



# **Helping Pay For CO<sub>2</sub> Capture Projects Through Geological Sequestration of CO<sub>2</sub> Used for Enhanced Oil Recovery (EOR)**

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Summit Power Group, LLC**

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# Summit Power Group & Summit Carbon Capture

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- Founded twenty-five (25) years ago by Don Hodel (Chairman emeritus), Secretary of Energy & Interior for President Reagan, and Earl Gjelde (Chairman), COO for Hodel at Energy & Under Secretary of Interior
- Types of power projects that Summit develops for itself and others:
  - Renewables: wind projects, solar projects, etc.
  - State-of-the-art natural gas-fired power plants
  - Coal gasification projects with carbon capture – and CO<sub>2</sub> for EOR
  - Post-combustion capture for fuel-burning power plants – & for EOR
- Summit has long-standing relationships with vendors, engineers, contractors, etc. – including new relationships with Chinese engineering and power companies, Chinese banks, and Chinese firms
- Summit projects completed to date: Totaling \$9 B (current US dollars) and over 9,500 MW
- Summit CO<sub>2</sub> for EOR projects in development: Will total at least an additional \$7-8 B (US dollars) when completed

# U.S. CO<sub>2</sub> Emissions, Emission Reductions, & EOR

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- United States emitted 5,383 million metric tons of CO<sub>2</sub> in 2012<sup>1</sup>
- Power generation accounts for 2,023 million metric tons of CO<sub>2</sub>
- Coal provided 52% of US electricity in 2000, and 37% in 2014
- President Obama and the US Environmental Protection Agency (EPA) have proposed to cut power plant CO<sub>2</sub> emissions by thirty percent (30%) from 2005 levels by 2030
- Efficiency, renewables, and nuclear power alone cannot achieve emissions reductions of this scale on a worldwide basis
- Carbon capture from coal and natural gas power plants will need to be implemented to decrease CO<sub>2</sub> emitted to the atmosphere
- Currently, CO<sub>2</sub> for Enhanced Oil Recovery (EOR) is the only economic large-scale way to cut CO<sub>2</sub> emissions from hydrocarbon based power plants (algae growing won't suffice)

<sup>1</sup> EPA: Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2012 (April 2014)

# EOR can help pay the costs of CO<sub>2</sub> capture

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## Power Plants:

1 MWh hour of coal  
combustion power



1 ton of CO<sub>2</sub> emitted

*or*

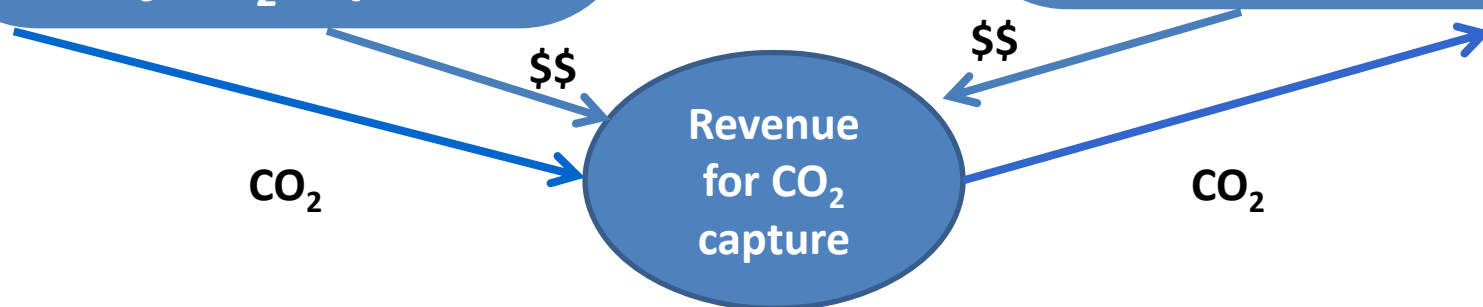
*1 ton of CO<sub>2</sub> captured*

## Oil Fields:

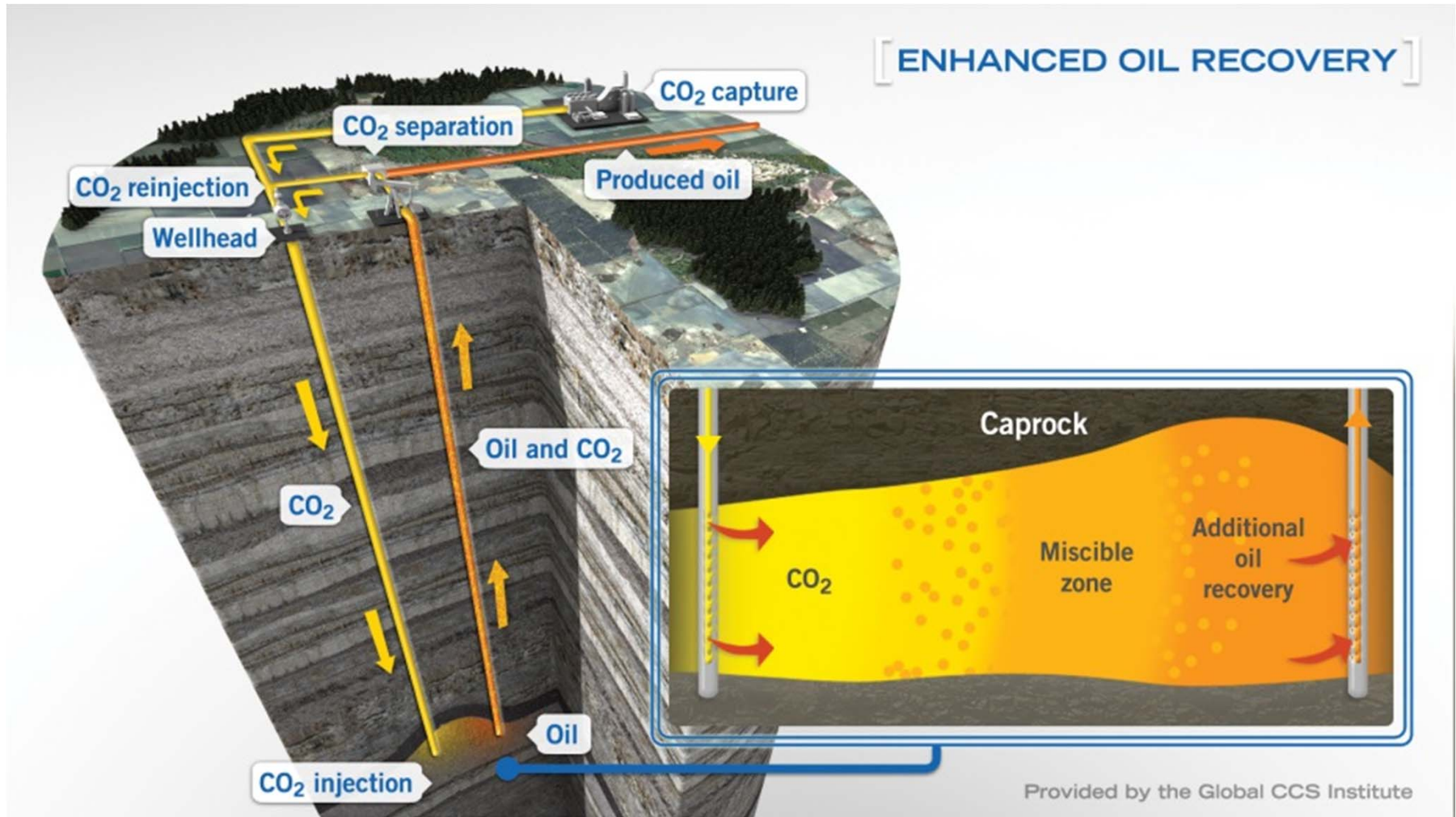
1 ton of CO<sub>2</sub> injected &  
re-injected until 100%  
is trapped underground



2-3 barrels of  
additional oil produced



# Use of CO<sub>2</sub> for Enhanced Oil Recovery (EOR)



CO<sub>2</sub> acts as a solvent – oil that is “stuck” to the rock is released<sub>5</sub>

# Long Ago: Original Reservoir is Fully Charged with Oil

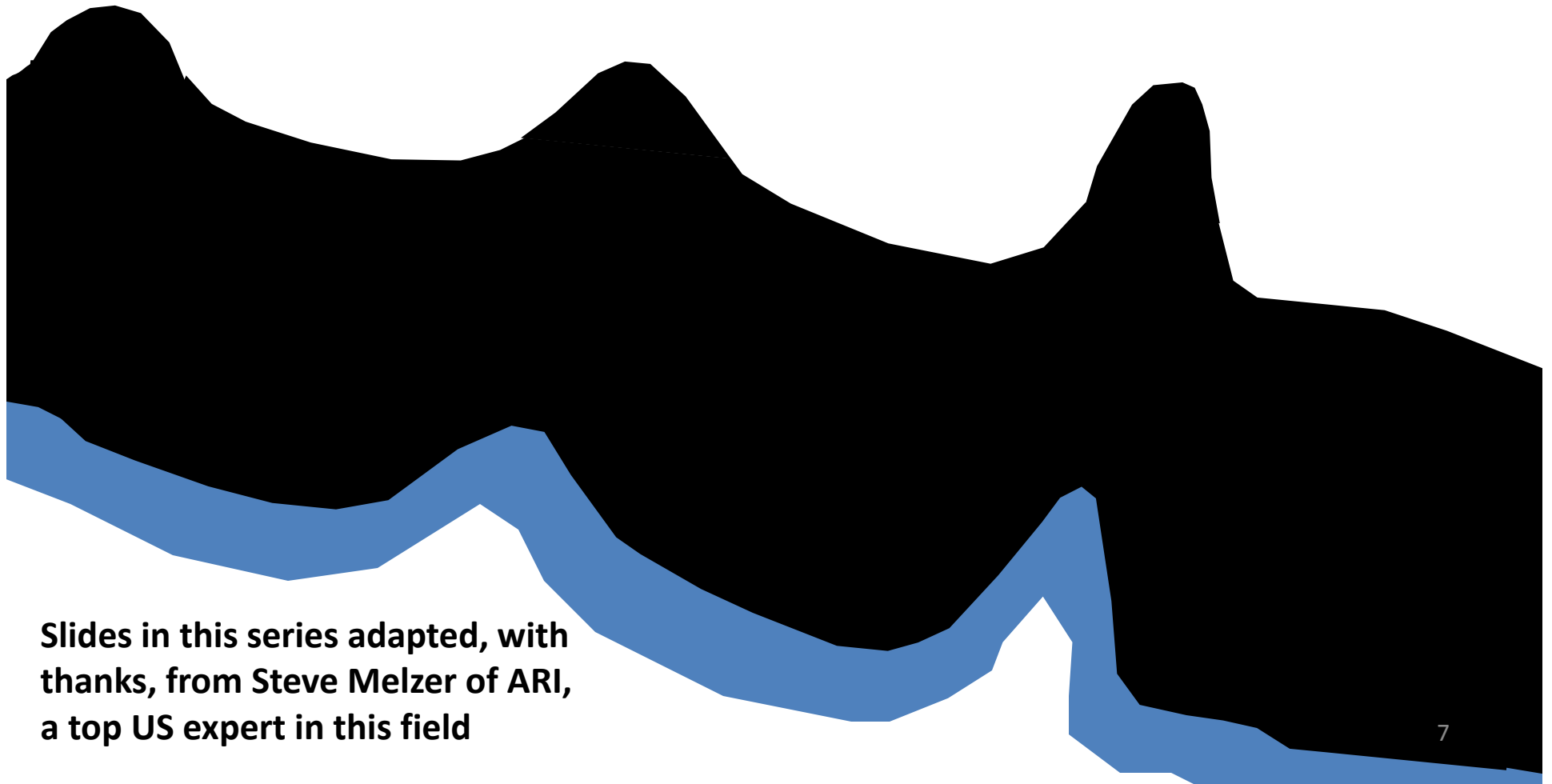
Surface

Cap Rock

Oil

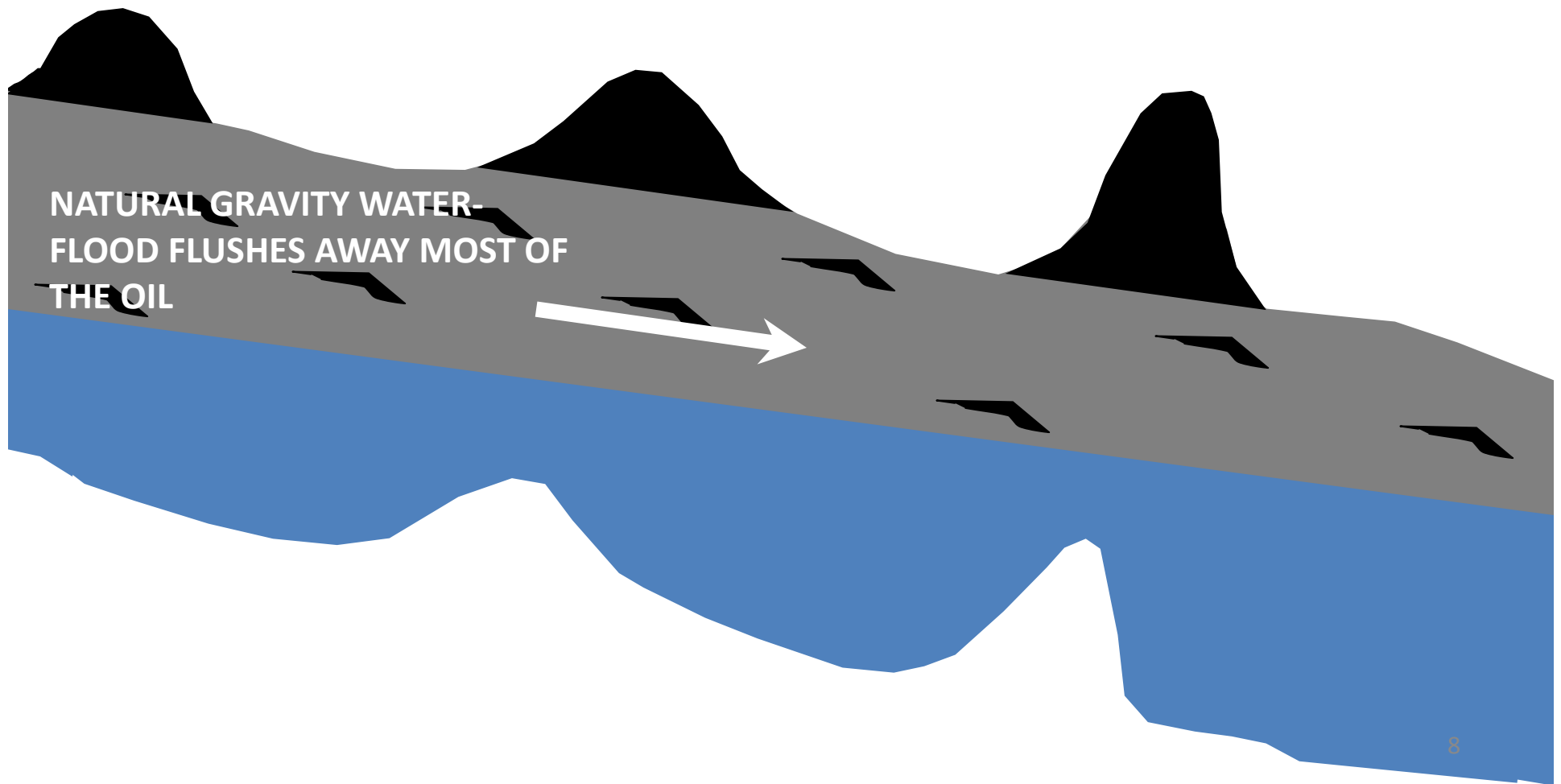
Water

## **Tectonic Activity Tilts & Structures Reservoir**



**Slides in this series adapted, with  
thanks, from Steve Melzer of ARI,  
a top US expert in this field**

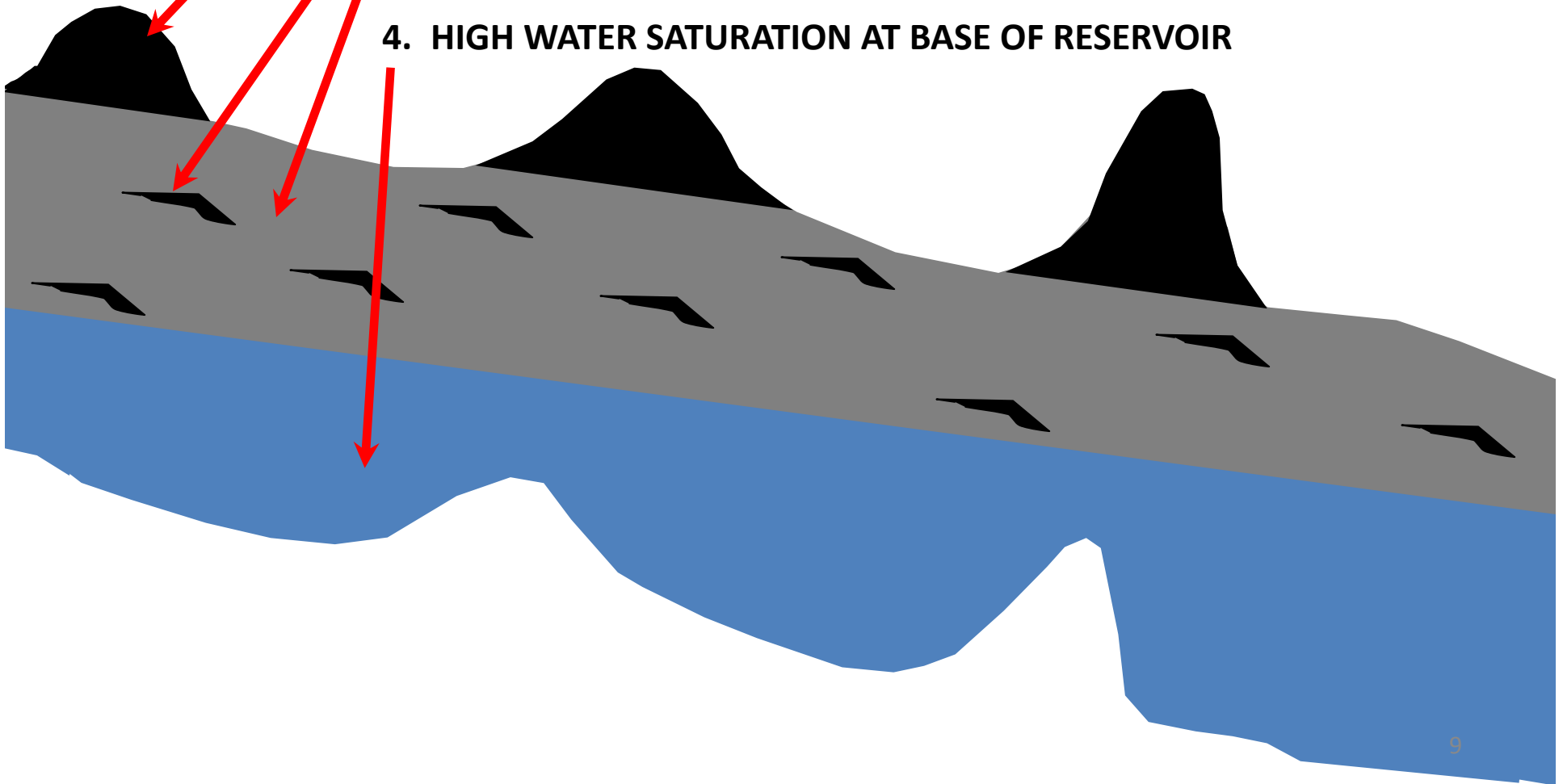
## **Water Entering Through The Surface Floods the Reservoir Over Geologic Time**





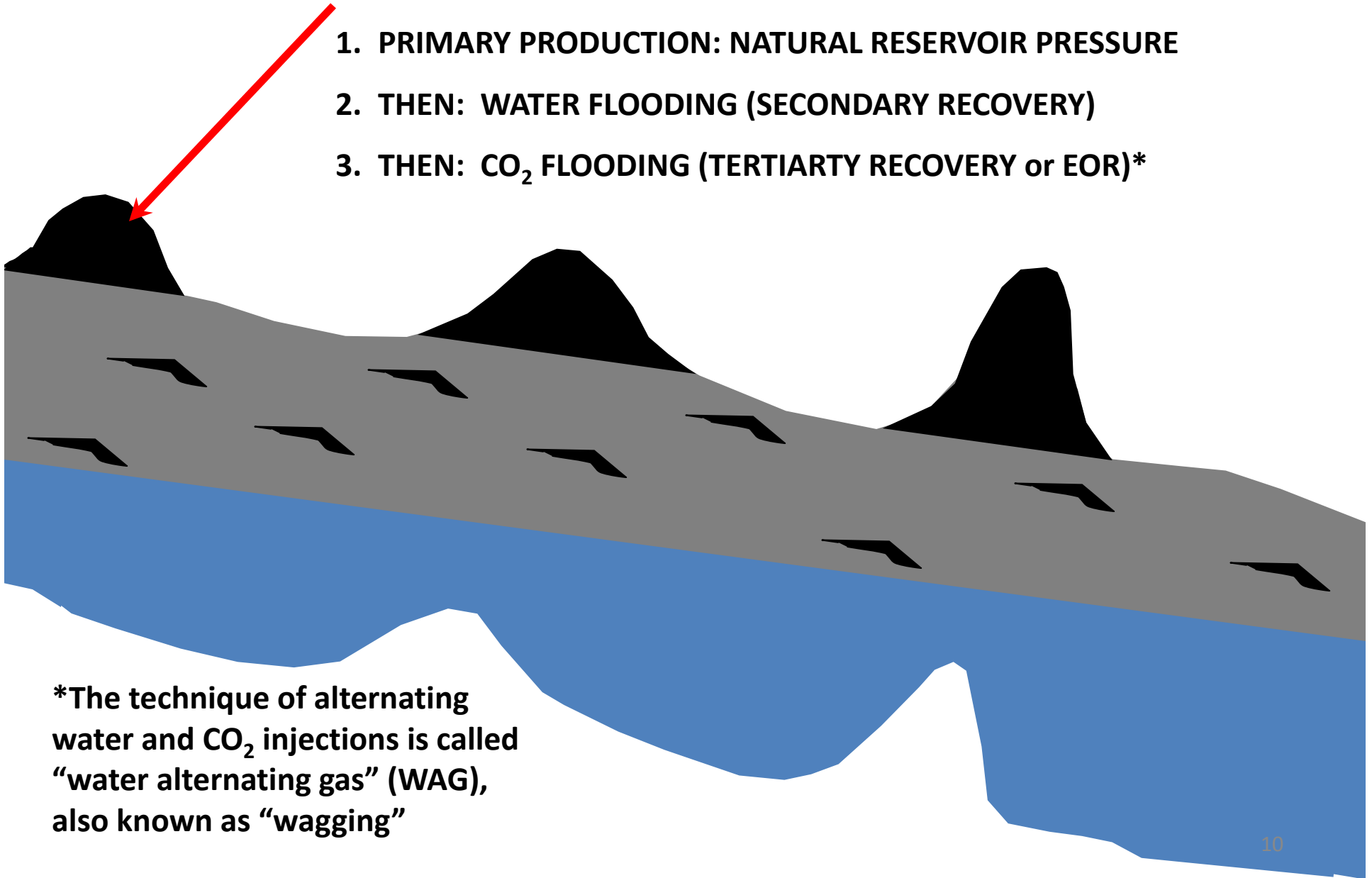
## **NATURE'S WATER FLOOD LEAVES BEHIND:**

1. HIGH OIL SATURATION IN STRUCTURAL HIGH AREAS (THESE BECOME "MAIN PAY ZONES")
2. SOME UNSWEPT OIL ACCUMULATIONS IN THE ROCK
3. RESIDUAL OIL MIXED WITH WATER (10-60% oil, average  $\leq 40\%$ )
4. HIGH WATER SATURATION AT BASE OF RESERVOIR



## **TYPICAL SEQUENCE OF OIL PRODUCTION IN MAIN PAY ZONE:**

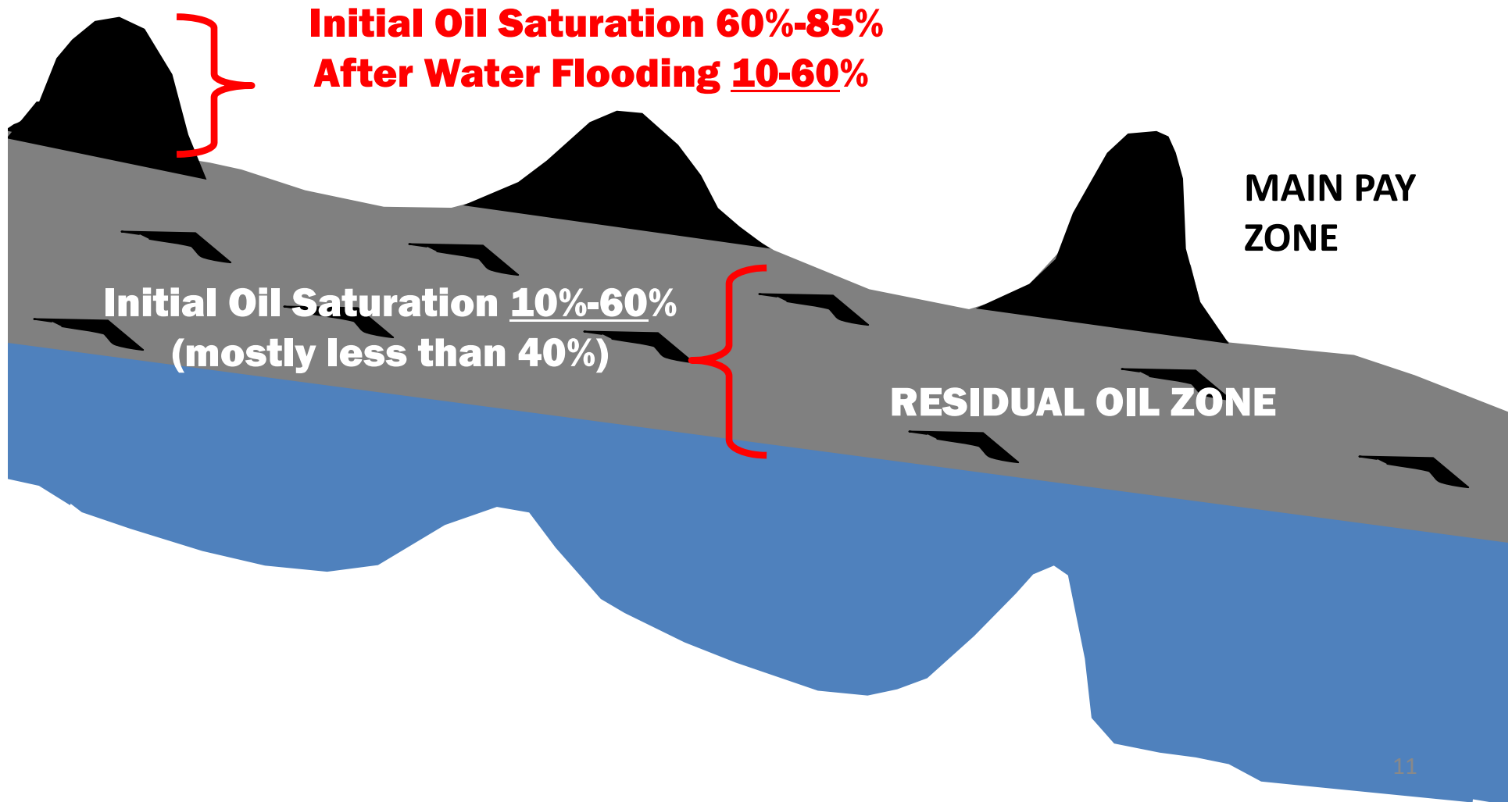
1. PRIMARY PRODUCTION: NATURAL RESERVOIR PRESSURE
2. THEN: WATER FLOODING (SECONDARY RECOVERY)
3. THEN: CO<sub>2</sub> FLOODING (TERTIARY RECOVERY or EOR)\*



**\*The technique of alternating water and CO<sub>2</sub> injections is called “water alternating gas” (WAG), also known as “wagging”**

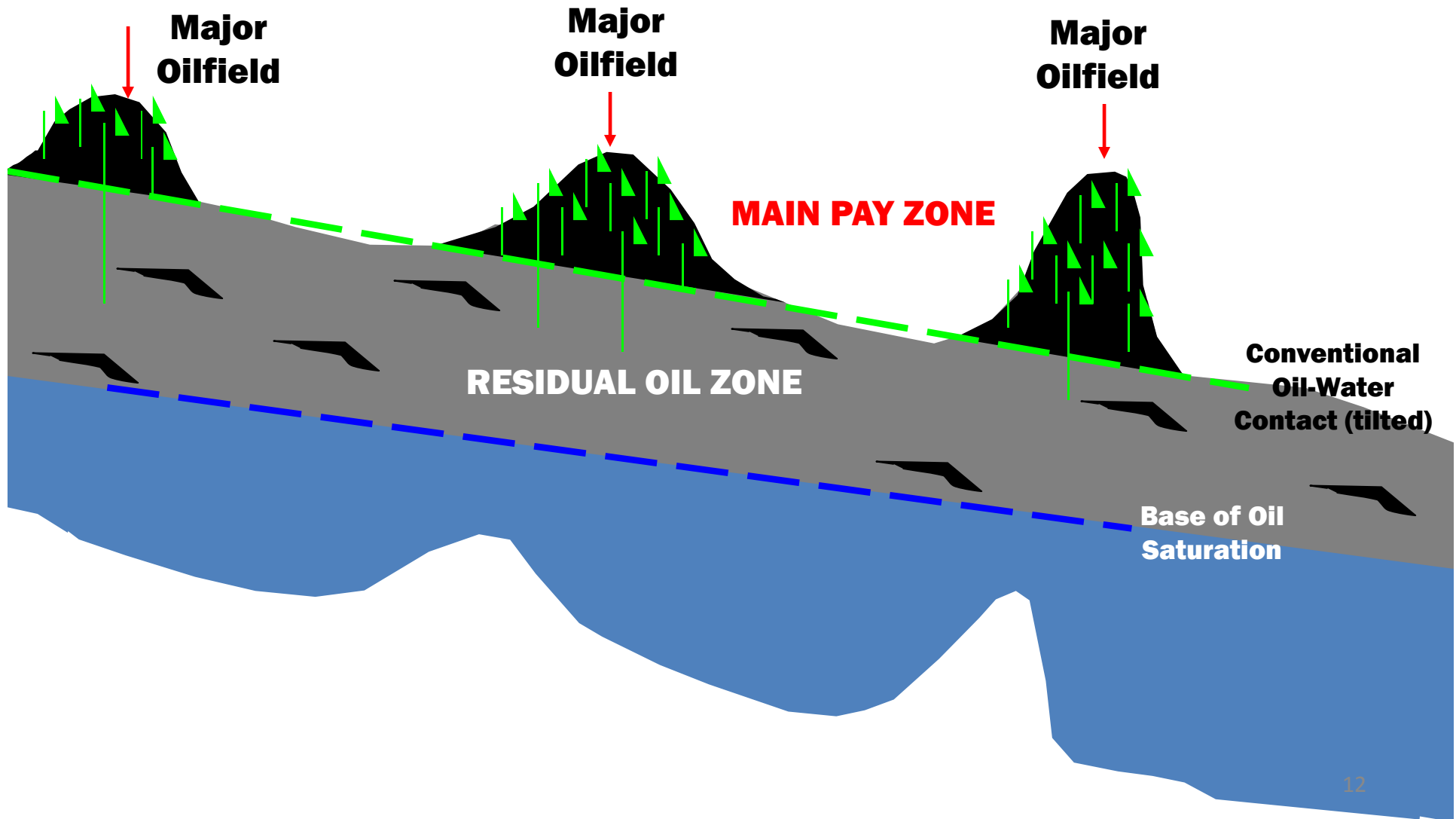
**Oil Saturation in the Residual Oil Zone (“ROZ”) Is Essentially Identical  
to that in the Main Pay Zone *AFTER* Water Flooding**

**This Makes the ROZ Attractive for CO<sub>2</sub> Flooding, Too**

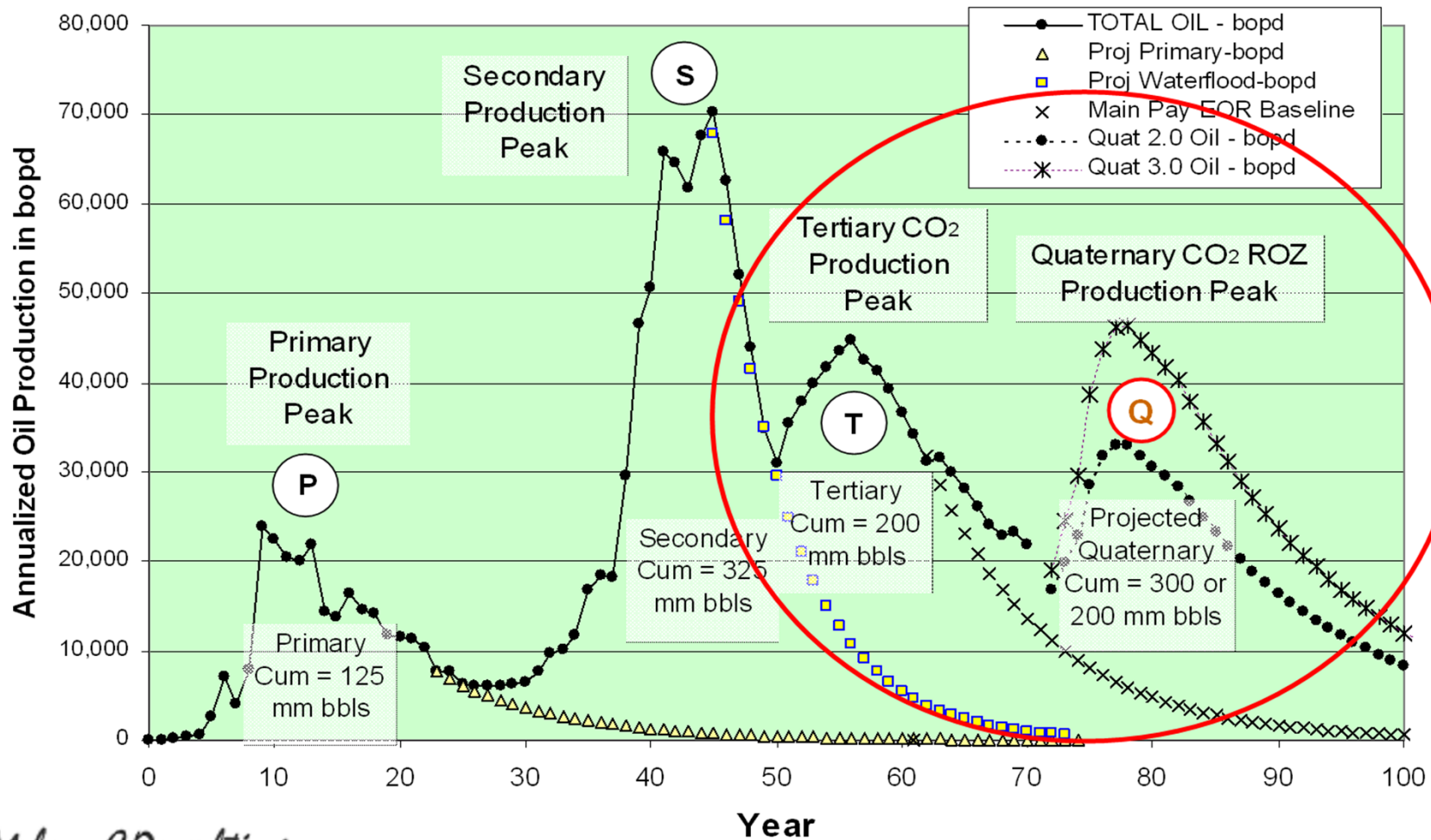


**Today – Major West Texas Oil Fields Have Been Water Flooded and  
More than 100 Fields are Under CO<sub>2</sub> Flooding in the Main Pay Zones**

**CO<sub>2</sub> Flooding is Now Being Performed in the Residual Oil Zone**



**Steve Melzer's Expert Analysis of CO<sub>2</sub> for EOR in a Texas Oilfield:**  
**Production in Red Circle = Total Barrels of Oil from CO<sub>2</sub>**  
**Production of "T" = Barrels from Tertiary CO<sub>2</sub> Recovery in Main Pay Zone**  
**"Q" = Barrels from "Quaternary" CO<sub>2</sub> Recovery in Residual Oil Zone**



# CO<sub>2</sub> for EOR Potential – The U.S. Example

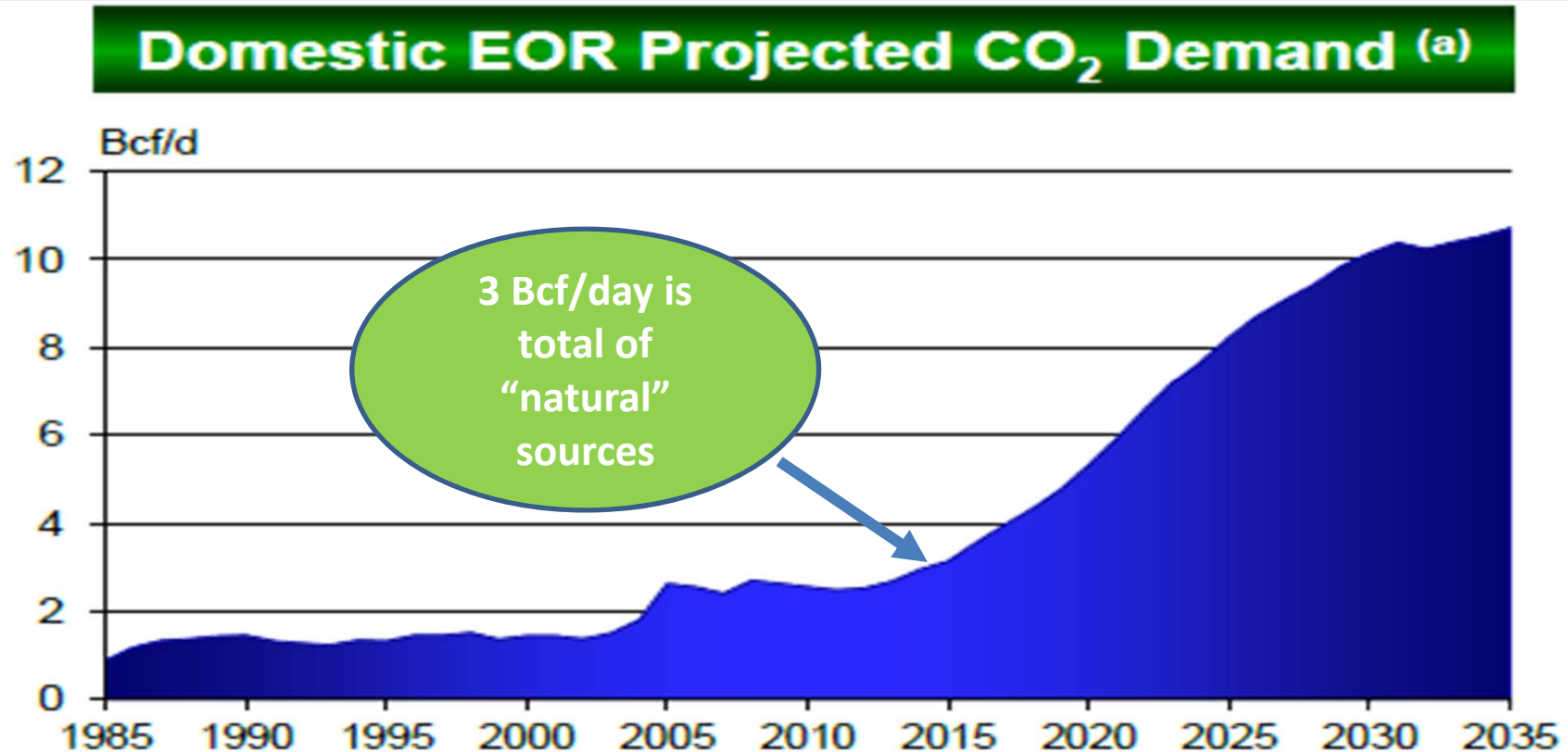
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- United States has at least 48 billion barrels of CO<sub>2</sub> EOR potential<sup>1</sup>
- Currently, 250,000 barrels a day of oil is produced with CO<sub>2</sub> EOR – at \$100 per barrel, this represents \$9+ billion in annual gross revenue
- About 20 billion tons of CO<sub>2</sub> is needed to produce 48 billion bbls of oil – if used for EOR, all 20 billion tons would be permanently sequestered
- Only ~60 million tons of CO<sub>2</sub> is currently injected per year for EOR
- At current rates of CO<sub>2</sub> injection, the US has at least 320 more years before depletion of EOR reservoirs (some estimates are much higher)
- But almost all CO<sub>2</sub> currently used for EOR is from geologic reservoirs
- Geologic reservoirs are depleting; must be replaced by anthropogenic CO<sub>2</sub> – that is, CO<sub>2</sub> captured from power plants and industrial facilities
- “The single largest barrier to expanding CO<sub>2</sub> flooding is the lack of substantial volumes of reliable and affordable CO<sub>2</sub>”<sup>1</sup>

<sup>1</sup> US Oil Production Potential From Accelerated Deployment of Carbon Capture and Storage, Advanced Resources International Inc., March 2010

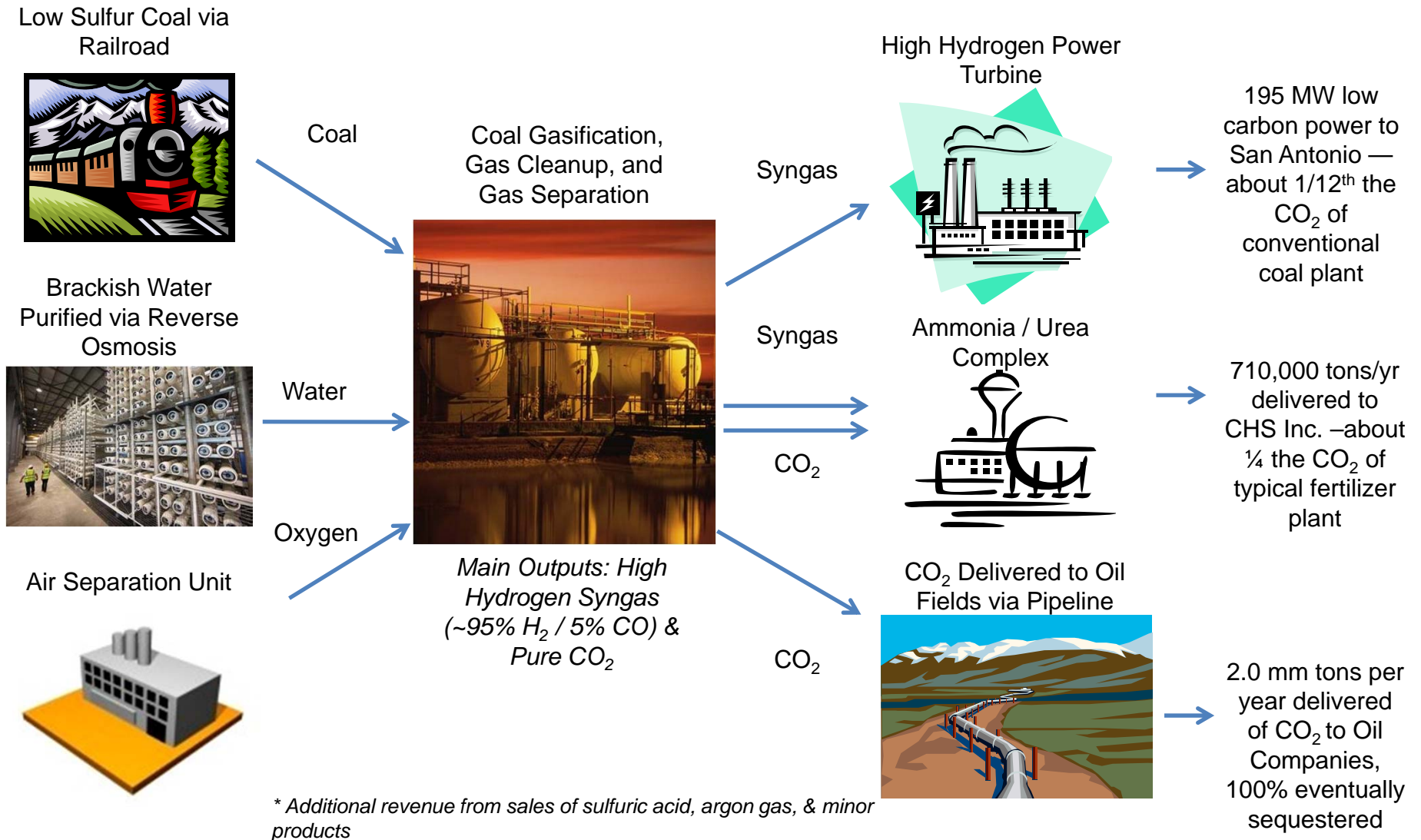
# Natural CO<sub>2</sub> supplies can't meet industry demand

Existing natural CO<sub>2</sub> sources in Texas Gulf, Permian, and Wyoming have capacity of  $\approx 3$  Bcf/day. Industry and US Government projections call for tripling of demand. Extra supply must come mostly from captured CO<sub>2</sub> (i.e., CCS from industry and power plants). One (1) Bcf/day is  $\approx 20$  million tons a year. **So Kinder Morgan's chart shows annual demand going from 60 million tons per year to 200 million tons per year.**



Source: Kinder Morgan 2012 Analyst Presentation

# Summit's Texas Clean Energy Project will turn Coal, Salty Water & Air into Near-Zero Carbon Power, Fertilizer, and Sequestered CO<sub>2</sub> for EOR





# What Makes the Texas Clean Energy Project (TCEP) Important?

**TCEP will be the first power project world wide to:**

- Use state of the art technology to gasify coal AND
- Transform the output into two separate gas streams of hydrogen and CO<sub>2</sub> AND
- Sequester more than 90% of the coal's CO<sub>2</sub> permanently AND
- Use the CO<sub>2</sub> commercially in enhanced oil recovery AND
- Demonstrate that this works for both the end use markets of power (lowest carbon content of any hydrocarbon power plant) and chemicals AND
- Pair China & the U.S. in funding & building a full-scale CO<sub>2</sub> capture power plant



Siemens Gasifiers in Ningxia, China



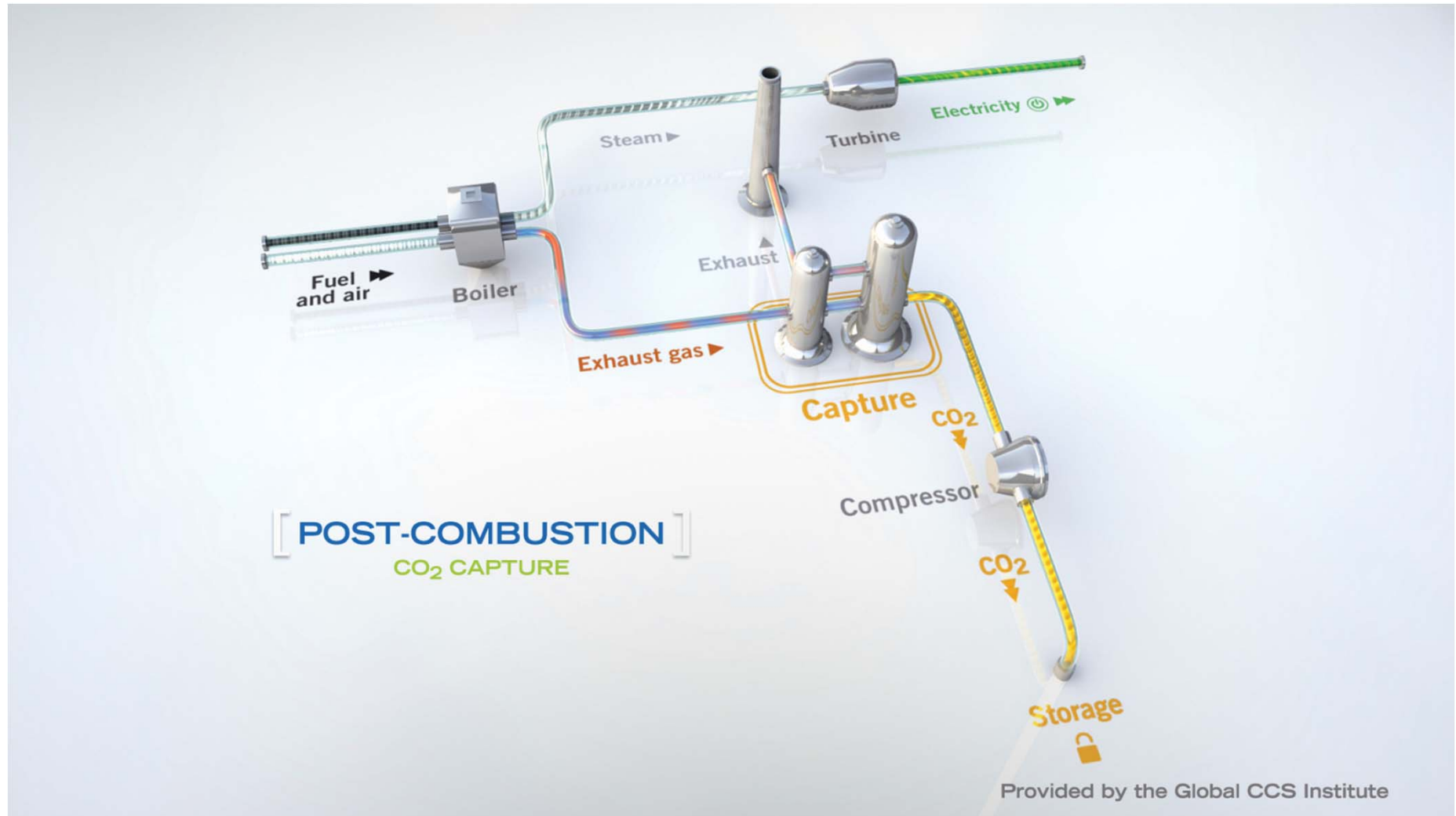
Linde Rectisol® CO<sub>2</sub> Separation

# World's largest gasification project: In Ningxia







**China leads the world in coal gasification for chemical products. China can lead the world in CO<sub>2</sub> capture from coal gasification, too. Why not oil production from captured CO<sub>2</sub> (EOR)? And low-carbon electric power from coal gasification?**

**CO<sub>2</sub> Can Also Be Captured from Coal-Burning Plants, including via Retrofitting those Plants. Capturing CO<sub>2</sub> from Flue Gas (Exhaust) of a Combustion Plant is Called “Post-Combustion Capture” (PCC).**





# Some active post-combustion capture projects

Project Name	Location	Fuel	Equipment Provider*	Status	Notes
Plant Barry	US (Alabama)	Coal	 MITSUBISHI	Operating Since June 2011	25 MW Slipstream. No EOR – all sequestered
Boundary Dam	Canada	Coal		Under Construction will be operating Fall 2014	160 MW. 90% capture. CO2 used for EOR.
W.A. Parish	US (TX)	Coal	 MITSUBISHI	Financial closing announced July 2014	250 MW. 90% Capture. CO2 used for EOR
Peterhead	UK (Scotland)	Gas		FEED stage	One of two winners of UK CCUS competition. Expected to begin operations in 2018

\*Other suppliers of proven PCC systems include Huaneng/CERI, Linde/BASF, Fluor, etc.

*Linde*



# Questions & Answers about CO<sub>2</sub> for EOR

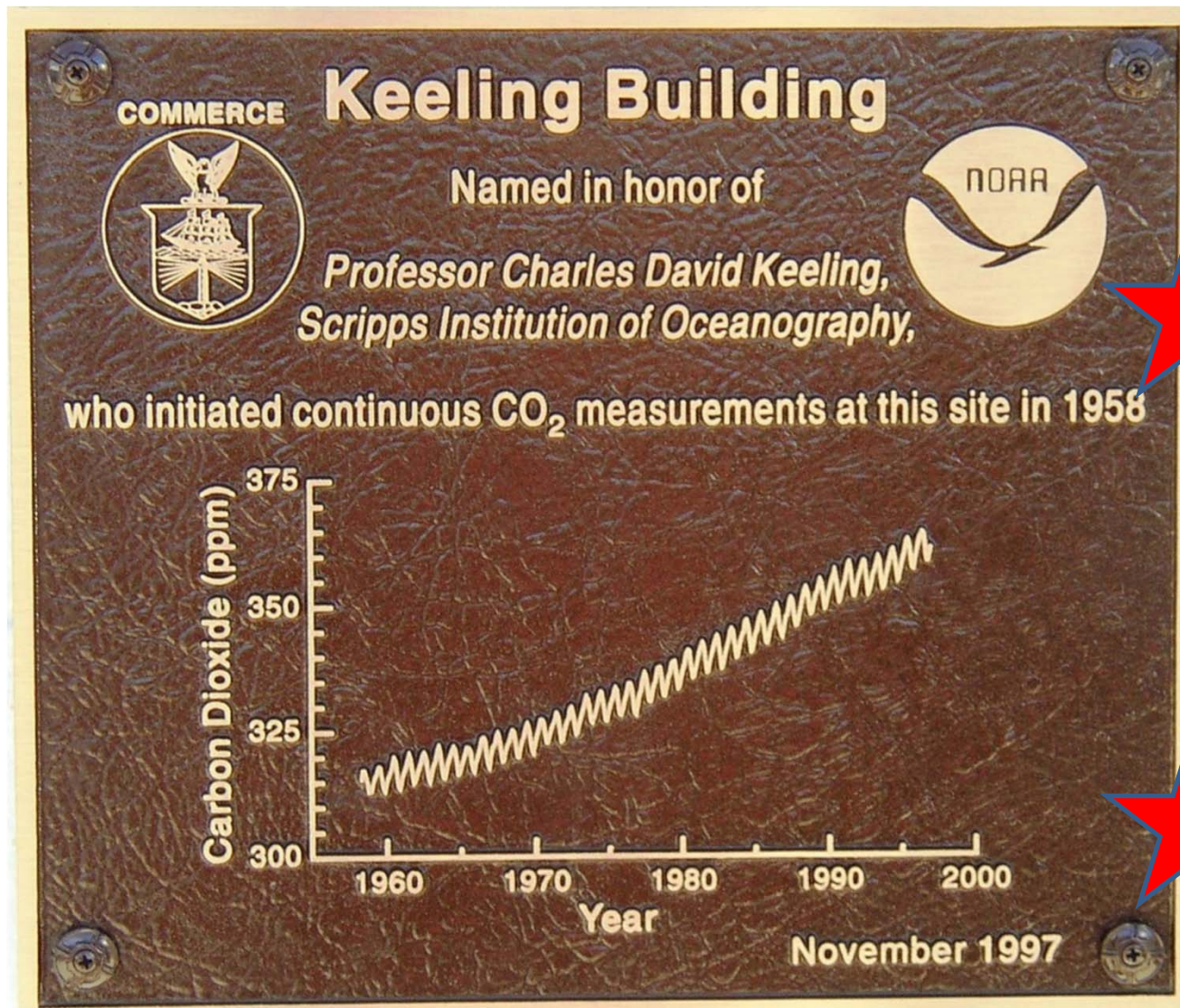
Question	Answer
Do power plants need to capture carbon?	Yes. Power sector is largest source of CO <sub>2</sub> . In the U.S., new rules demand huge cut in CO <sub>2</sub> emissions. <b><i>Reduced carbon emissions = high priority in U.S. <u>and</u> China.</i></b>
Can power plants capture carbon?	Yes. Huaneng /CERI has captured CO <sub>2</sub> in China. Systems being installed now in North America (Shell & Mitsubishi).
Can oil wells really use CO <sub>2</sub> ?	Yes. In the US, about 100 million barrels/year come from CO <sub>2</sub> use. China could produce as much or more. China has suitable geology in main pay zones and residual oil zones.
Will oil producers pay for CO <sub>2</sub> ?	Yes. Current prices about \$35-40 per ton in Texas. Lower in some states, potentially higher in other states.
Can CO <sub>2</sub> be transported?	Yes. Already ≈ 5,000 miles of CO <sub>2</sub> pipelines in the U.S.
Does CO <sub>2</sub> for EOR produce permanent carbon sequestration?	Yes. CO <sub>2</sub> that comes to the surface with oil is re-compressed and re-injected. Ultimately it all stays down.
Doesn't the produced oil have carbon, too?	Yes. But much less than the CO <sub>2</sub> that's injected. No other oil production method traps CO <sub>2</sub> underground.

# Dr. S. Julio Friedmann, US Department of Energy



*“Last year, the world used more wind power, solar energy, biomass, and hydro energy than ever before. We also used more coal, oil, natural gas, and nuclear power than ever before. We used more energy in total than ever before.”*

# Why CO<sub>2</sub> Sequestration Matters



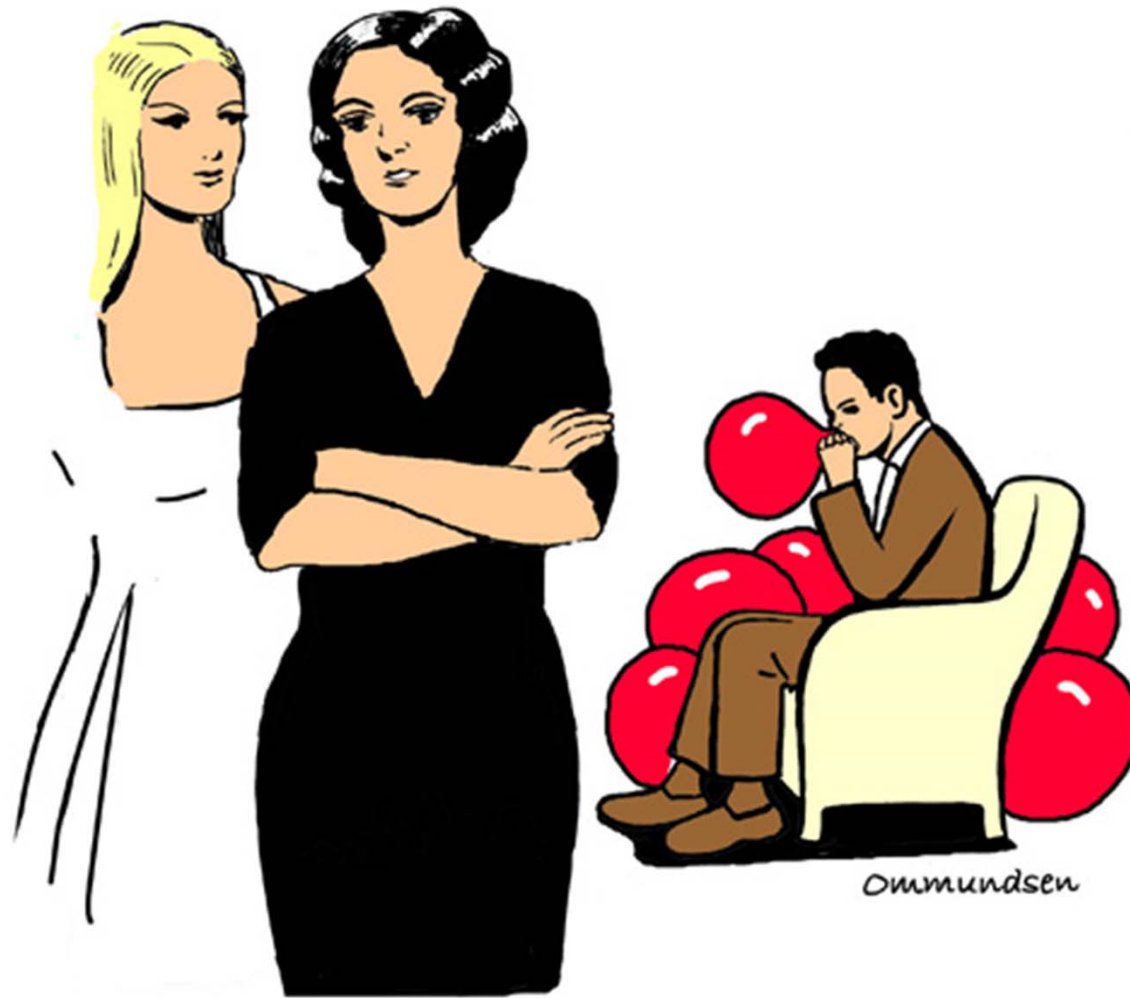
400 ppm

*Plaque on  
Mauna Loa  
in Hawai'i*

2014



**Conclusion: CO<sub>2</sub> EOR is not new, it is important for sequestration – and it can help pay for CO<sub>2</sub> capture**



**“Frank’s into carbon sequestration.”**



*谢谢! Thank you!*

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