



CO₂ Storage in Depleted Oil Fields: The Worldwide Potential for Carbon Dioxide Enhanced Oil Recovery

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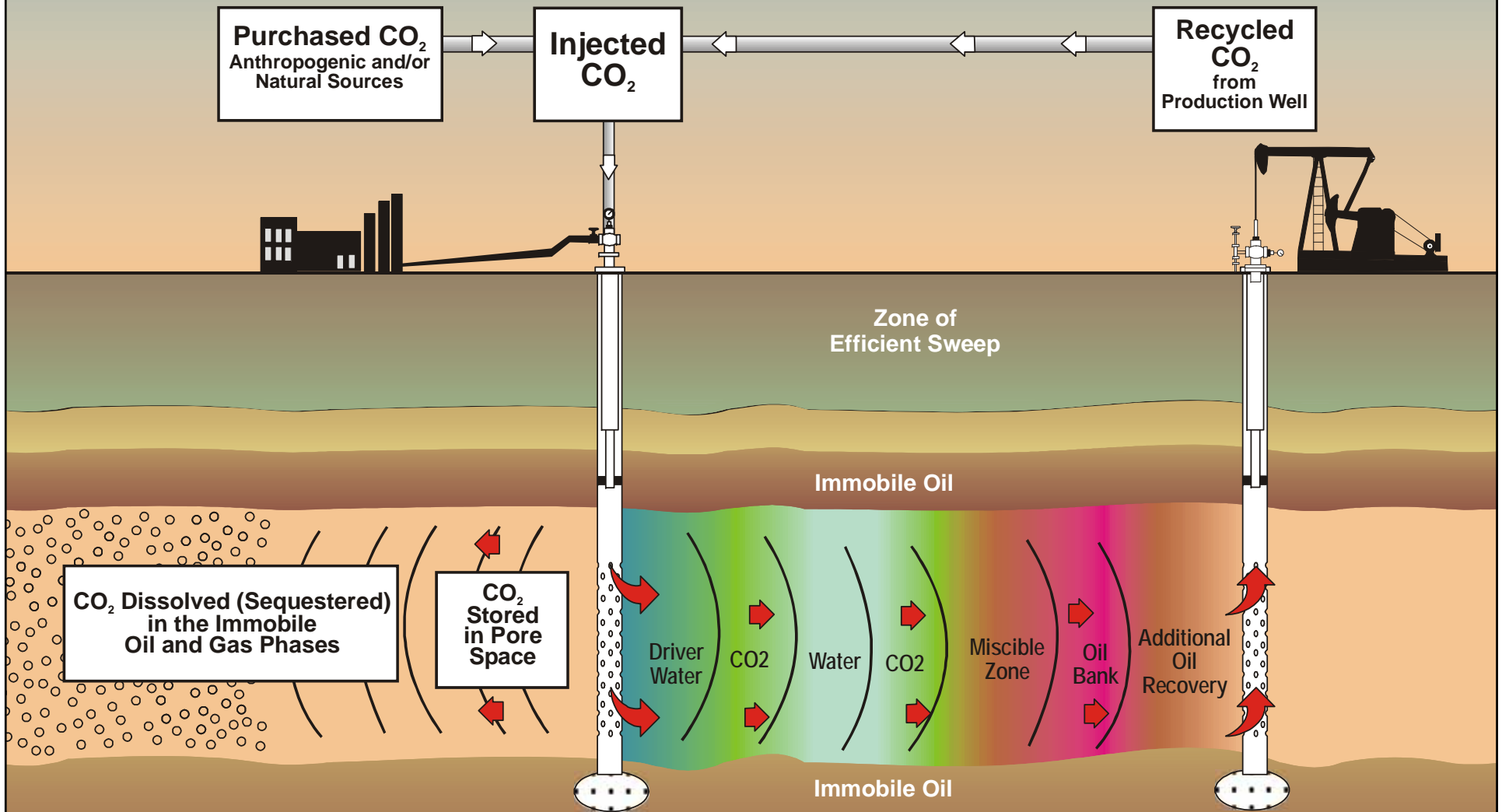
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Unconventional Resources • Enhanced Recovery • Carbon Sequestration



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What is CO₂-EOR?



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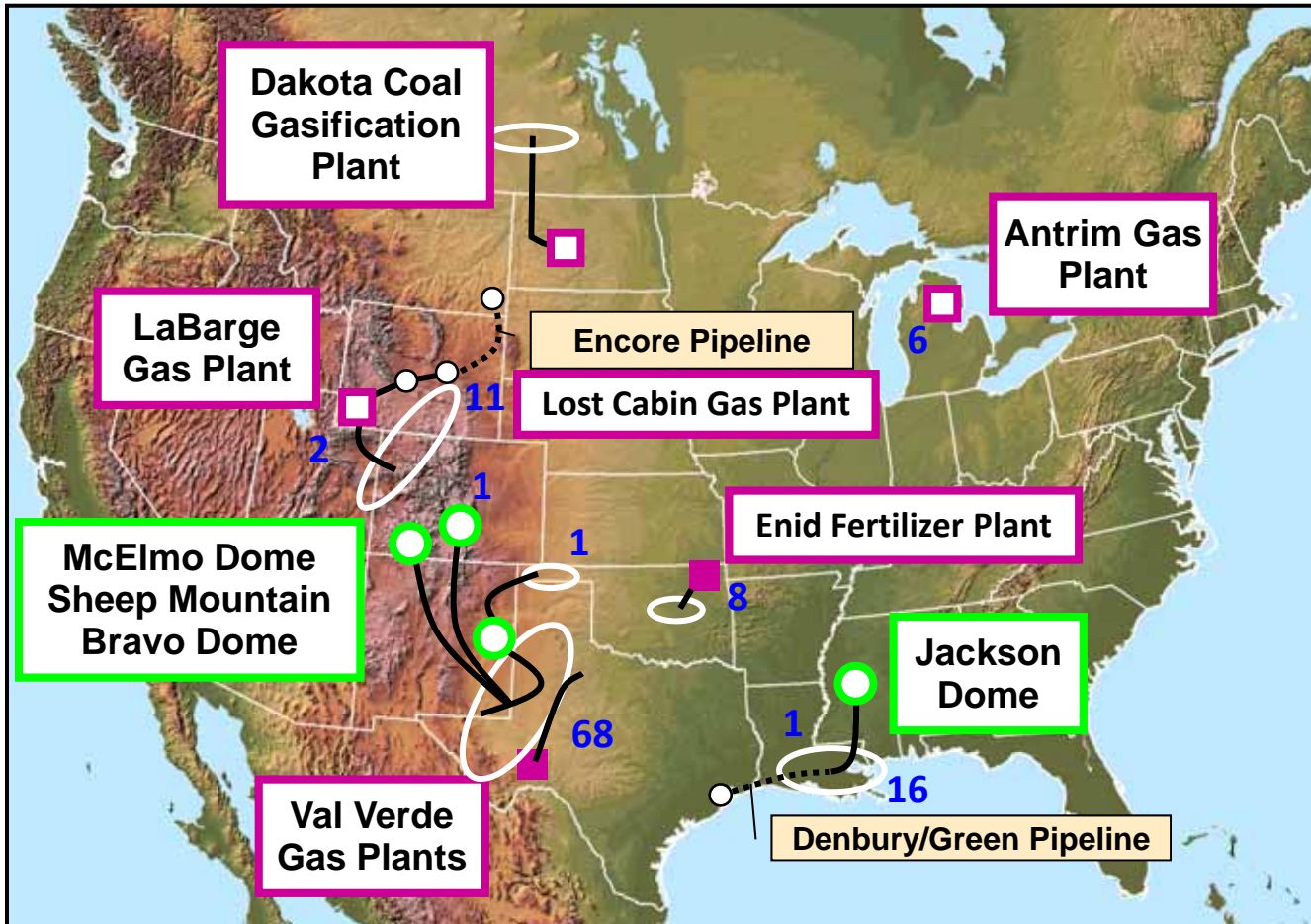
Study Objectives

- 1. How large is the world-wide oil resource potential offered by CO₂-EOR**
 - Along with associated CO₂ storage capacity
- 2. What factors have facilitated or hindered the wide-scale deployment of CO₂-EOR?**
- 3. What set of actions could significantly increase storage potential from the integrated application of CO₂-EOR and CO₂ storage?**

Overview of Study

- 1. Reviewed worldwide CO₂-EOR operations conducted to date (successes and failures)**
- 2. Built database of world's largest 54 oil basins**
 - 95% of world's recoverable oil potential
- 3. Assessed CO₂-EOR oil recovery and CO₂ storage capacity potential in these basins**
 - Using the U.S. experience as analogue
- 4. Examined ways to expand CO₂ storage capacity in conjunction with CO₂-EOR**

U.S. CO₂-EOR Activity – Oil Fields and CO₂ Sources



114 Number of CO₂-EOR Projects

Natural CO₂ Source

Industrial CO₂ Source

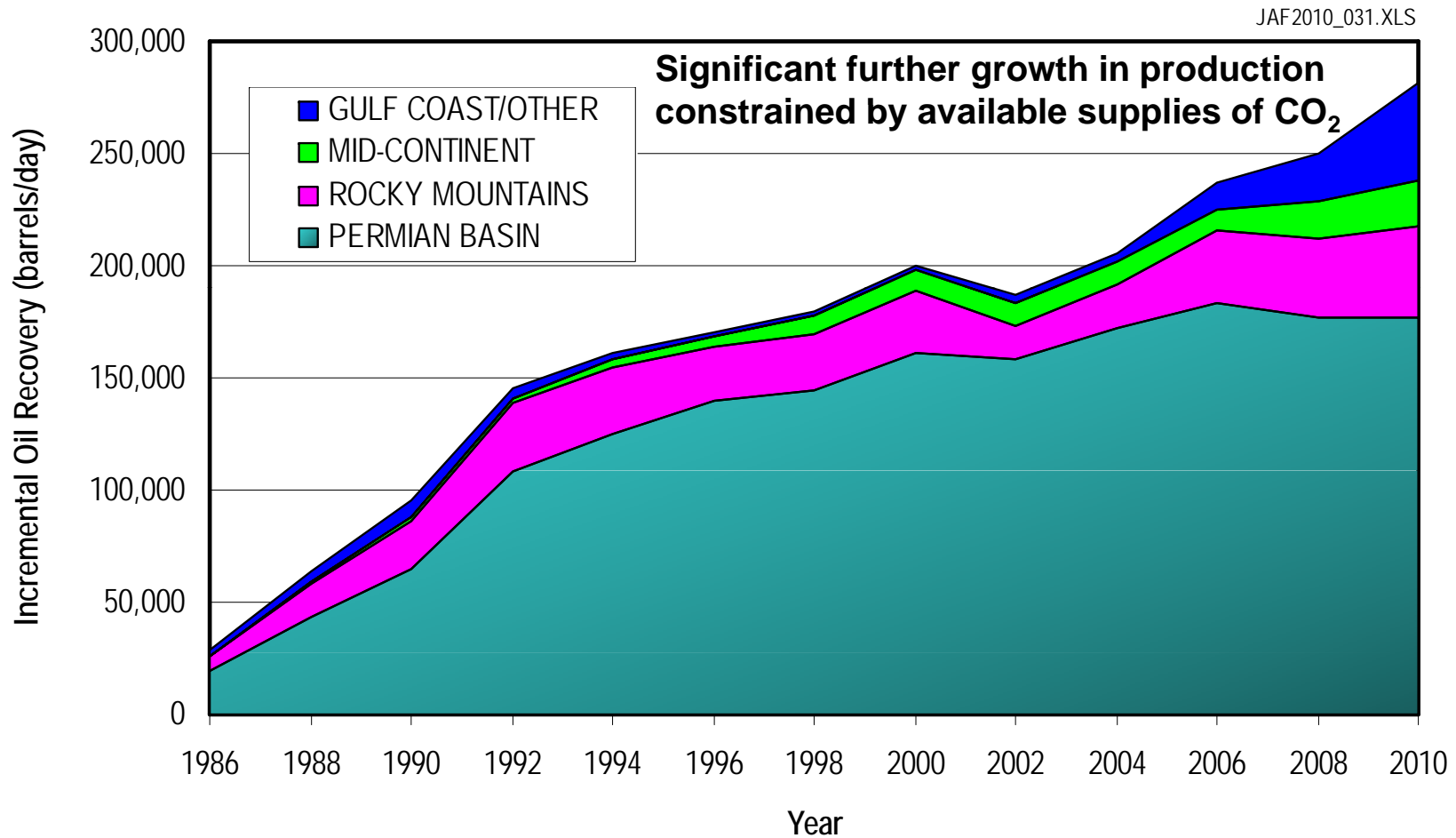
Existing CO₂ Pipeline

CO₂ Pipeline Under Development

- Most CO₂-EOR activity currently in North America
- Currently, 114 projects provide 281,000 B/D in U.S.
- Additional projects planned to help increase CO₂ supply to CO₂-EOR
 - Natural & anthropogenic
 - New CO₂ pipelines

Source: Advanced Resources International, Inc., based on Oil and Gas Journal, 2010 and other sources.

Growth Of CO₂-EOR Production in the U.S.



Source: Advanced Resources Int'l., based on Oil and Gas Journal, 2010.

Overview of Resource Assessment Methodology

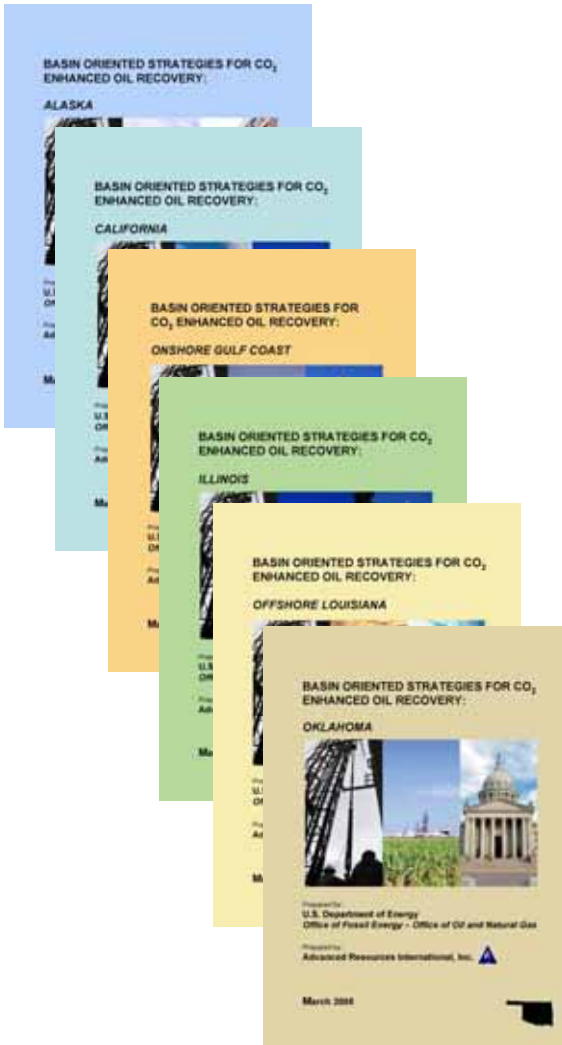
1. **Select oil basins favorable for CO₂-EOR operations**
2. **Estimate the volume of original oil in place (OOIP) in world oil basins**
3. **Characterize oil basins, and the potential fields within these basins, amenable to CO₂-EOR**
4. **Estimate CO₂-EOR flood performance/recovery efficiency**
5. **Estimate the volume of oil technically recoverable with CO₂-EOR**
6. **Estimate volume of CO₂ that could be stored by these CO₂-EOR operations**

World Characterization Based on Detailed Assessment of CO₂-EOR Potential In U.S.

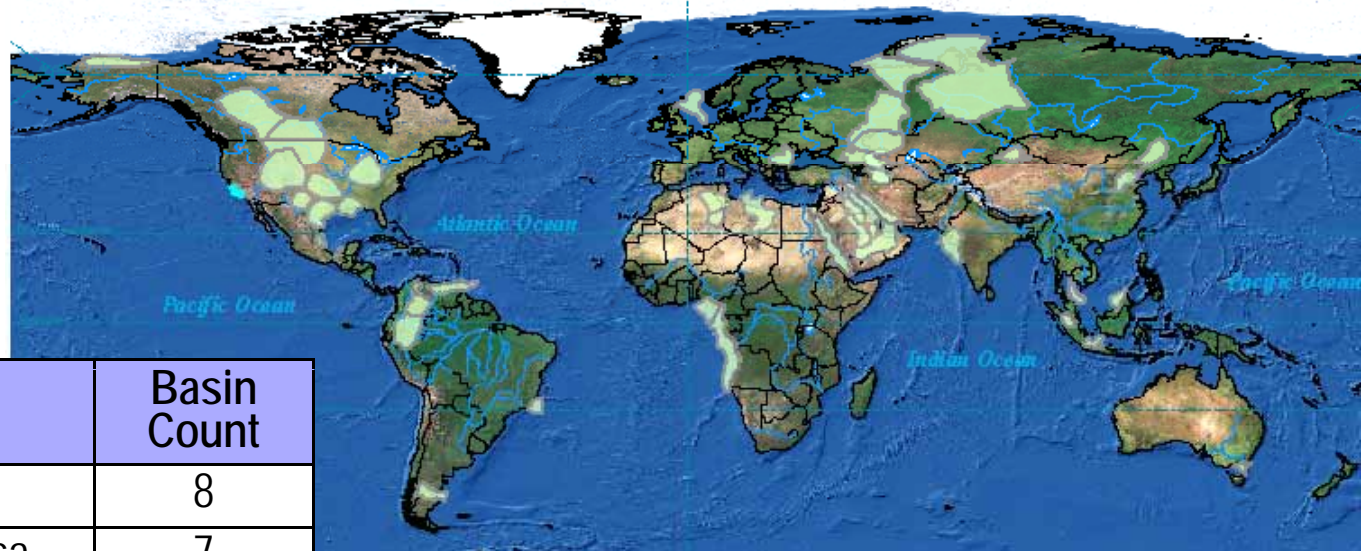
Advanced Resources assessed potential of applying “state-of-the-art” CO₂-EOR in the U.S.:

- 82 billion barrels of technically recoverable resource
- 37 to 68 billion barrels of economically recoverable resource, depending on oil price and CO₂ costs.

Results are based on applying streamline reservoir simulation and economic analyses to over 6,000 large oil reservoirs (75% of U.S. oil production).



Basins Assessed for CO₂-EOR Potential



Region Name	Basin Count
Asia Pacific	8
Central and South America	7
Europe	2
Former Soviet Union	6
Middle East and North Africa	11
North America/Other	3
North America/United States	14
South Asia	1
S. Africa/Antarctica	2
Total	54

Assessed 54 large world oil basins for CO₂-based Enhanced Oil Recovery

- High level, 1st order assessment of CO₂-EOR and associated storage potential, using U.S. experience as analog.
- Tested basin-level estimates with detailed modeling of 47 large oil fields in 6 basins.

CO₂-EOR Potential in World's Oil Basins*

(Billions of Barrels)

Region	CO ₂ -EOR, Discovered Fields		CO ₂ -EOR, Undiscovered Resources	Total Potential
	Large	Small		
1. Asia Pacific	18	7	5	30
2. C. & S. America	32	12	16	60
3. Europe	16	6	6	28
4. FSU	79	29	44	152
5. M. East/N. Africa	231	85	96	412
6. NA/Other	18	7	4	29
7. NA/U.S.**	60	23	38	121
8. South Asia	-	-	-	-
9. S. Africa/Antarctica	15	5	29	49
TOTAL	469	174	238	881

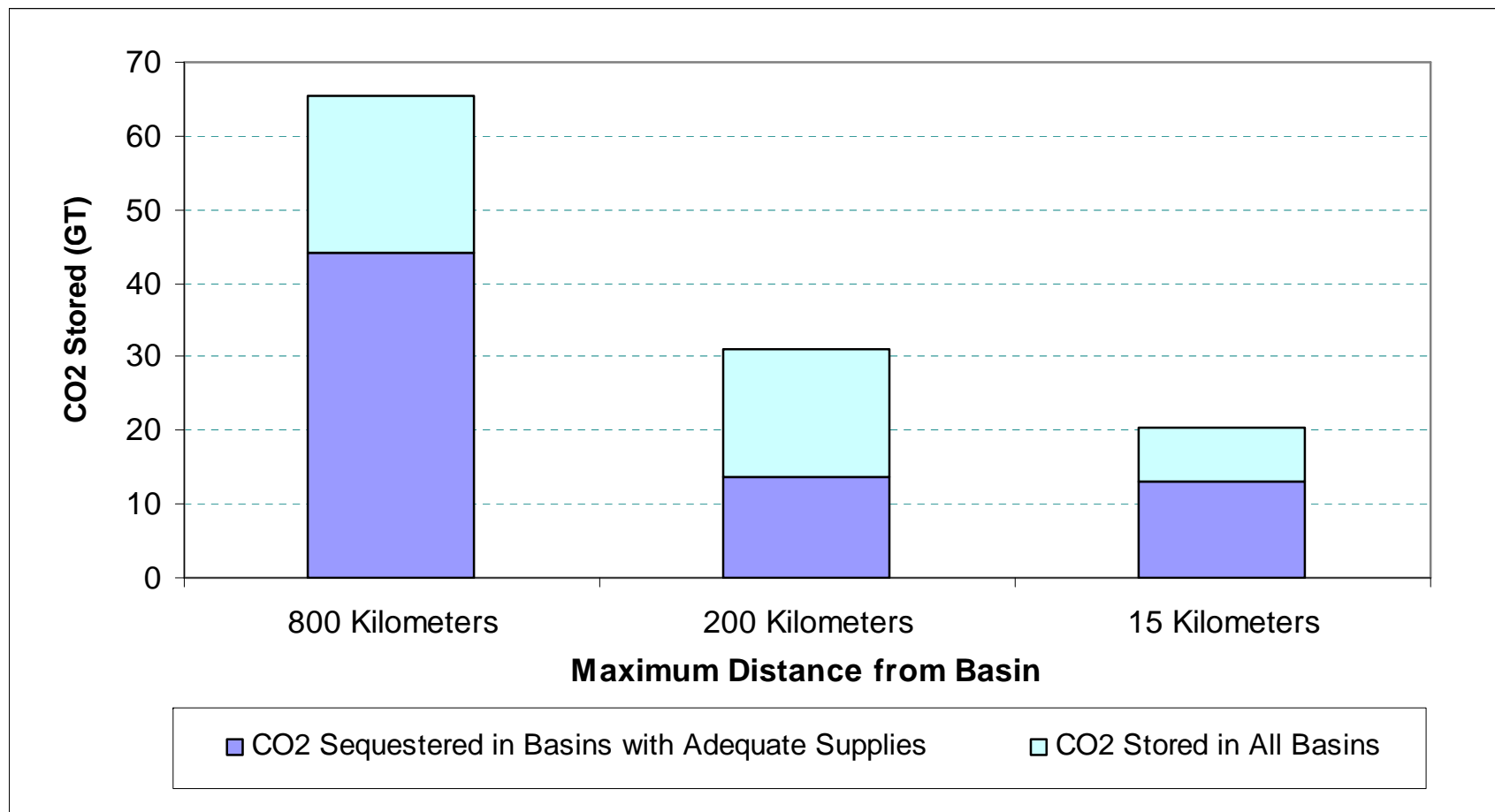
* Includes potential from discovered and undiscovered fields, but not estimated future growth in discovered fields

** Not including offshore & Alaska

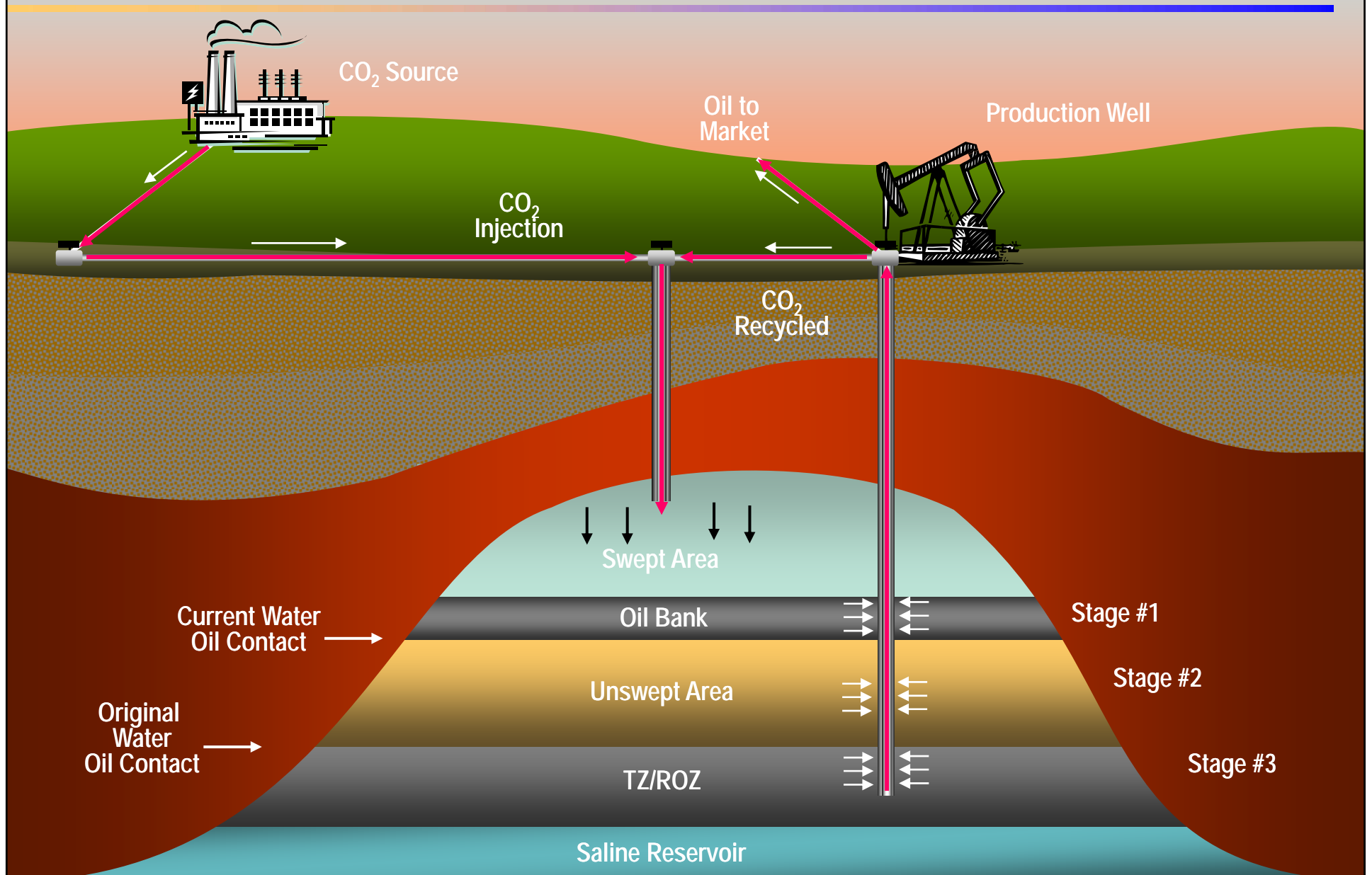
CO₂ Storage Potential with CO₂-EOR (inc. Reserves Growth)

Region	CO ₂ -EOR Potential (Billion Barrels)	CO ₂ Storage Potential (billion tonnes)
1. Asia Pacific	30	8
2. C. & S. America	60	20
3. Europe	28	8
4. FSU	152	42
5. Middle East/N. Africa		125
6. N. America/Non U.S	29	9
7. United States	121	34
8. South Asia	-	-
9. S. Africa/Antarctica	49	15
Subtotal	881	261
Add'l w/ Res. Growth	191	57
TOTAL	1,072	318

Storage Potential Associated with CO₂-EOR in Basins with Sufficient CO₂ Supplies



Integrating CO₂-EOR and CO₂ Storage Could Increase Storage Potential



Conclusions

- 1. CO₂-EOR is not a new phenomena**
 - Underway > 30 years in favorable fields with access to affordable CO₂
- 2. CO₂-EOR has potential to produce 470 - 1,070 billion barrels**
- 3. And store up to 320 billion metric tons of CO₂**
 - Equivalent to the emissions of 4,300 one-GW size coal-fired power plants for 40 years of operation
- 4. Half the CO₂ demand for CO₂-EOR can be met by industrial sources within distances comparable to current CO₂ pipelines serving EOR projects**
- 4. Numerous options and actions could further increase oil recovery and CO₂ storage capacity**