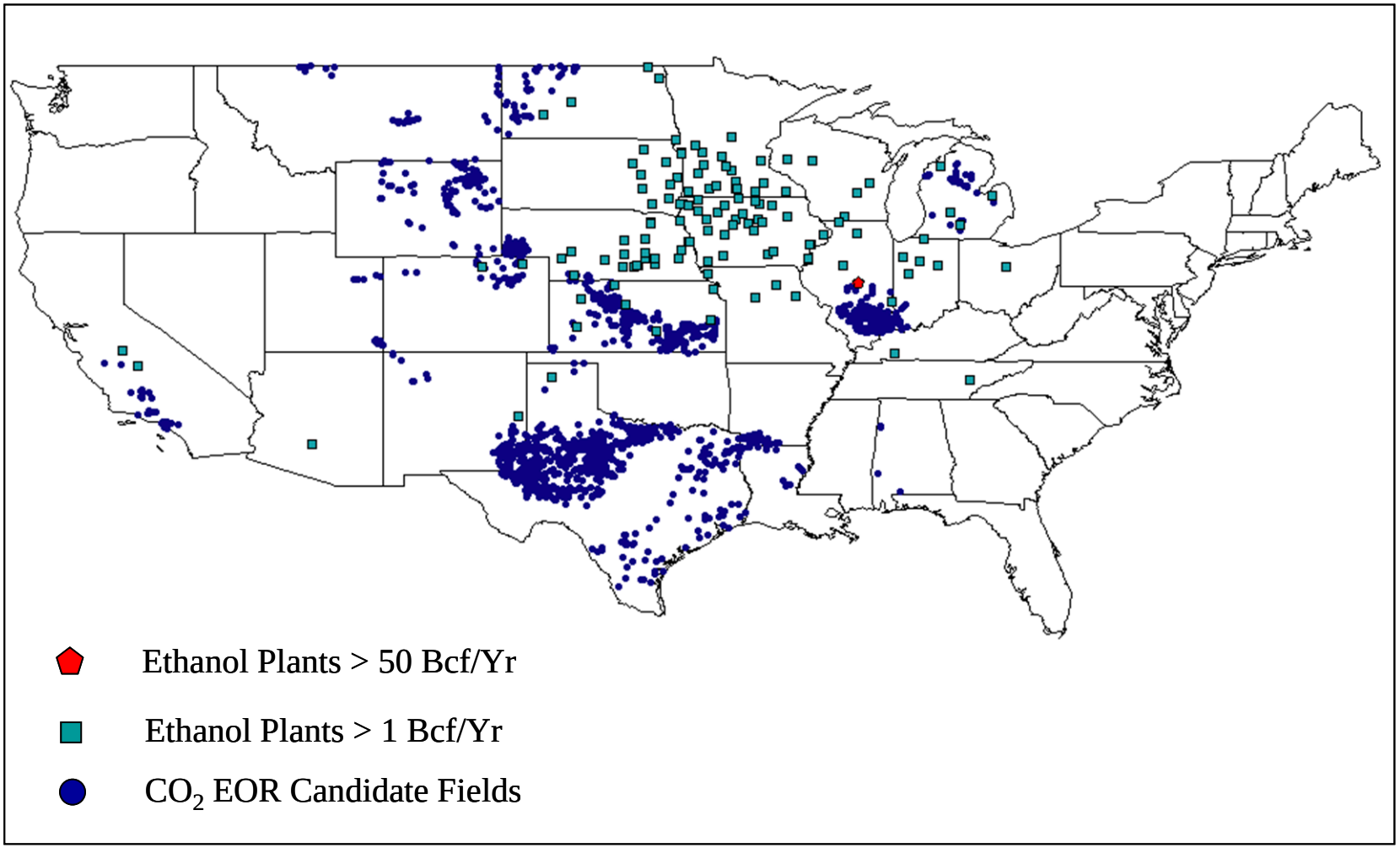
**1094 Bcf/yr (60.81 MMtn/yr)**

| Source | Pipeline | States Supplied | Daily Rate MMCF/D |
|---|---|---|---|
| LaBarge | LaBarge | Wyoming | 350 |
| | | Colorado | |
| Jackson Dome | Denbury-Jackson | Mississippi | 220 |
| McElmo Dome | Cortez | Texas | 1,300 |
| | McElmo Creek | Utah | 60 |
| Sheep Mountain Dome | Sheep Mountain | Texas | 480 |
| Bravo Dome | Bravo | Texas | 482 |
| Val Verde Gas Plants | Val Verde | Texas | 70 |
| Oklahoma Fertilizer Plant | Local Pipeline | Oklahoma | 35 |
| | | **Total Daily Rate** | **2,997** |

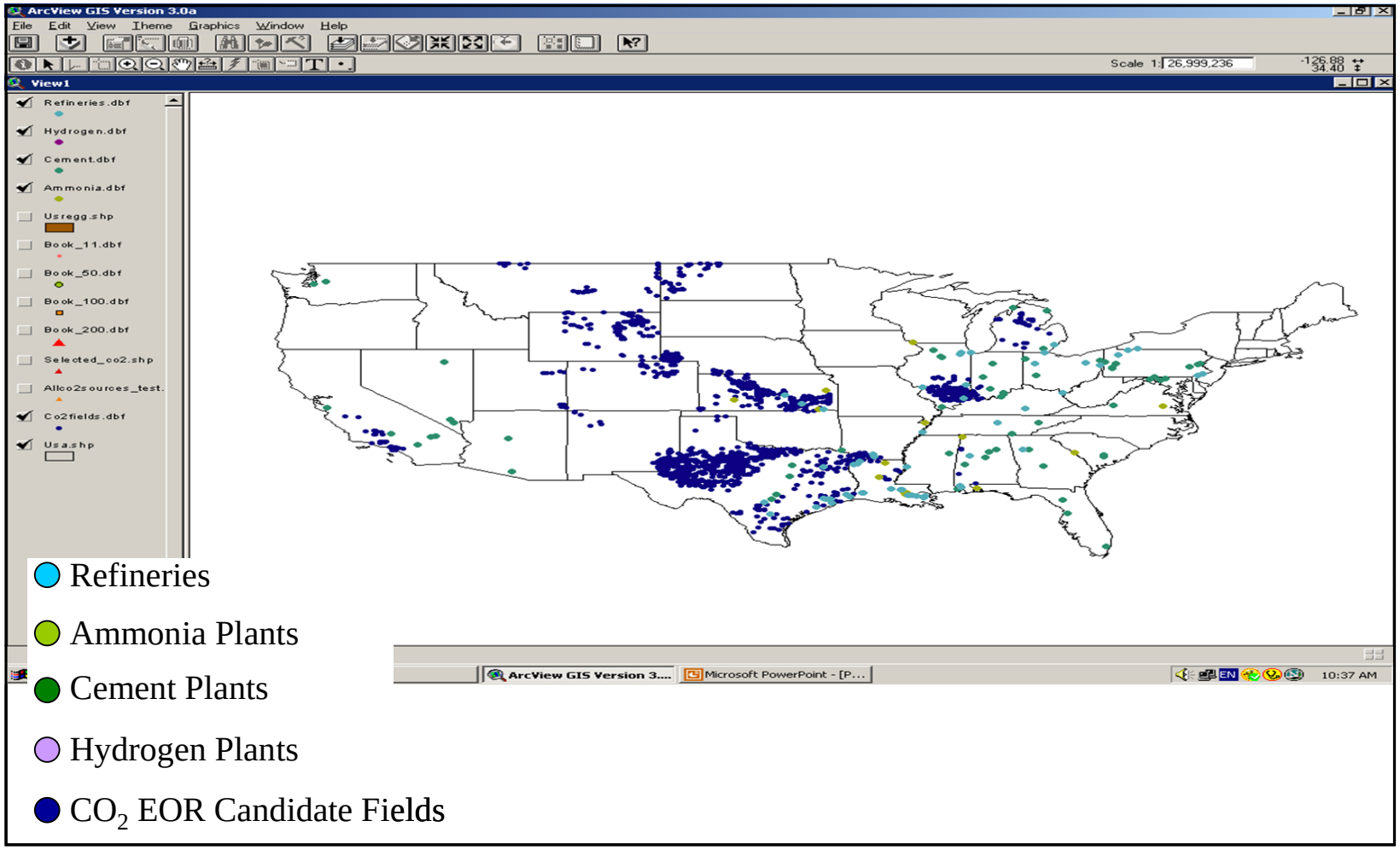
# Industrial Sources of $CO_2$ – Fossil Fuel Plants



# Industrial Sources of $CO_2$ – Ethanol Plants



# Industrial Sources of $CO_2$ – Other Plant Types



# Volume of $CO_2$ Available (MMtn)

| OGSM Region | | Annual Volume of Natural $CO_2$ Available | Annual Volume of Industrial $CO_2$ Available (MMtn) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants |
| **East Coast** | | | 721.58 | 24.68 | 15.12 | 0.67 | | 1.71 |
| **Gulf Coast** | | 4.45 | 218.47 | 64.04 | 7.28 | 8.12 | 6.56 | |
| **Midcontinent** | | 0.72 | 41.80 | 5.72 | | 0.44 | 0.44 | 4.29 |
| **Southwest** | | 41.25 | | 16.23 | | | | |
| **Rocky Mountain** | **Rocky Mountain (OGSM)** | 6.34 | 161.60 | 3.11 | | 0.28 | | |
| | **Northern Great Plains (OLOGSS)** | | 63.04 | 1.95 | | 0.50 | | |
| **West Coast** | | | 3.34 | | | 9.06 | | |
| **Total** | | 52.76 | 1209.83 | 115.73 | 22.40 | 19.07 | 7.00 | 6.00 |

# Volume of $CO_2$ Available (Bcf)

| OGSM Region | | Annual Volume of Natural $CO_2$ Available | Annual Volume of Industrial $CO_2$ Available (Bcf) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants |
| **East Coast** | | | 12980 | 444 | 272 | 12 | | 31 |
| **Gulf Coast** | | 80 | 3930 | 1152 | 131 | 146 | 118 | |
| **Midcontinent** | | 13 | 752 | 103 | | 8 | 8 | 77 |
| **Southwest** | | 742 | | 292 | | | | |
| **Rocky Mountain** | **Rocky Mountain (OGSM)** | 114 | 2907 | 56 | | 5 | | |
| | **Northern Great Plains (OLOGSS)** | | 1134 | 35 | | 9 | | |
| **West Coast** | | | 60 | | | 163 | | |
| **Total** | | 949 | 21763 | 2082 | 403 | 343 | 126 | 108 |

# Cost of $CO_2$

- **Natural Sources**
  - $CO_2$ Price $= f($ *oil price*, *state*$)$
- **Industrial Sources**
  - Capture Costs
  - Pipeline Transportation Tariff
  - $CO_2$ Price $= f($ *capture costs*, *pipeline tariff*$)$

# $CO_2$ Capture Costs

- **Depends on plant type**
  - Pulverized Coal Plants
  - Natural Gasification Combined Cycle (NGCC) Plants
  - Integrated Gasification Combined Cycle (IGCC) Plants
  - Hydrogen Plants (stand alone or within refinery)
  - Cement Plants
  - Refinery (includes $CO_2$ form process heaters and FCC's)
  - Ammonia Plants
- **Depends on plant age**
  - Existing plant
  - New plant

# $CO_2$ Capture Costs ($/tn)

| OGSM Region | | Capture Costs ($/tn) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | | Refineries | | Cement Plants | | Hydrogen Plants | | Ammonia Plants | | Ethanol Plants | | New IGCC Plants | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| East Coast | | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |
| Gulf Coast | | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |
| Midcontinent | | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |
| Southwest | | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |
| Rocky Mountain | Rocky Mountain (OGSM) | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |
| | Northern Great Plains (OLOGSS) | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |
| West Coast | | 38.31 | 63.32 | 35.00 | 55.00 | 35.00 | 55.00 | 6.00 | 12.00 | 6.00 | 12.00 | 6.00 | 12.00 | 25.00 | 40.00 |

# $CO_2$ Capture Costs ($/Mcf)

| OGSM Region | | Capture Costs ($/Mcf) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | | Refineries | | Cement Plants | | Hydrogen Plants | | Ammonia Plants | | Ethanol Plants | | New IGCC Plants | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| East Coast | | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |
| Gulf Coast | | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |
| Midcontinent | | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |
| Southwest | | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |
| Rocky Mountain | Rocky Mountain (OGSM) | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |
| | Northern Great Plains (OLOGSS) | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |
| West Coast | | 2.13 | 3.52 | 1.95 | 3.06 | 1.95 | 3.06 | 0.33 | 0.67 | 0.33 | 0.67 | 0.33 | 0.67 | 1.39 | 2.22 |

# Pipeline Transportation Tariff

- **Pipeline transportation tariff depends on**
  - Length (calculated using GIS)
  - Capacity (volume available/required)
  - Base pressure
  - Operating Pressure
  - Number of stages for compressor
  - Other

Used in the *Pipeline Tariff Calculation Model*©

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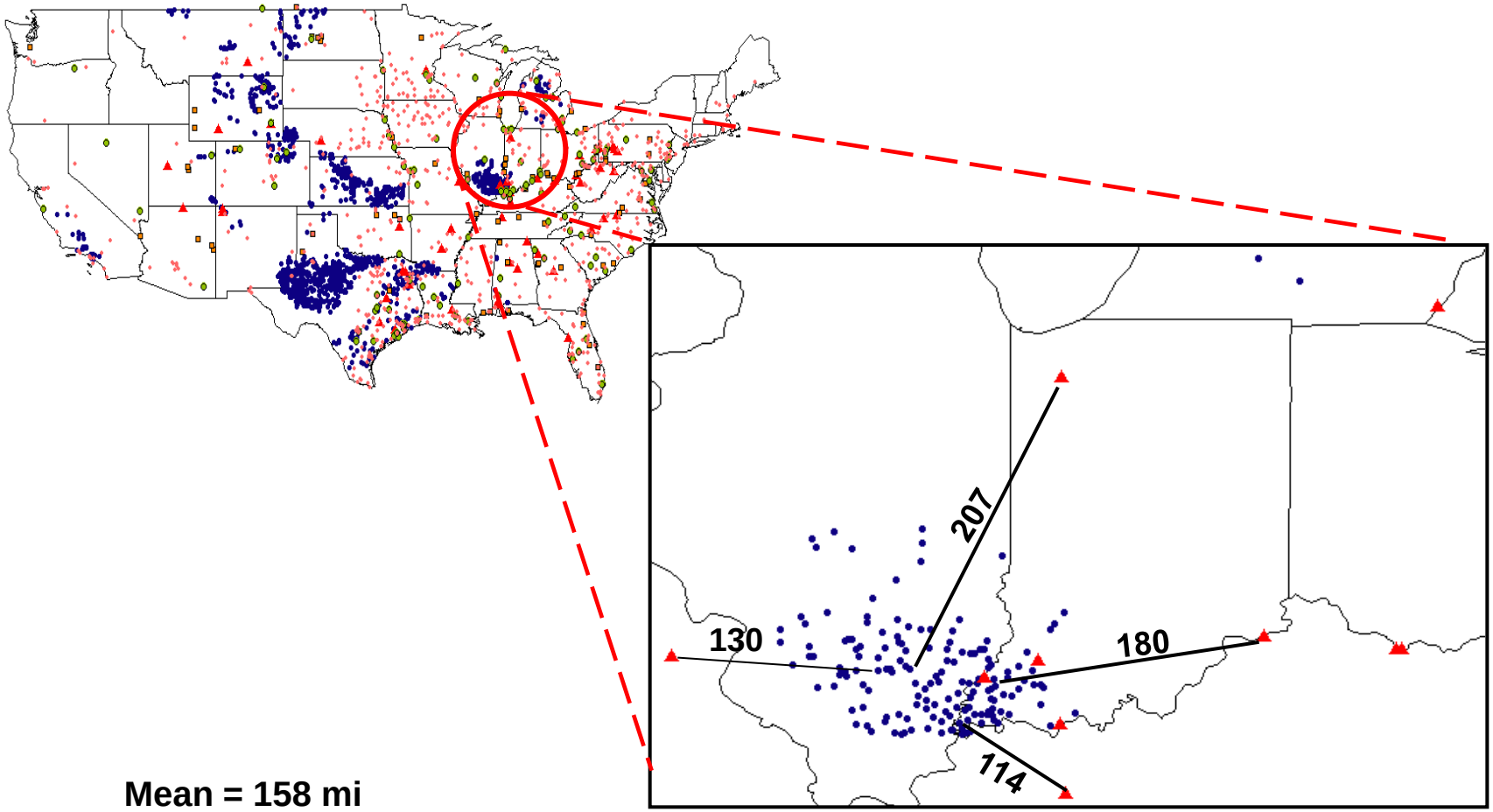
# Example: Determining Average Pipeline Length




**Mean = 158 mi**

**Std Deviation = 43 mi**

# Pipeline Transportation Tariff

- **Average pipeline length will be calculated for each OGSM region and source type**

- **Regional source-specific pipeline tariffs are determined**

# Pipeline Transportation Tariffs ($/tn)

| OGSM Region | | Regional Pipeline Tariff ($/tn) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants |
| East Coast | | 7.02 | 7.73 | 7.56 | 7.56 | 7.56 | 8.81 |
| Gulf Coast | | 7.02 | 7.56 | 7.38 | 7.56 | 7.73 | 9.17 |
| Midcontinent | | 7.02 | 7.73 | 7.20 | 7.56 | 7.20 | 9.35 |
| Southwest | | 7.02 | 7.73 | 7.38 | 7.56 | 7.56 | 9.17 |
| Rocky Mountain | Rocky Mountain (OGSM) | 7.02 | 7.73 | 7.38 | 7.56 | 7.56 | 9.17 |
| | Northern Great Plains (OLOGSS) | 7.02 | 7.73 | 7.56 | 7.56 | 7.56 | 9.17 |
| West Coast | | 7.02 | 7.73 | 7.38 | 7.56 | 7.56 | 9.17 |

# Pipeline Transportation Tariffs ($/Mcf)

| OGSM Region | | Regional Pipeline Tariff ($/Mcf) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants |
| East Coast | | 0.39 | 0.43 | 0.42 | 0.42 | 0.42 | 0.49 |
| Gulf Coast | | 0.39 | 0.42 | 0.41 | 0.42 | 0.43 | 0.51 |
| Midcontinent | | 0.39 | 0.43 | 0.4 | 0.42 | 0.4 | 0.52 |
| Southwest | | 0.39 | 0.43 | 0.41 | 0.42 | 0.42 | 0.51 |
| Rocky Mountain | Rocky Mountain (OGSM) | 0.39 | 0.43 | 0.41 | 0.42 | 0.42 | 0.51 |
| | Northern Great Plains (OLOGSS) | 0.39 | 0.43 | 0.42 | 0.42 | 0.42 | 0.51 |
| West Coast | | 0.39 | 0.43 | 0.41 | 0.42 | 0.42 | 0.51 |

# Capture Cost Technology Case Definitions

- **Low technology case – has higher capture costs**
- **Average technology case – has average capture costs**
- **High technology case – has lower capture costs**

Note: Goal is to achieve lower capture costs in the future

# Total $CO_2$ Cost at Wellhead ($/tn)

## Average Capture Technology Case

| OGSM Region | | Average Capture Costs + Pipeline Tariffs ($/tn) * | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants | New IGCC Plants |
| East Coast | | 57.83 | 52.73 | 52.56 | 16.56 | 16.56 | 17.81 | 40.20 |
| Gulf Coast | | 57.83 | 52.56 | 52.38 | 16.56 | 16.73 | 18.17 | 40.23 |
| Midcontinent | | 57.83 | 52.73 | 52.20 | 16.56 | 16.20 | 18.35 | 40.17 |
| Southwest | | 57.83 | 52.73 | 52.38 | 16.56 | 16.56 | 18.17 | 40.23 |
| Rocky Mountain | Rocky Mountain (OGSM) | 57.83 | 52.73 | 52.38 | 16.56 | 16.56 | 18.17 | 40.23 |
| | Northern Great Plains (OLOGSS) | 57.83 | 52.73 | 52.56 | 16.56 | 16.56 | 18.17 | 40.26 |
| West Coast | | 57.83 | 52.73 | 52.38 | 16.56 | 16.56 | 18.17 | 40.23 |

* Price paid by an EOR project does not include value of $CO_2$ traded due to Cap & Trade programs (if any)

# Total $CO_2$ Cost at Wellhead ($/tn)

## High Capture Technology Case

| OGSM Region | | Minimum Capture Costs + Pipeline Tariffs ($/tn) * | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants | New IGCC Plants |
| East Coast | | 45.33 | 42.73 | 42.56 | 13.56 | 13.56 | 14.81 | 32.70 |
| Gulf Coast | | 45.33 | 42.56 | 42.38 | 13.56 | 13.73 | 15.17 | 32.73 |
| Midcontinent | | 45.33 | 42.73 | 42.20 | 13.56 | 13.20 | 15.35 | 32.67 |
| Southwest | | 45.33 | 42.73 | 42.38 | 13.56 | 13.56 | 15.17 | 32.73 |
| Rocky Mountain | Rocky Mountain (OGSM) | 45.33 | 42.73 | 42.38 | 13.56 | 13.56 | 15.17 | 32.73 |
| | Northern Great Plains (OLOGSS) | 45.33 | 42.73 | 42.56 | 13.56 | 13.56 | 15.17 | 32.76 |
| West Coast | | 45.33 | 42.73 | 42.38 | 13.56 | 13.56 | 15.17 | 32.73 |

* Price paid by an EOR project does not include value of $CO_2$ traded due to Cap & Trade programs (if any)

# Total $CO_2$ Cost at Wellhead ($/tn)

## Low Capture Technology Case

| OGSM Region | | Maximum Capture Costs + Pipeline Tariffs ($/tn) * | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants | New IGCC Plants |
| East Coast | | 70.34 | 62.73 | 62.56 | 19.56 | 19.56 | 20.81 | 47.70 |
| Gulf Coast | | 70.34 | 62.56 | 62.38 | 19.56 | 19.73 | 21.17 | 47.73 |
| Midcontinent | | 70.34 | 62.73 | 62.20 | 19.56 | 19.20 | 21.35 | 47.67 |
| Southwest | | 70.34 | 62.73 | 62.38 | 19.56 | 19.56 | 21.17 | 47.73 |
| Rocky Mountain | Rocky Mountain (OGSM) | 70.34 | 62.73 | 62.38 | 19.56 | 19.56 | 21.17 | 47.73 |
| | Northern Great Plains (OLOGSS) | 70.34 | 62.73 | 62.56 | 19.56 | 19.56 | 21.17 | 47.76 |
| West Coast | | 70.34 | 62.73 | 62.38 | 19.56 | 19.56 | 21.17 | 47.73 |

* Price paid by an EOR project does not include value of $CO_2$ traded due to Cap & Trade programs (if any)

# Total $CO_2$ Cost at Wellhead ($/Mcf)

## Average Capture Technology Case

| OGSM Region | | Average Capture Costs + Pipeline Tariffs ($/Mcf)* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants | New IGCC Plants |
| East Coast | | 3.22 | 2.94 | 2.93 | 0.92 | 0.92 | 0.99 | 2.23 |
| Gulf Coast | | 3.22 | 2.93 | 2.92 | 0.92 | 0.93 | 1.01 | 2.24 |
| Midcontinent | | 3.22 | 2.94 | 2.91 | 0.92 | 0.90 | 1.02 | 2.23 |
| Southwest | | 3.22 | 2.94 | 2.92 | 0.92 | 0.92 | 1.01 | 2.24 |
| Rocky Mountain | Rocky Mountain (OGSM) | 3.22 | 2.94 | 2.92 | 0.92 | 0.92 | 1.01 | 2.24 |
| | Northern Great Plains (OLOGSS) | 3.22 | 2.94 | 2.93 | 0.92 | 0.92 | 1.01 | 2.24 |
| West Coast | | 3.22 | 2.94 | 2.92 | 0.92 | 0.92 | 1.01 | 2.24 |

* Price paid by an EOR project does not include value of $CO_2$ traded due to Cap & Trade programs (if any)

# Total $CO_2$ Cost at Wellhead ($/Mcf)

## High Capture Technology Case

| OGSM Region | | Minimum Capture Costs + Pipeline Tariffs ($/Mcf) * | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants | New IGCC Plants |
| East Coast | | 2.52 | 2.38 | 2.37 | 0.75 | 0.75 | 0.82 | 1.82 |
| Gulf Coast | | 2.52 | 2.37 | 2.36 | 0.75 | 0.76 | 0.84 | 1.82 |
| Midcontinent | | 2.52 | 2.38 | 2.35 | 0.75 | 0.73 | 0.85 | 1.82 |
| Southwest | | 2.52 | 2.38 | 2.36 | 0.75 | 0.75 | 0.84 | 1.82 |
| Rocky Mountain | Rocky Mountain (OGSM) | 2.52 | 2.38 | 2.36 | 0.75 | 0.75 | 0.84 | 1.82 |
| | Northern Great Plains (OLOGSS) | 2.52 | 2.38 | 2.37 | 0.75 | 0.75 | 0.84 | 1.82 |
| West Coast | | 2.52 | 2.38 | 2.36 | 0.75 | 0.75 | 0.84 | 1.82 |

* Price paid by an EOR project does not include value of $CO_2$ traded due to Cap & Trade programs (if any)

# Total $CO_2$ Cost at Wellhead ($/Mcf)

## Low Capture Technology Case

| OGSM Region | | Maximum Capture Costs + Pipeline Tariffs ($/Mcf) * | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Fossil Fuel Plants | Refineries | Cement Plants | Hydrogen Plants | Ammonia Plants | Ethanol Plants | New IGCC Plants |
| East Coast | | 3.91 | 3.49 | 3.48 | 1.09 | 1.09 | 1.16 | 2.65 |
| Gulf Coast | | 3.91 | 3.48 | 3.47 | 1.09 | 1.10 | 1.18 | 2.65 |
| Midcontinent | | 3.91 | 3.49 | 3.46 | 1.09 | 1.07 | 1.19 | 2.65 |
| Southwest | | 3.91 | 3.49 | 3.47 | 1.09 | 1.09 | 1.18 | 2.65 |
| Rocky Mountain | Rocky Mountain (OGSM) | 3.91 | 3.49 | 3.47 | 1.09 | 1.09 | 1.18 | 2.65 |
| | Northern Great Plains (OLOGSS) | 3.91 | 3.49 | 3.48 | 1.09 | 1.09 | 1.18 | 2.65 |
| West Coast | | 3.91 | 3.49 | 3.47 | 1.09 | 1.09 | 1.18 | 2.65 |

* Price paid by an EOR project does not include value of $CO_2$ traded due to Cap & Trade programs (if any)

# $CO_2$ Availability Assumption revised 9-21-07

- **Natural sources of $CO_2$ are available immediately**

- **Availability of industrial sources of $CO_2$ is delayed for infrastructure development**
  - Hydrogen Plants: 4 Years (Pipeline)
  - Ammonia Plants: 4 Years (Pipeline)
  - Ethanol Plants 4 Years (Pipeline)
  - Cement Plants: 5 Years (Capture & Pipeline)
  - Refineries: 8 Years (Capture & Pipeline)
  - Fossil Fuel Plants: 8 Years (Capture & Pipeline)

# Economic Module

- **The Economic Module will pick the most economic $CO_2$ available in any given region subject to availability of $CO_2$ for the life cycle of the project.**
- **Other development and economic assumptions:**
  - 10 year development schedule for a $CO_2$ EOR project
  - 15% ROR
  - 34.5% Federal tax rate
  - 12.5% royalty rate on Federal lands
  - EOR tax credit
  - 8 year MACRS depreciation schedule

# Model Levers Available for R&D default HCPV now = 1.0 (9-21-07)

| R&D Area | Levers |
|---|---|
| ■ $CO_2$ capture technology improvement | ■ Reduction in capture costs |
| ■ Acceleration of capture technology | ■ Capture technology R&D Phase<br>– Years<br>■ Capure technology & pipeline construction phase<br>– Years<br>■ Market acceptance phase<br>– Years<br>– Rate of acceptance<br>– Ultimate market acceptance<br>■ Availability of $CO_2$ |
| ■ Increase injection rate | ■ Value of $CO_2$ injection<br>– 0.4 HCPV* (default)<br>– Others to be determined |
| ■ Economic risk | ■ Rate of Return (ROR) |

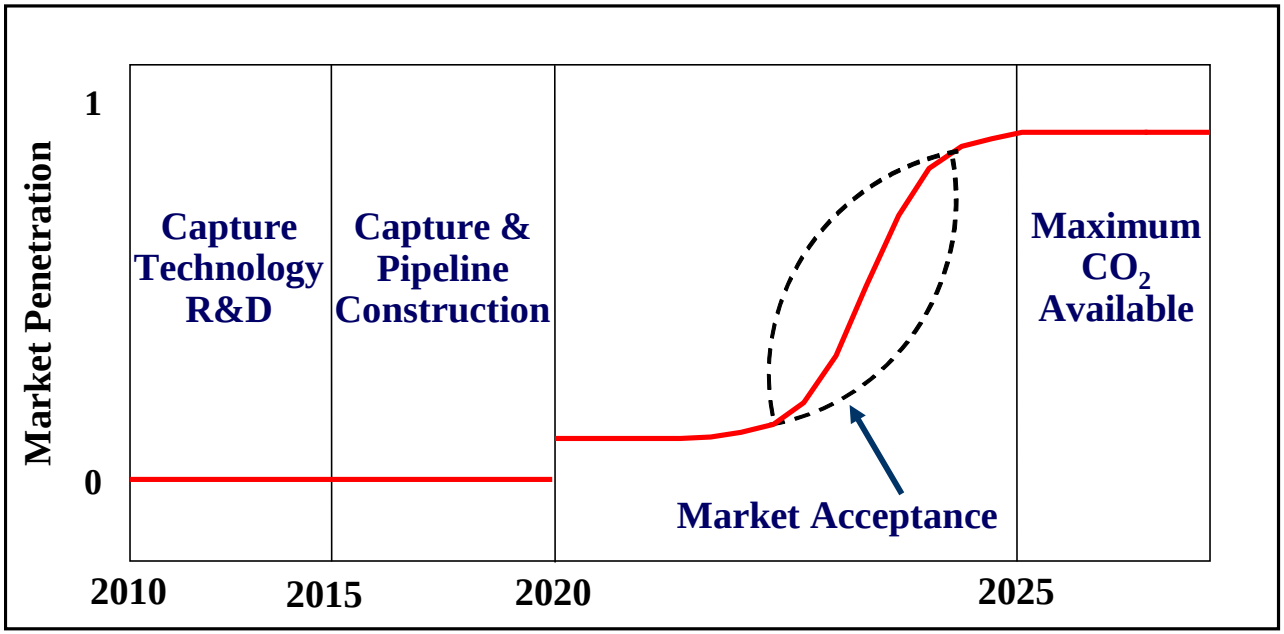
*HCPV = Hydrocarbon Pore Volume

# Industrial $CO_2$ Availability Assumptions see revised table in e-mail 9-21-07

| Source Type | R&D Phase (Years) | Infrastructure Development (Years) | Market Acceptance (Years) | Annual Market Acceptance (%) | Ultimate Market Acceptance (%) |
|---|---|---|---|---|---|
| **Ammonia Plants** | 2 | 2 | 5 | 20% | 100% |
| **Ethanol Plants** | 2 | 2 | 5 | 20% | 100% |
| **Hydrogen Plants** | 2 | 2 | 5 | 20% | 100% |
| **Cement Plants** | 6 | 4 | 5 | 20% | 100% |
| **Refineries** | 6 | 4 | 5 | 20% | 100% |
| **Fossil Fuel Plants** | 6 | 8 | 5 | 20% | 100% |

# Industrial $CO_2$ Availability Assumptions has been modified (9-21-07)

- **Example: Cement Plants**
  - Start year: 2015
  - Capture Technology Development  5 years
  - Construction lead time: 4-5 years
  - Market Acceptance period: 5 years
  - Maximum $CO_2$ availability: 2025



# Sample Price Supply Curves

- **Three cases**
  - AEO 2007 Low Price case
  - AEO 2007 Reference Price case
  - AEO 2007 High Price case

- **Sample results**
  - Total $CO_2$ injected
  - Regional and national oil production

Supporting data for all cases is provided in attached text files

# Price Supply Curve Assumptions

- **Lower 48 Onshore only**
  - Does not include the Gulf of Mexico and Alaska
- **Average $CO_2$ capture and transportation costs**
- **1.0 HCPV (revised 9-21-07)**
- **100% of all existing industrial sources is available**
  - Using availability assumptions on page 32
- **Natural sources of $CO_2$ are available immediately**
- **No planned industrial $CO_2$ sources**