National Enhanced Oil Recovery Initiative

Meeting One

Hyatt Regency Washington

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U.S. EOR Industry: An Overview

Current State of Play and Future Potential

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Melzer CO_2nsulting

U.S. EOR Industry: An Overview

Current State of Play and Future Potential

1) CO_2 Enhanced Oil Recovery – A Quick Look at the Technology
2) Where, How Much Oil and CO_2, Who are the Key Players?
3) The Growing Demand for CO_2
    A) Oil Pricing
    B) New Targets (ROZs)
4) Market Issues and Barriers to Greater Deployment

Primary, Secondary and Tertiary Recovery

Primary: New Wells Are Drilled, Pressures within the Fluids in the Reservoir Cause Them to Flow to Surface

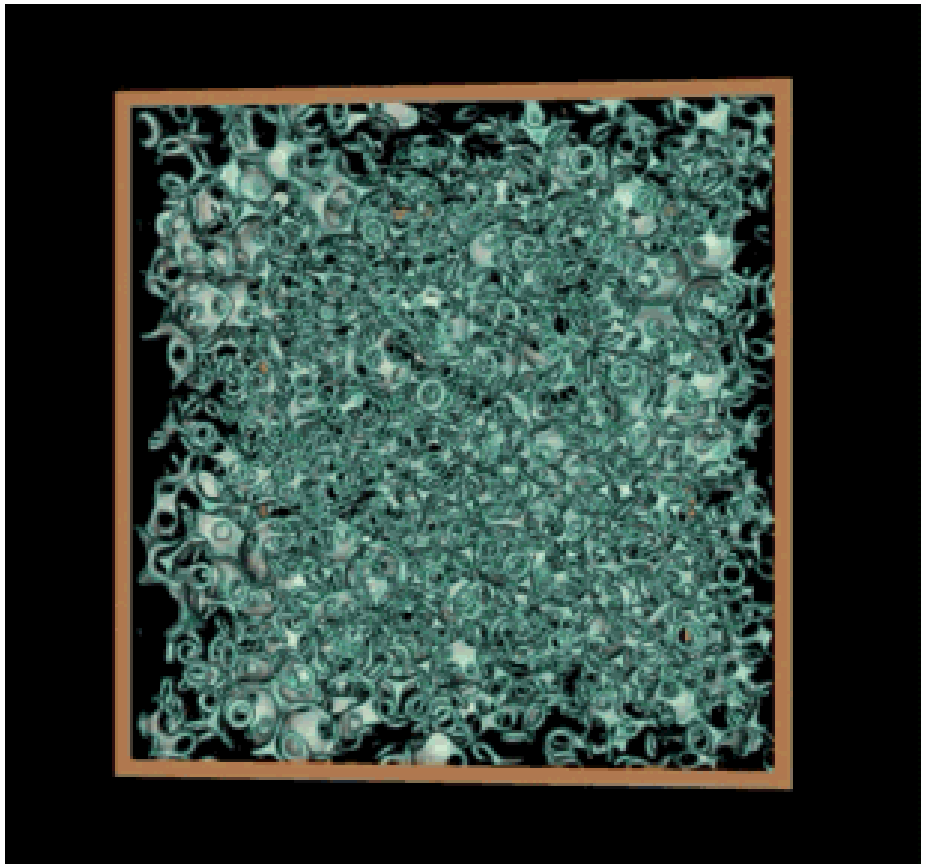
Secondary: Comes after the Reservoir Pressures are Depleted, Some Wells are Recompleted to Become Injection Wells and a Fluid is Injected to Repressure and Sweep Additional Oil; Generally the Injected Fluid is Water and we call it waterflooding (water and oil do not mix)

Tertiary: The Injectant used causes the oil properties to change hence allowing more of the bypassed oil in the secondary phase to be produced; heat (steam), CO_2, and surfactant like chemicals are the most common types; At depths greater than 2500 feet, the CO_2 is not a gas – has the density of a liquid

SYNONYMS

- CO_2 Enhanced Oil Recovery and CO_2 Flooding will be used interchangeably herein
- Tertiary Flooding is sometimes used as a substitute term for CO_2 EOR but does imply that the CO_2 flood follows a waterflood

JUST A REMINDER: THE OIL IS IN PORES, NOT IN UNDERGROUND POOLS



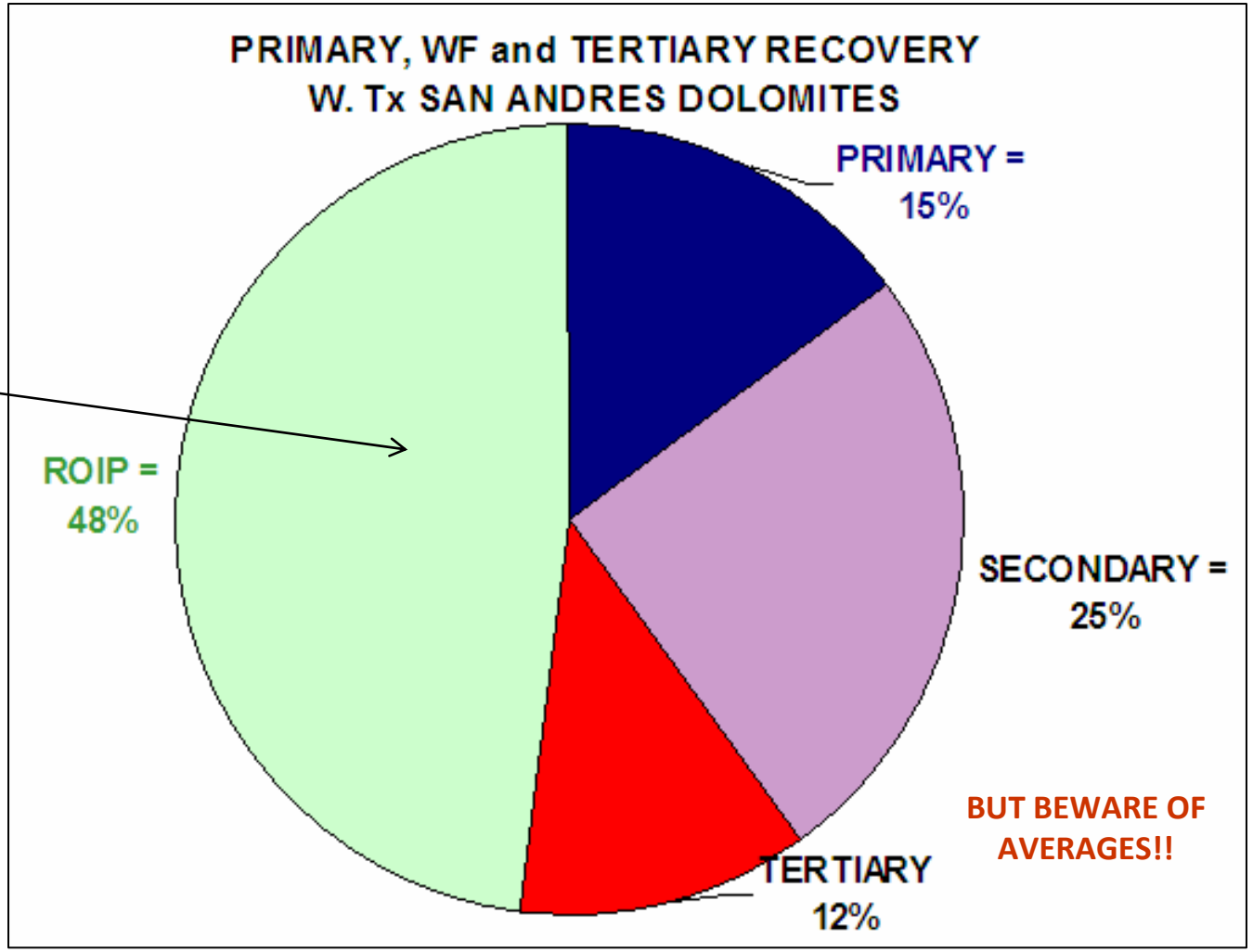
Pore Geometries

Courtesy of Mark Knackstedt

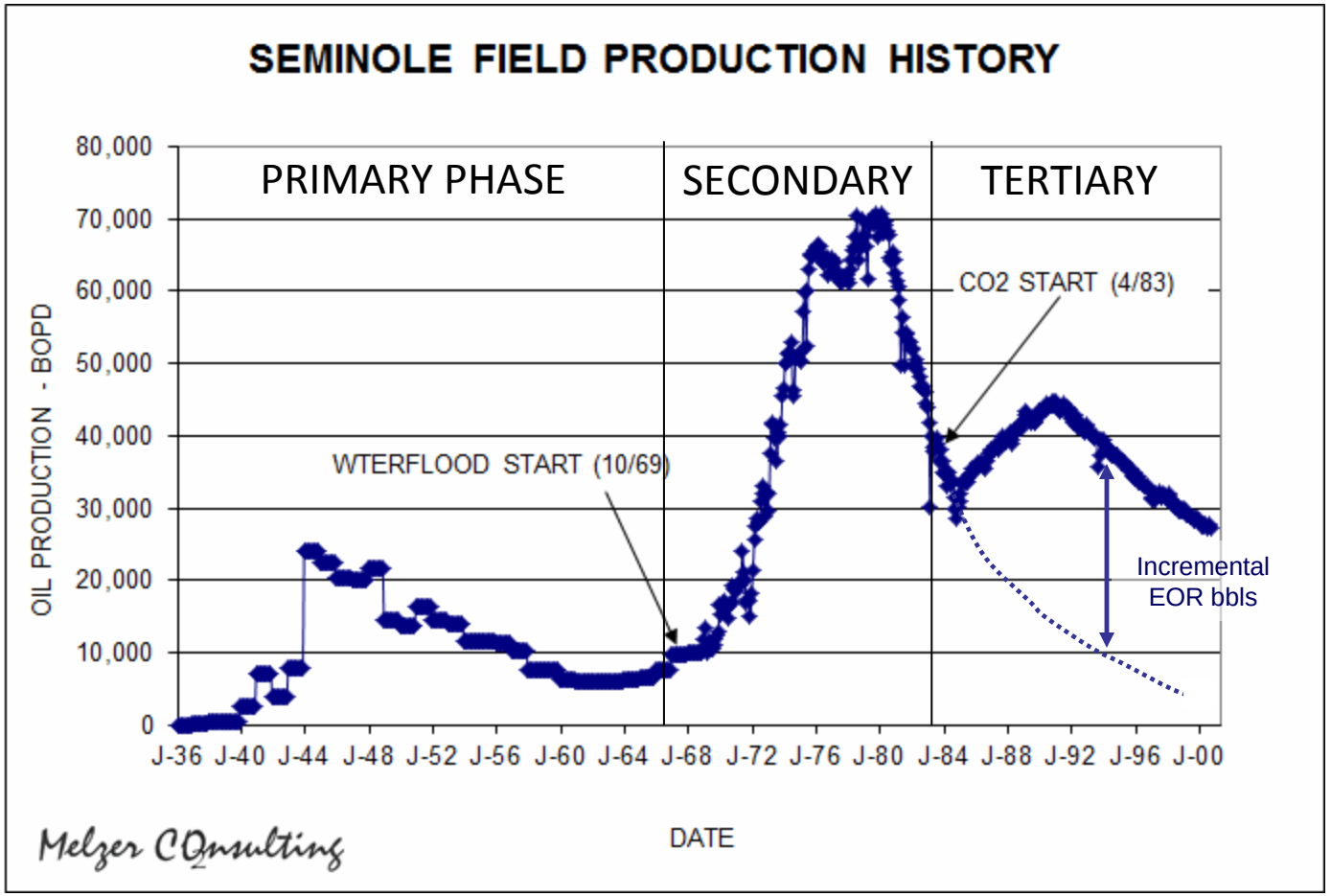
Australian National University

PRIMARY, WF AND TERTIARY RECOVERY FROM THE W. TX SAN ANDRES FORMATION EXPERIENCE

NEARLY HALF THE OIL IS STILL THERE, EVEN AFTER TERTIARY (CO_2) PHASE!



Primary, Secondary and Tertiary Oil
(an example)



CO_2 EOR

How It Works

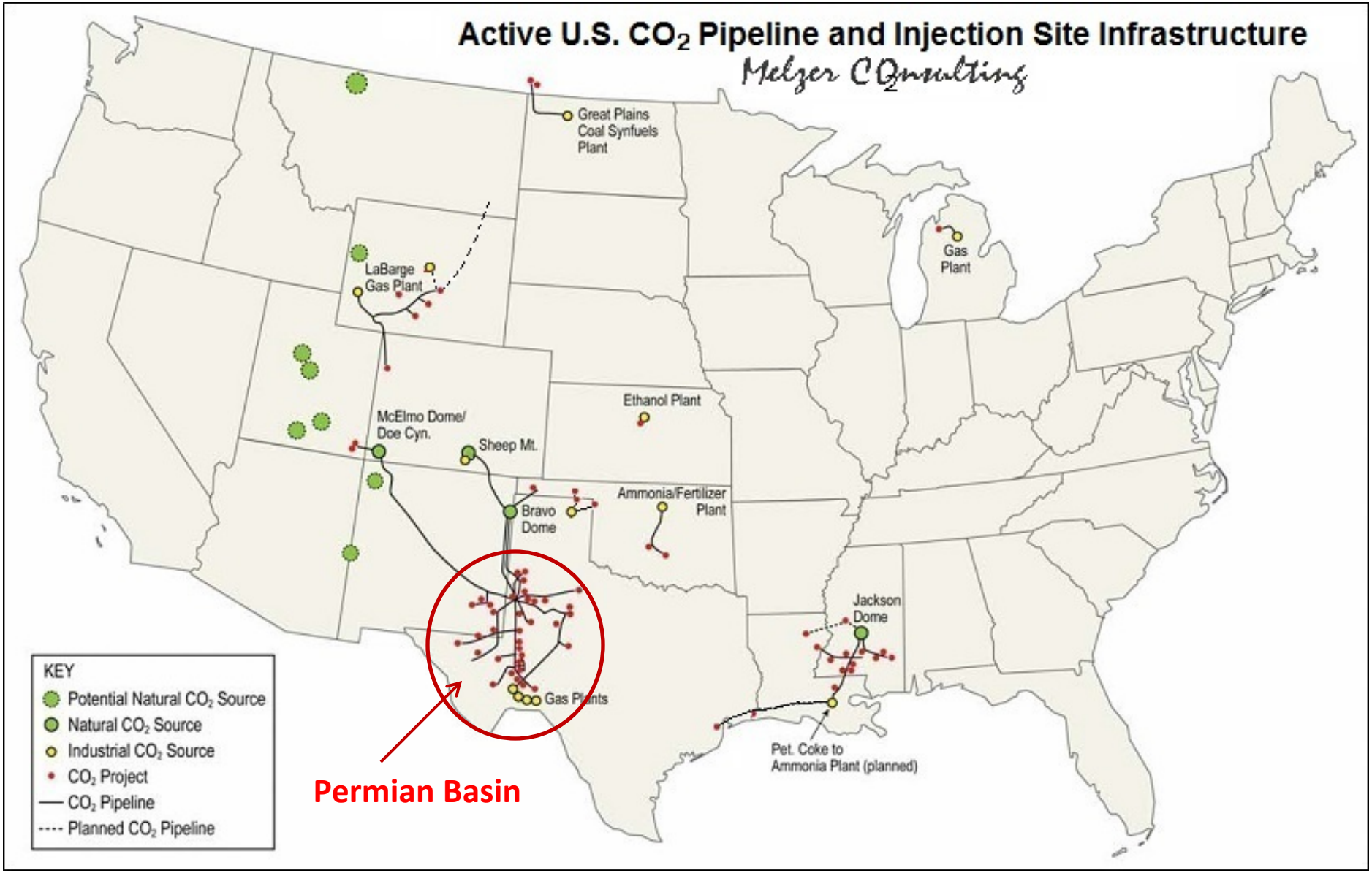
- CO_2 dissolves in oil, lowers oil viscosity, reduces interfacial tension, and swells the oil, thereby allowing oil affixed to the rock and trapped in pore spaces to flow more freely.
- The early phase of oil production (called primary production) decreases the fluid pressures in a reservoir. CO_2 injection repressures the reservoir, thereby reestablishing a drive mechanism. CO_2 EOR can follow primary production or follow a water injection (waterflooding) phase. Historically, since CO_2 is more expensive than water, it has followed waterflooding but if CO_2 storage has value, secondary CO_2 floods could become commonplace.
- A portion of the injected CO_2 will be produced with the oil and water, separated at the surface, and recycled to be used again in the reservoir. The recycle volumes, as a percentage of **total*** injection volumes, will vary from 0% early in the flood to as much as 60% in a very mature flood.
- Typically 90-100% of the purchased CO_2 volume is retained in reservoir (dead end pores and channels).*

CO_2 EOR technology has been around at a commercial scale since the early 1970's

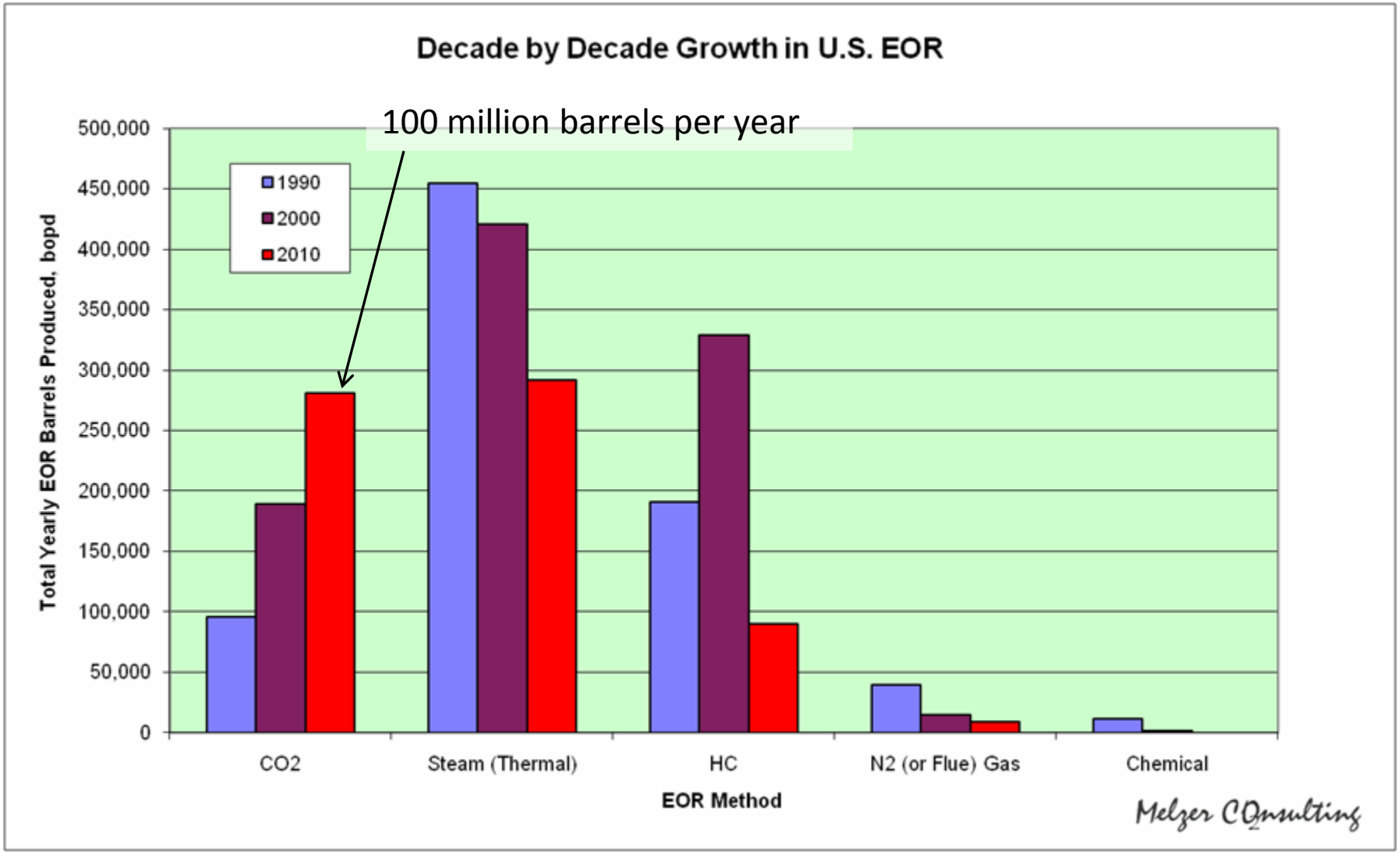
* *The percentage of stored volumes will be 90%+ of the Purchased Volumes*

Section 2

CO_2 EOR:
Where, How Much and Who are the Key Players


Active U.S. CO_2 Pipeline and Injection Site Infrastructure
Melzer CQnsulting
Great Plains Coal Synfuels Plant
LaBarge Gas Plant
Gas Plant
McElmo Dome/ Doe Cyn.
Sheep Mt.
Ethanol Plant
Bravo Dome
Ammonia/Fertilizer Plant
Jackson Dome
Gas Plants
Pet. Coke to Ammonia Plant (planned)
Permian Basin
KEY
Potential Natural CO_2 Source
Natural CO_2 Source
Industrial CO_2 Source
CO_2 Project
CO_2 Pipeline
Planned CO_2 Pipeline

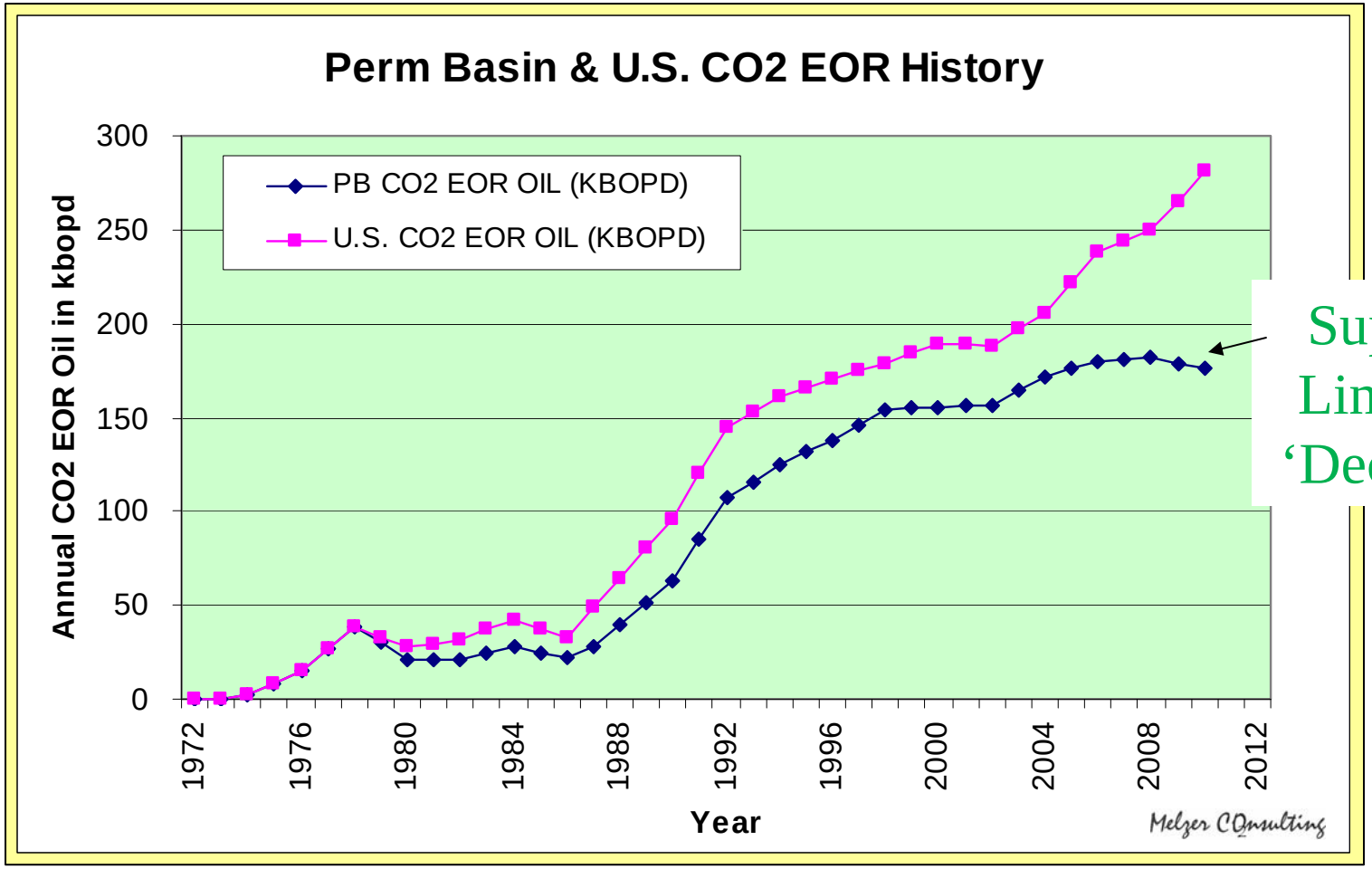
CO_2 EOR: Coming of Age



Ref: Oil & Gas Journal Biennial EOR Reports: Apr of Even Numbered Years

U.S. & Permian Basin CO_2 EOR Production Growth (1972-2010)

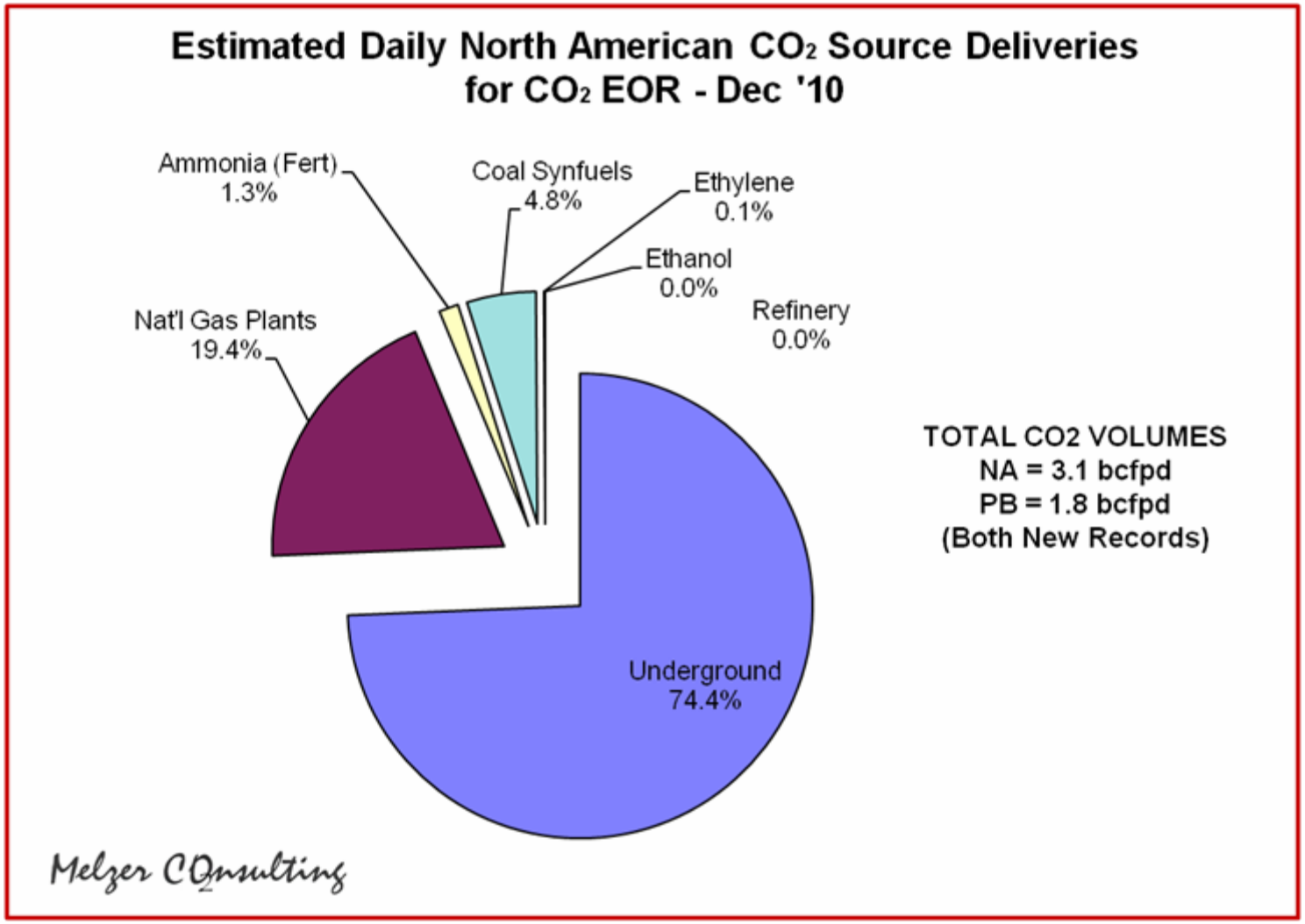
Plus a Case History (PB) of a CO_2 Supply Constrained Market



Supply Limited 'Decline'

So How Much CO_2 is Used in EOR?

Volumes and Sources of CO_2 for EOR*



* From Hargrove, B. et al (2010), CO_2 Conference Presentation in Midland, Dec 2010 – see www.CO2Conference.net

The CO_2 Injection and Transportation Companies

SIGNIFICANT CO_2 SUPPLIERS/TRANSPORTERS

Denbury Resources (Jackson***)	SandRidge/Oxy (Val Verde*)
KinderMorgan (McElmo*, Doe Canyon*, Bravo*)	CVR Partners: Coffeyville (under construction)
ExxonMobil (McElmo*, Sheep Mtn*, LaBarge**)	Chaparral Energy (Ok)
Occidental (Bravo*, Sheep Mtn*)	Chevron (McElmo*)
Dakota Gasification (N. Dak)	Core Energy (MI)

* Permian Basin, ** Wyoming, *** Mississippi, Gulf Coast (Tx, La), Wy/Mt (coming)

CO_2 FLOOD OPERATORS

As of Jan '10

Anadarko (5)	Great Western (1)
Apache Corp.(4)	George R. Brown Partnership (1)
Chaparral Energy (7)	Hess Corporation (4)
Chevron (7)	Kinder Morgan (2)
ConocoPhillips (2)	Merit Energy (7)
Core Energy (6)	Orla Petco (1)
Denbury Resources (13)	Oxy Permian (31)
Devon (1)	Resolute Nat'l Resources (2)
Energen (1)	SandRidge Tertiary (1)
ExxonMobil (1)	Whiting Petroleum (4)
Fasken (5)	XTO Energy (4)

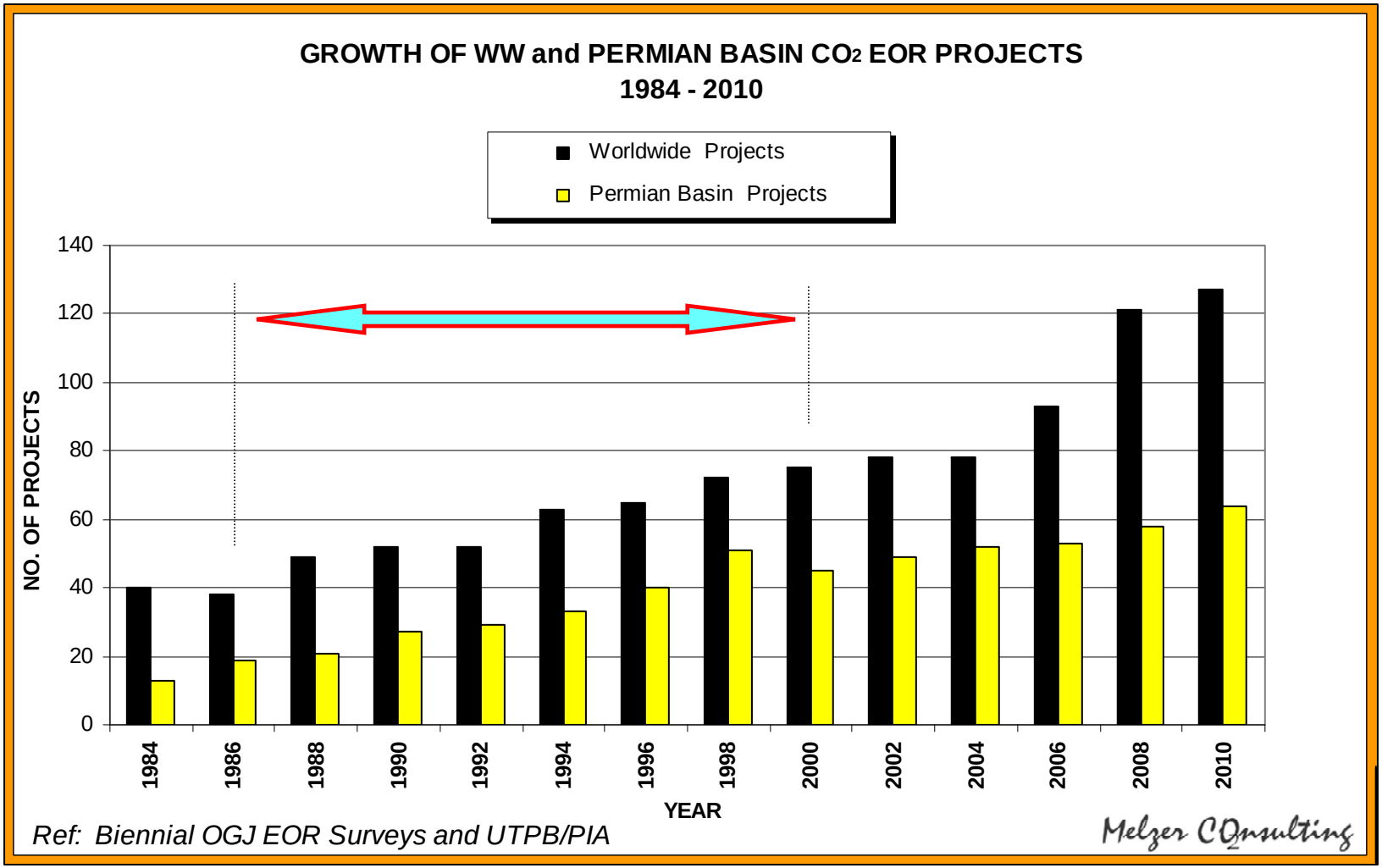
Data source: Oil & Gas Journal Annual Production Report, Apr 19, 2010, and UTPB Petroleum Industry Alliance (5/2010)

Section 3

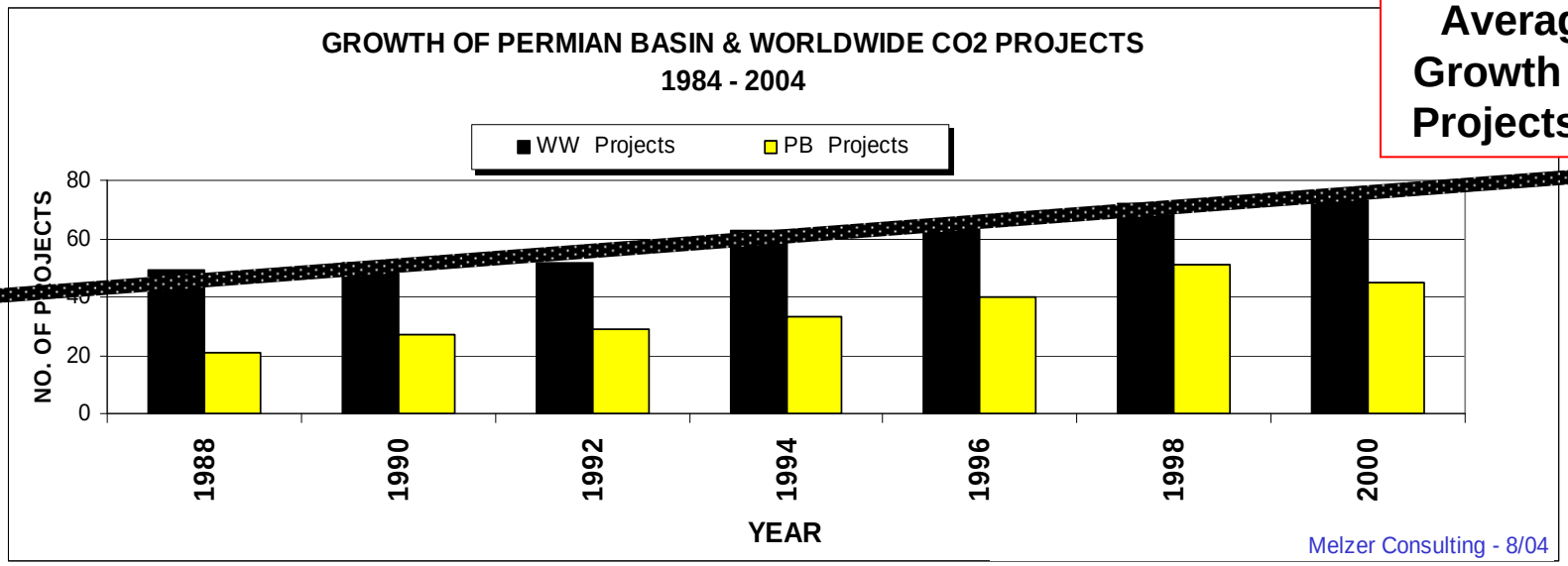
THE GROWING DEMAND FOR CO_2

BACKGROUND

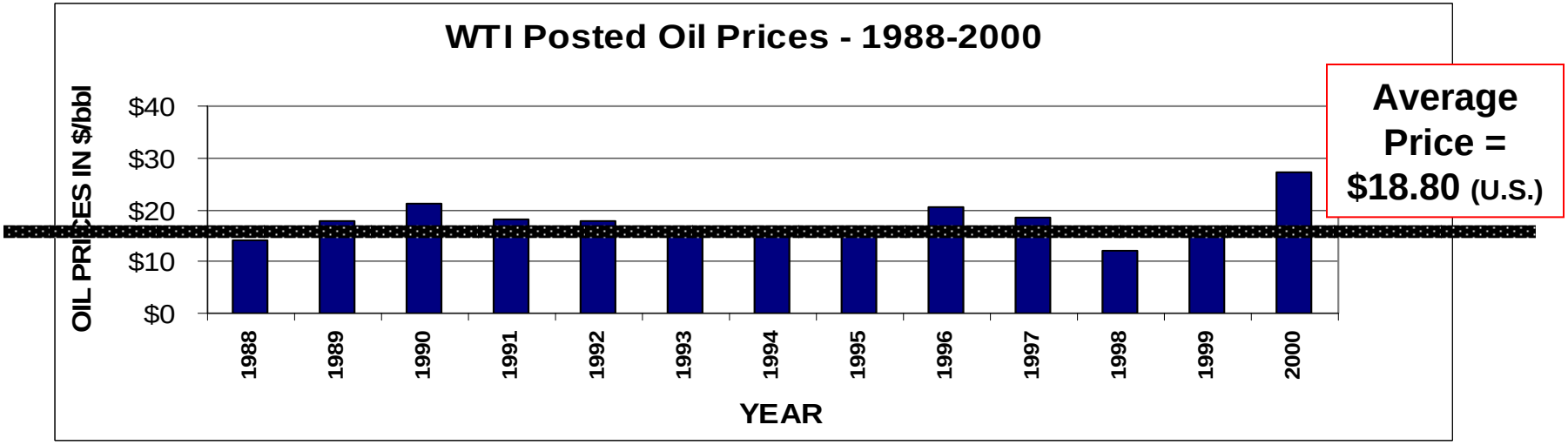
(OF CO_2 EOR PROJECT GROWTH*)



…..and Growth Even with Languishing Oil Pricing



Average Growth > 2 Projects/Yr



Average Price = $18.80 (U.S.)

There is Pent Up Growth
Just from Conventional EOR Targets

but….

A Huge New Set of Targets are
Coming of Age

The Science

- Many Basins in the U.S. have had more than one stage of tectonics affect them
- Any Post Subsidence/Oil Entrapment Stage can move oil around
- The oil industry is expert at looking at where the oil went
- We are just now realizing where it came from is also valuable (let's call those zones 'naturally waterflooded' intervals)

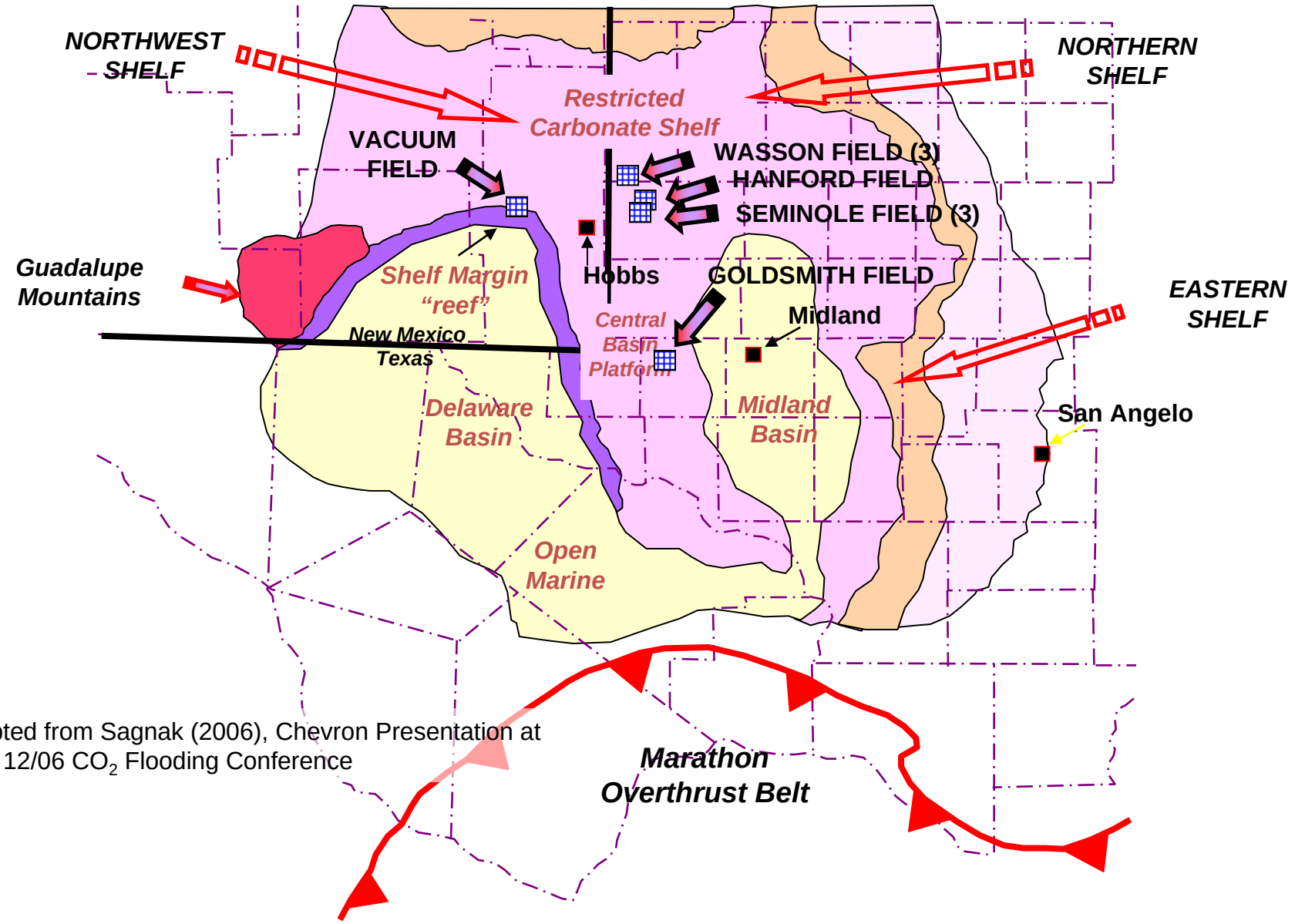
The Engineering

- The oil industry goes after the residual oil targets left behind in our own waterfloods
- Why can't the industry go after those zones that have been naturally waterflooded?
- Let's call those residual oil zones (ROZs)

- Industry is (quietly) doing just this today in the Permian Basin

MIDDLE SAN ANDRES PALEOGEOGRAPHY

with Location of Industry Documented ROZ Zones/Fields*

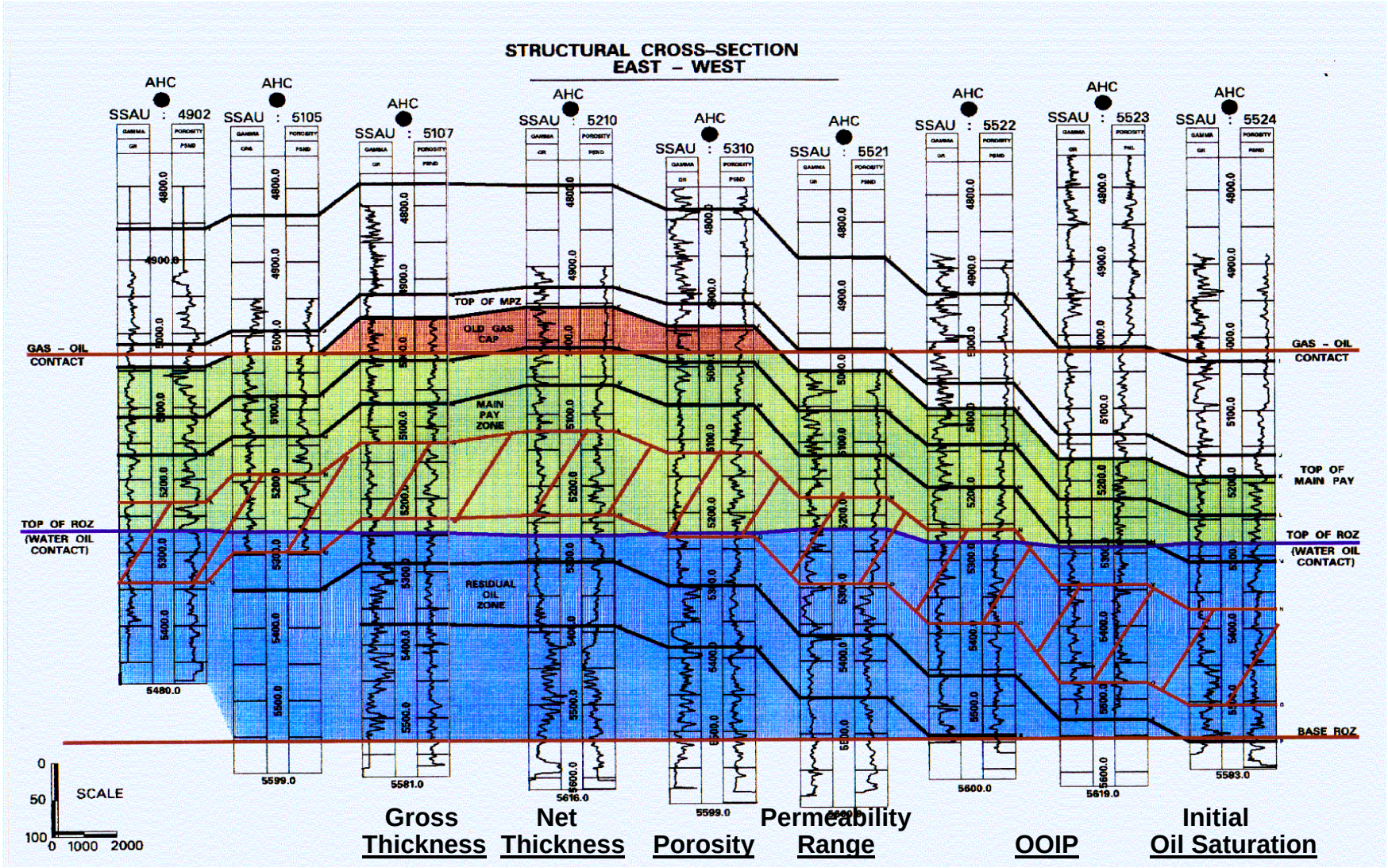


* Adapted from Sagnak (2006), Chevron Presentation at the 12/06 CO_2 Flooding Conference

The List of On-going ROZ Projects

Type and operator	Field	State	County	Top MPZ Depth, ft	Pay zone
Active CO_2 miscible					
Chevron	Vacuum San Andres Grayburg Unit	NM	Lea Co.	4,550	San Andres/Grayburg
Fasken	Hanford	Tex.	Gaines	5,500	San Andres
Hess	Seminole Unit-ROZ Phase 1	Tex.	Gaines	5,500	San Andres
Hess	Seminole Unit-ROZ Phase 2	Tex.	Gaines	5,500	San Andres
Hess	Seminole Unit-ROZ Stage 1 Full Field Dev	Tex.	Gaines	5,500	San Andres
Legado	Goldsmith-Landreth Unit	Tex.	Ector	4,200	San Andres
Occidental	Wasson Bennett Ranch Unit	Tex.	Yoakum	5,250	San Andres
Occidental	Wasson Denver Unit	Tex.	Yoakum	5,200	San Andres
Occidental	Wasson ODC	Tex.	& Gaines	5,200	San Andres

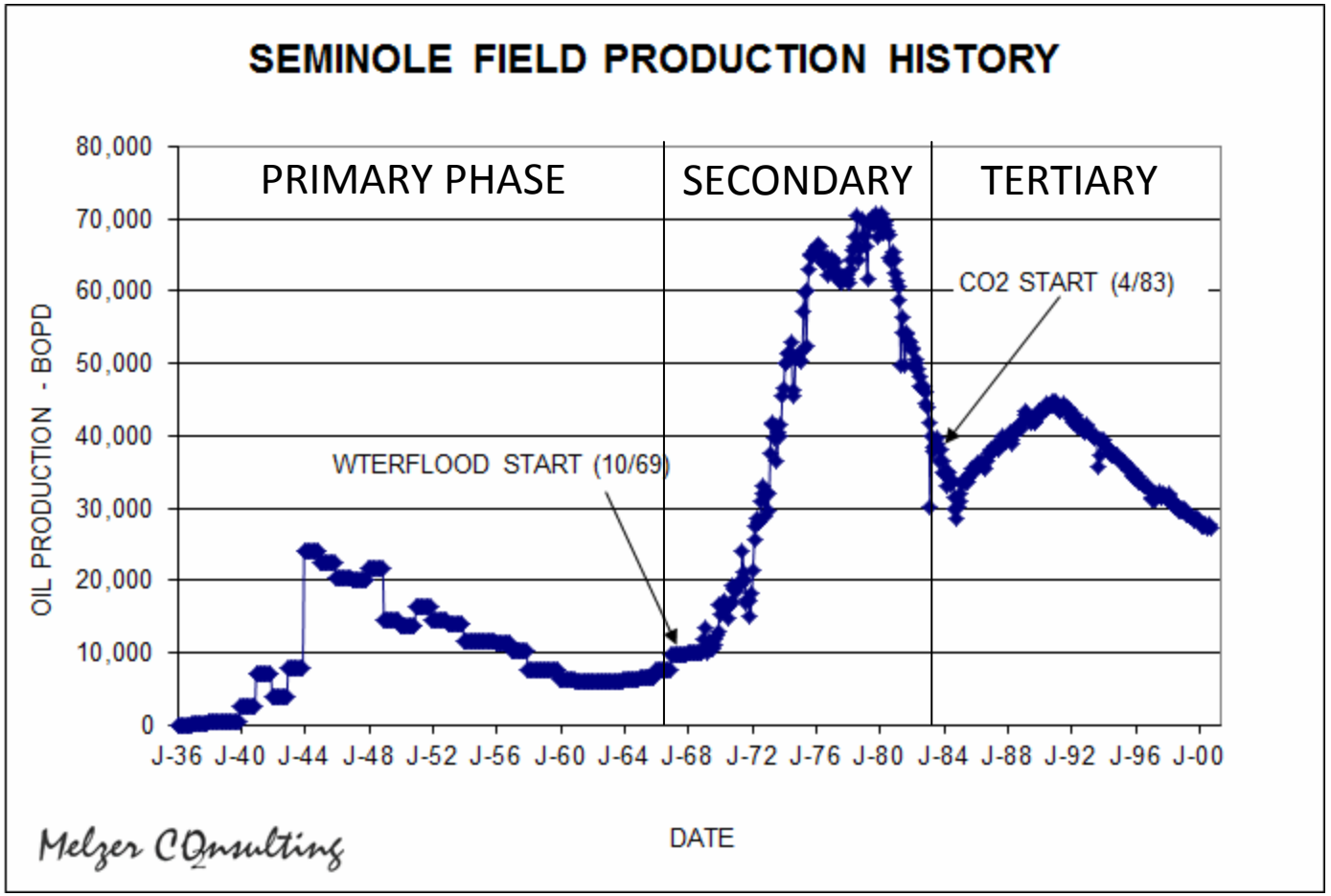
SSAU MPZ & ROZ Crossection and Zonal Attributes*



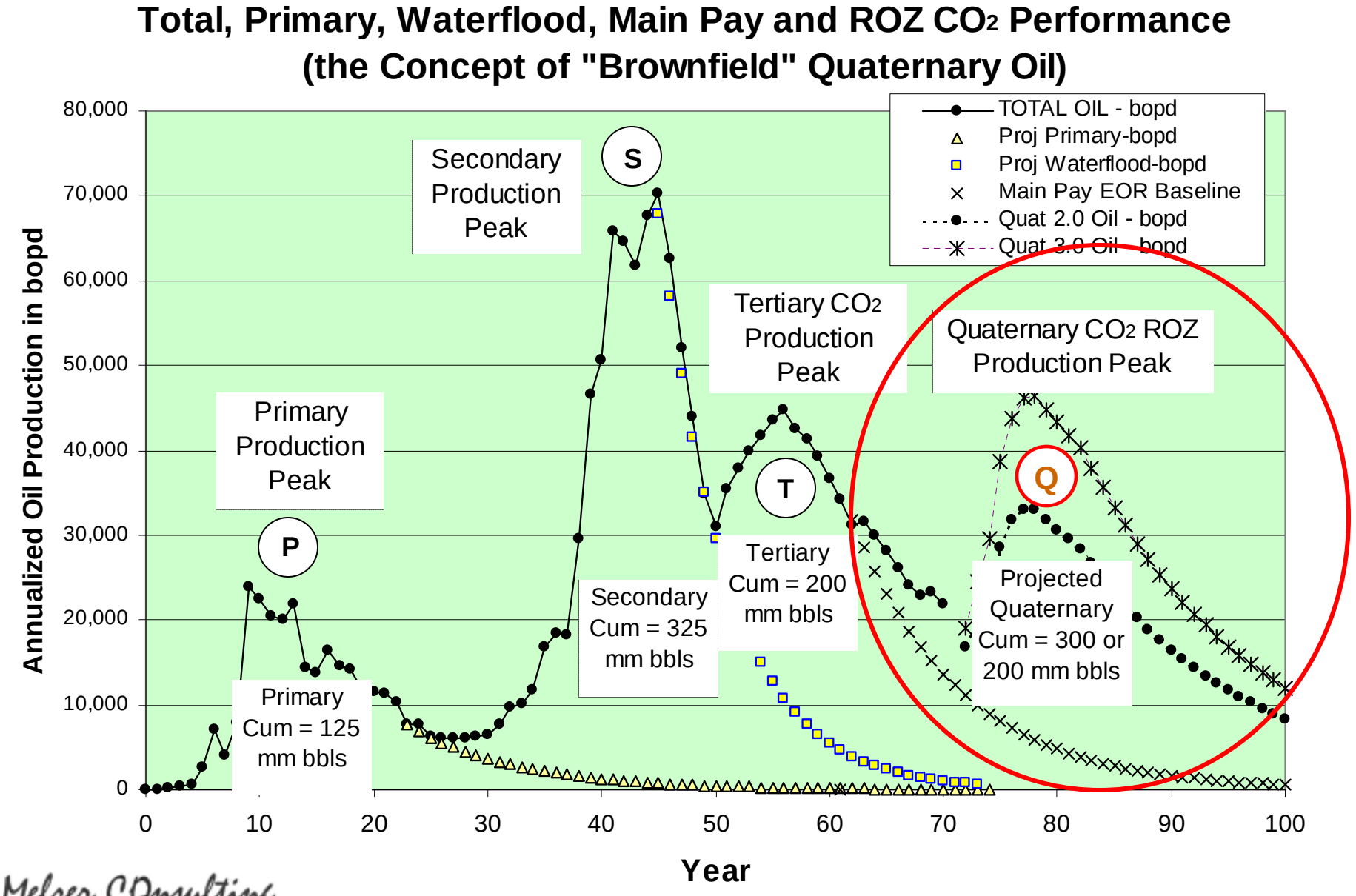
	Gross Thickness	Net Thickness	Porosity	Permeability Range	OOIP	Initial Oil Saturation
Main Pay Zone (MPZ):	160’	126’	12%	0.8-120 md	1 billion stbo	0.84
Residual Oil Zone (ROZ):	246’	197’	12.6%	0.5-270 md	960 million stbo	0.32

* Source: Hess Corporation References from the 2001 and 2008 CO_2 Flooding Conferences

Remember this Chart?



‘Quaternary’ Oil at the Seminole Field (Given Access to Needed CO_2 Supplies)



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HOW BIG IS THIS ROZ BUSINESS?

- Type II ROZs are Ubiquitous in the Permian Basin, We are Finding Them on the West and East Sides of the Central Basin Platform, on the North and Northwest Shelves; They Seem to lie in 'Fairways'
- It is Extremely Common to see the ROZs 200 feet in thickness, They are **not** Restricted to Existing Fields
- Porosities of 10-14% are common with Permeabilities of >10 millidarcies.
- ROZs are Commonly Better Developed than the the CO_2 data base, i.e., the Main Pay Zones
- Residual oil saturations ($S_{orw's}$) are Generally 20-40% for most of the ROZ thickness – very analogous to water swept zones in Main Payzones
- Now that we have begun to look, we are finding these ROZs to be very common in other U.S. Basins

RPSEA
Research Partnership to Secure Energy for America

Section 4

Market Issues and Barriers to Greater Deployment

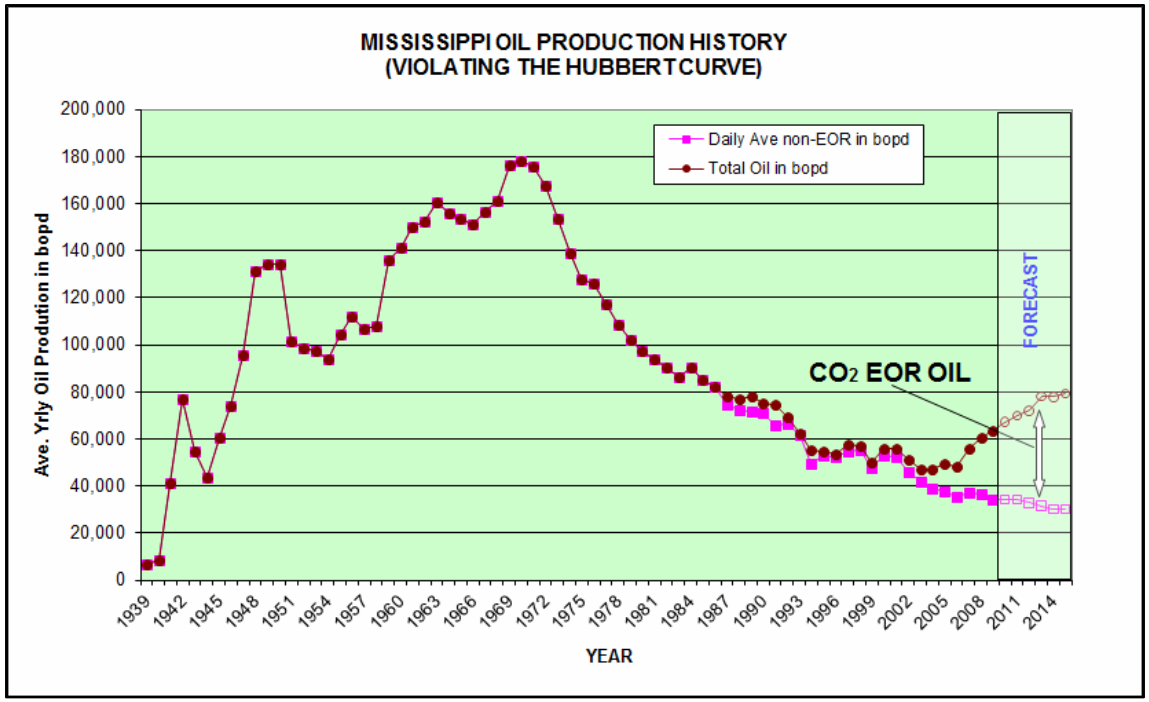
HISTORICAL BARRIERS TO WIDER CO_2 EOR DEPLOYMENT

- The Oil/Gas Industry Is Increasingly Exploration Focused
- Until the mid-90's, Technology has been Tightly Held
- CO_2 EOR is Very Capital Intensive, Most of Which Comes Up Front Leading to Low Rates of Returns
- Availability of CO_2 
- Widely Held Bias that EOR Targets Were Small

CO_2 SUPPLY CONSTRAINTS ARE NOW HOLDING BACK DEPLOYMENT OF CO_2 EOR

This has been a Huge Problem in the Permian Basin, Also True in Rockies although Shute Creek Expansion is helping in the Short Term

In Mississippi where Denbury Worked Hard to Avoid the CO_2 Supply Problem….



Next Year, CO_2 EOR could be half the State's Production

Thank you

Time for Questions?

…and our industry partners

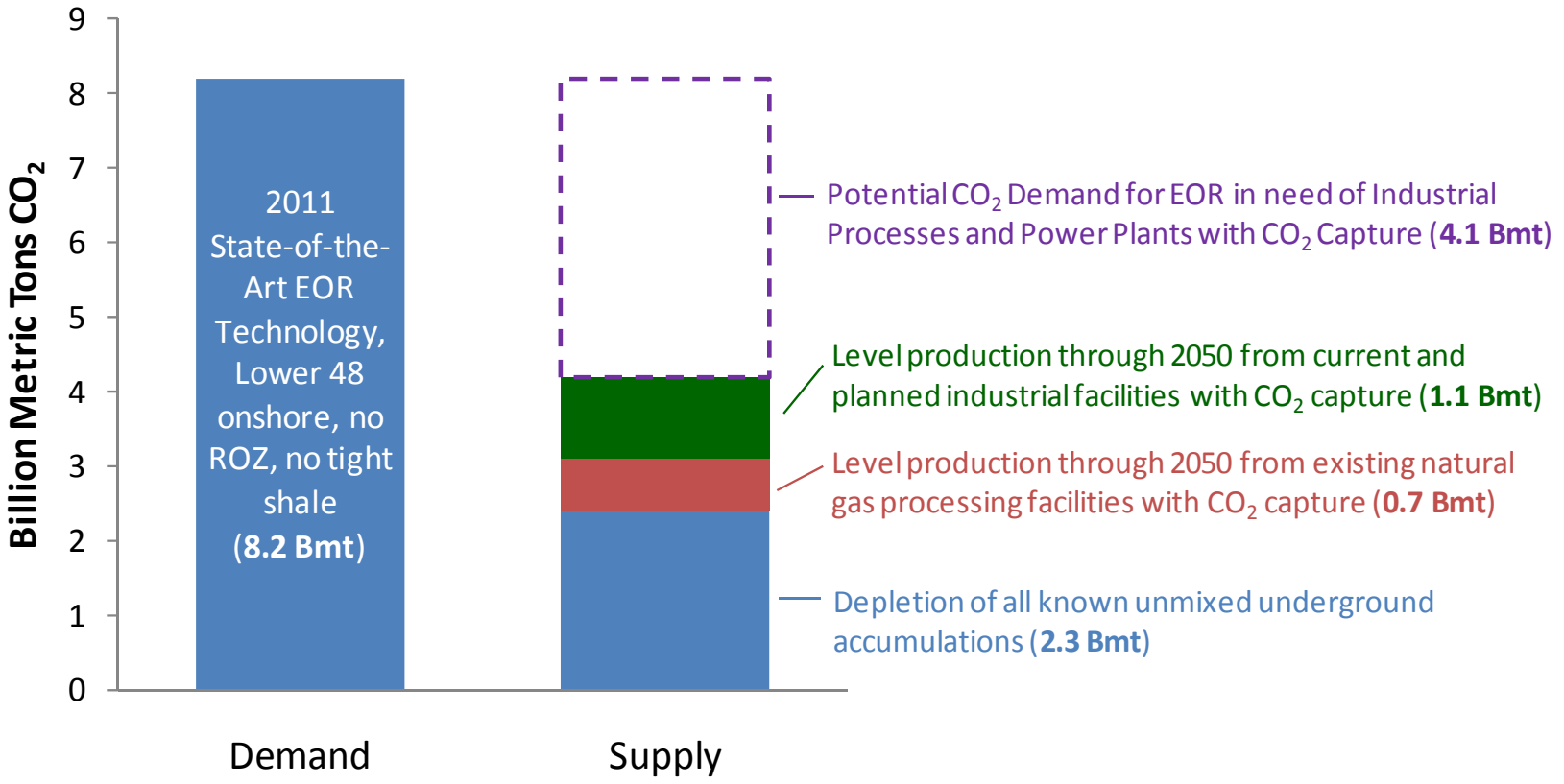
Backup Slides

The Model Forecasts

Just With EOR State-of-the-Art

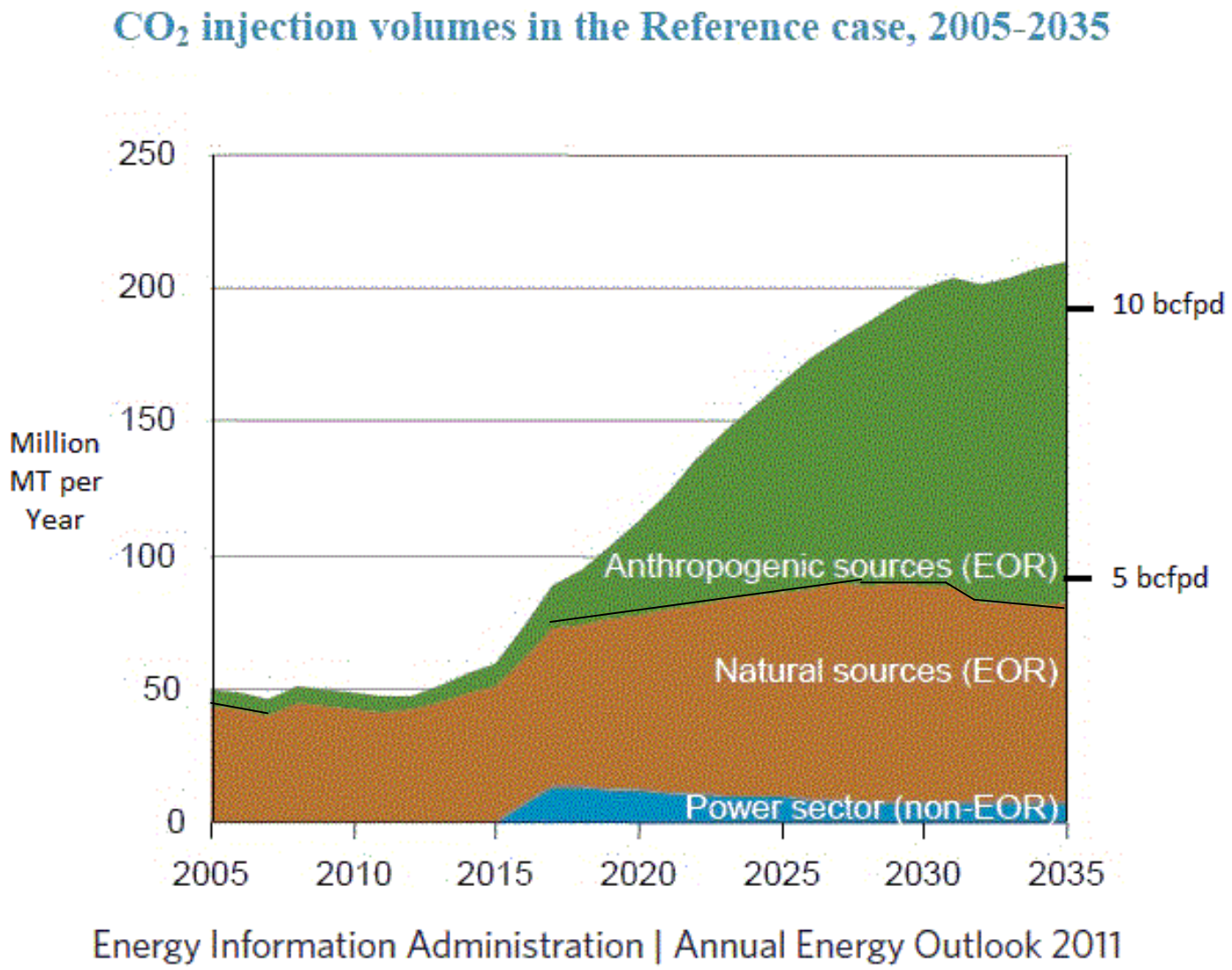
What are the Needs for CO_2?*

Exhibit 6. U.S. CO_2 Demand and Supply Situation Through 2050

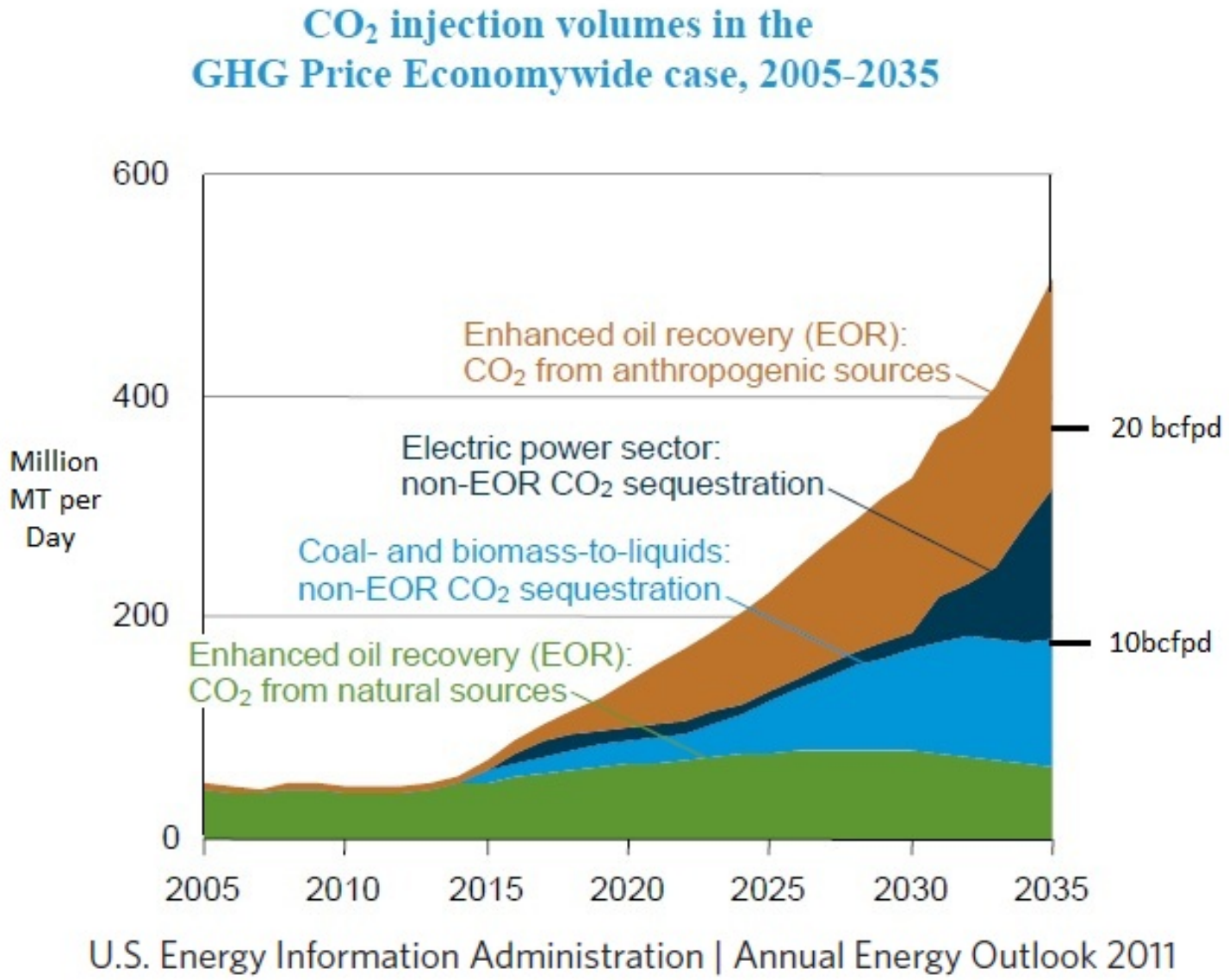


* Dipietro, P., et al (2011), "Improving Domestic Energy Security and Lowering CO2 Emissions with "Next Generation" CO2-Enhanced Oil Recovery , June, 2011, DOE/NETL-draft report

EIA 2011 (Just Released)

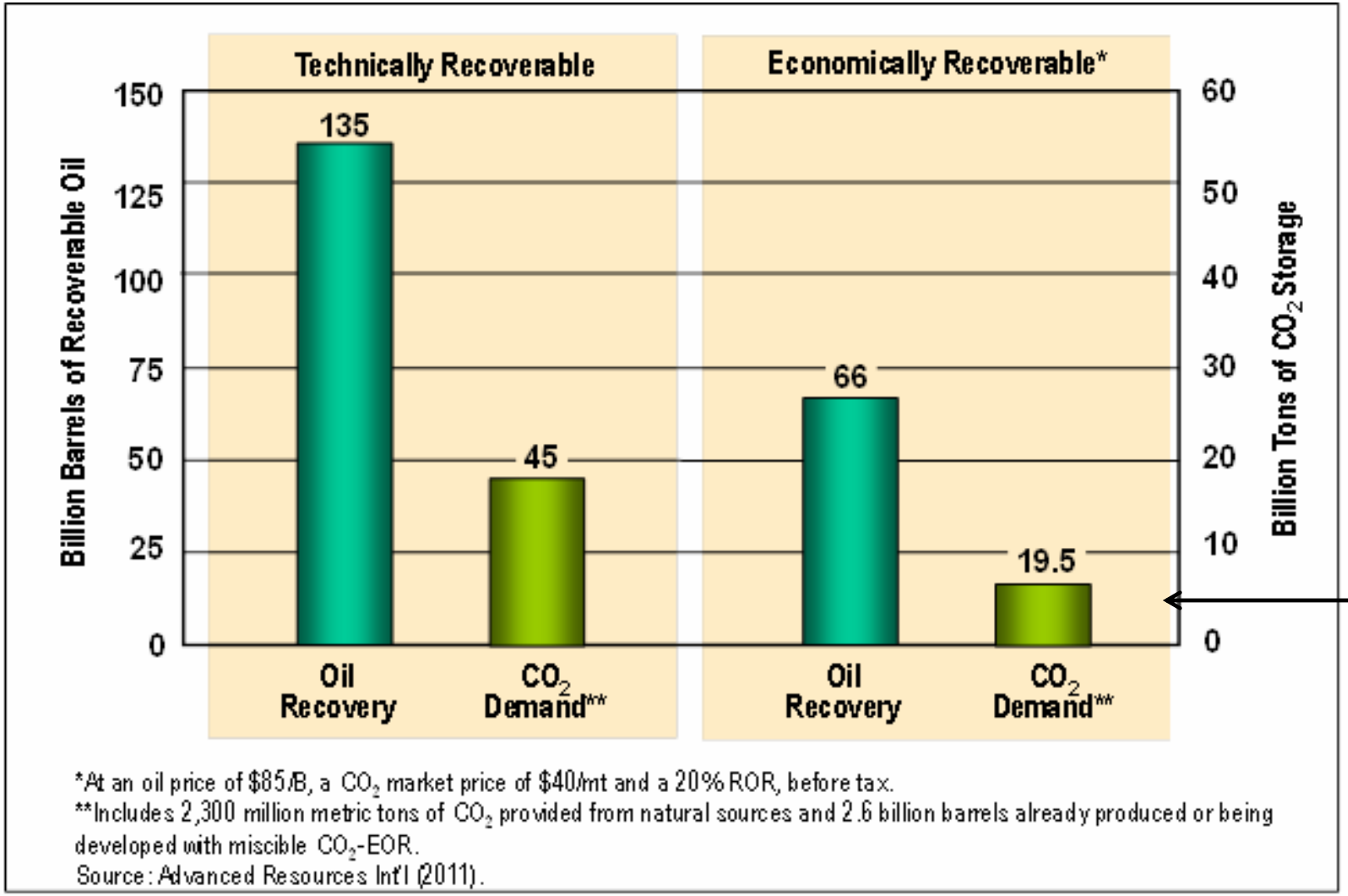


AEO 2011 Total Injection Volumes



And Then There are All These New Targets

ARI Calls 'Next Gen'



*At an oil price of $85/B, a CO_2 market price of $40/mt and a 20% ROR, before tax.

**Includes 2,300 million metric tons of CO_2 provided from natural sources and 2.6 billion barrels already produced or being developed with miscible CO_2-EOR.

Source: Advanced Resources Int'l (2011).

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The NRDC Look at CO_2 EOR & Demand for CO_2

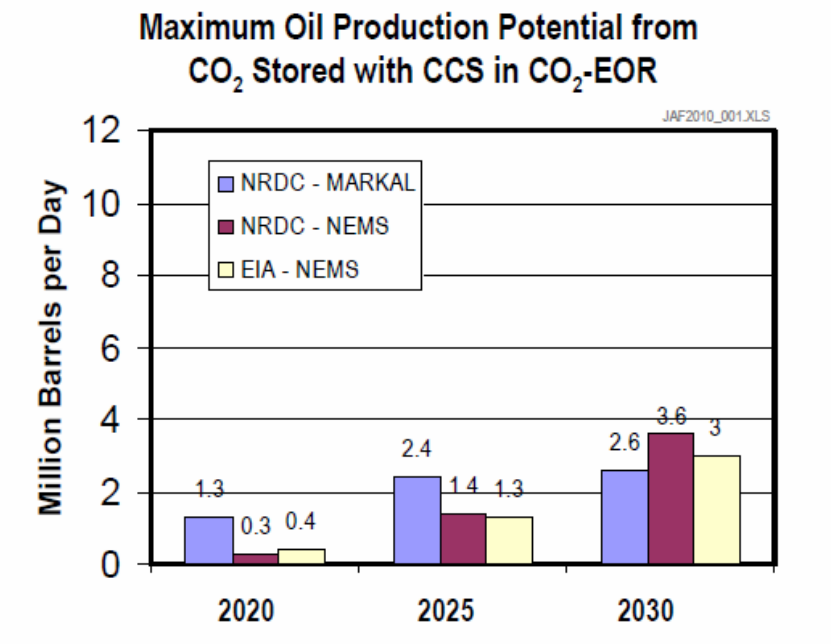

Figure 6. Carbon Dioxide Captured from Electricity Generation Technologies with CCS in 2020 and 2030