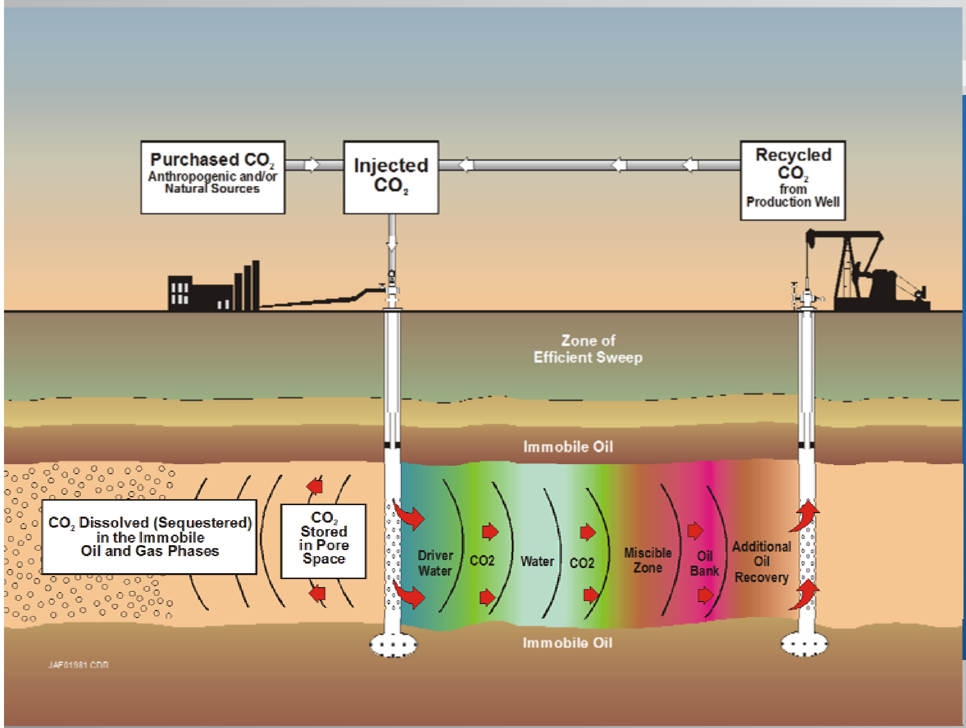

An In-Depth Look at "Next Generation" CO_2-EOR Technology

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September 23, 2013

U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

Acknowledgement / Disclaimer

This slide deck was a collaborative effort among federal and contractor staff. Co-authors Vello Kuuskraa and Matt Wallace of Advanced Resources International performed under the ESPA contract (DE-FE0004001, task 150.07.02). The task was managed within NETL's Strategic Energy Analysis and Planning Division. Funding was provided by the NETL Strategic Center for Natural Gas and Oil.

The authors would like to acknowledge valuable reviews and input from John Duda, Don Remson, Al Yost, and Dave Morgan.

Contents

[Click here to watch video of the authors discussing the analysis]

Dis-aggregated Next Generation CO_2-EOR Study:
One-page Summary

Goal

– Take a more in-depth look at the "Next Generation" CO_2-EOR concept, including its challenges and benefits.

Methodology

– Exercise the CO_2-PROPHET model to simulate each of the four CO_2-EOR technologies, applied singularly and in combination, on 1,824 Lower-48 onshore reservoirs that screen prospective for CO_2-EOR.

Results

– *Incremental benefit for incremental investment. "*Next Generation" CO_2-EOR can provide significant benefits:

  - 2 million barrels per day* of increased domestic crude oil production for 50 years, just from Lower-48 onshore oil fields,
  - Nearly 300 billion dollars of CO_2 purchase revenues to buy down CO_2 capture and transport infrastructure, and
  - 60% improvement in efficiency of CO_2 utilization (4 Bbls/mtCO_2 vs. 2.5 Bbls/mt CO_2 with current CO_2-EOR technology)

  . . . but it is not free. Technology development is required and next generation CO_2 EOR designs require capital and operating outlays roughly two times higher than current best practices.

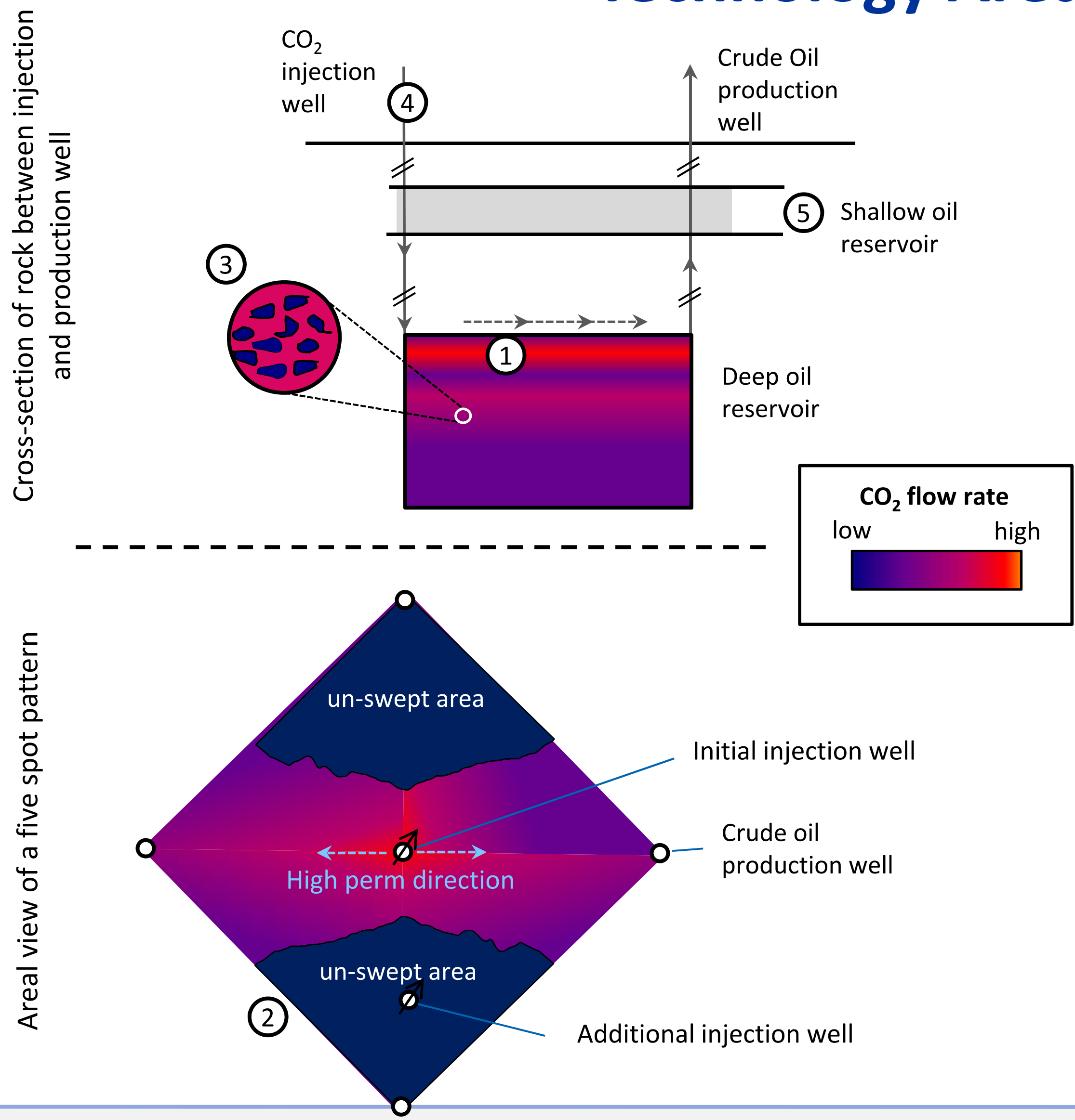
– *Technology and Synergy.* Integrated application of all four "Next Generation" technologies provides 30% more oil recovery than the sum of the individual application of these four technologies.

– *Importance of Next Generation CO_2-EOR Technology.* Half of the increased oil production and 80% of the increased CO_2 demand is from oil reservoirs that only become economically viable with use of "Next Generation" CO_2-EOR.

– *Regional Impacts.* Each of the "Next Generation" technologies has a preferred regional setting. California's oil fields benefit most from Advanced CO_2 Flood Design (Technology #2); oil fields in the Permian Basin benefit most from Increased Volumes of Efficiently Used CO_2 (Technology #4).

* Note: 2 million bpd is difference in ERR going from current technology to next gen (63.3 – 21.4) Bbls over 50 years. Does not includes Alaska, offshore GOM, or residual oil zones. Economics based on delivered CO_2 cost of \$40/mtCO_2 oil price of \$90/bbl, and 20% rate or return before tax.

Next Generation CO_2 Enhanced Oil Recovery: Technology Areas



1. **Improved Conformance Control.** Reduce the unproductive channeling of CO_2 through high permeability reservoir flow paths

2. **Advanced Flood Design.** Target and produce the high oil saturation reservoir segments bypassed or poorly swept by the waterflood.

3. **Enhanced Mobility Ratio.** Reduce fingering, create a more uniform and effective flow front in swept areas.

4. **Increased volumes of efficiently-injected CO_2.** Improve sweep efficiency and reduce oil saturation toward the theoretical maximum.

5. **Near-miscible CO_2 EOR**. Apply CO_2 EOR in shallow reservoirs that are close to but not above minimum miscibility pressure (MMP).

Also required for next generation CO_2 EOR are three enabling technology that cross-cut the primary technologies:

- **Robust reservoir characterization**
- **Enhanced fluid injectivity via near well completion**
- **Extensive monitoring, diagnostics and process control.**

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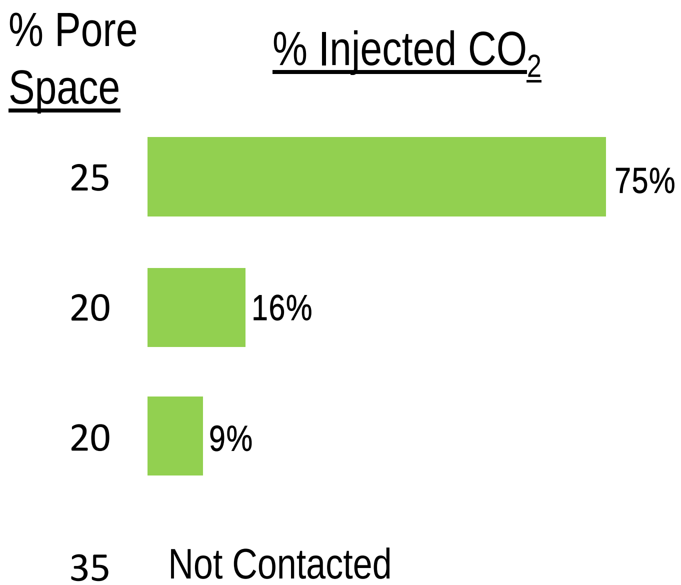
Challenges Addressed by Next Generation CO_2 EOR Technology are Drawn from Actual Experience

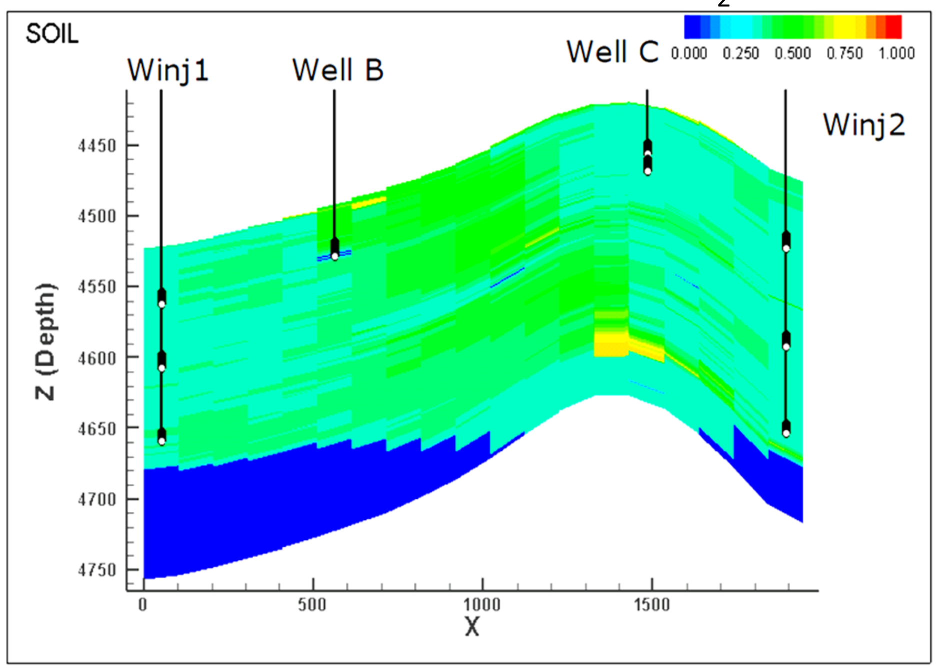
Wasson (Denver Unit) operated by Occidental



Preferential flow of CO_2 through high permeability horizontal layers, limiting optimum reservoir contact

Reinecke Oil Field in West Texas Operated by Chevron

Oil Saturation Distribution Prior to CO_2 Flood



Shows un-swept regions of a carbonate formation with high remaining oil saturations

An In-depth Look at "Next Generation" CO_2-Enhanced Oil Recovery: Summary Results

Under a "next generation" technology scenario – with all five primary technology areas applied - the economically recoverable resource for CO_2-EOR increases from 21.4 Bbbls to 63.3 Bbbls (onshore lower 48, no residual oil zones). The demand for CO_2 from these economically viable reservoirs increases from 8.9 Bmt CO_2 to 16.2 B mt CO_2.

The efficiency of CO_2 use (bbls of crude oil produced per unit of CO_2 purchased) increases by 60% going from current best practices (CBP) to "next generation."

	Recoverable Resource (BBbls)*		Demand for CO_2 (Billion Metric Tons)		Average CO_2 Utilization (bbls/mtCO_2)	
	CBP*	Next Gen.	CBP*	Next Gen.	CBP*	Next Gen.
Technical	36.7	79.3	17.0	20.4	2.2	3.9
Economic**	21.4	63.3	8.9	16.2	2.4	3.9

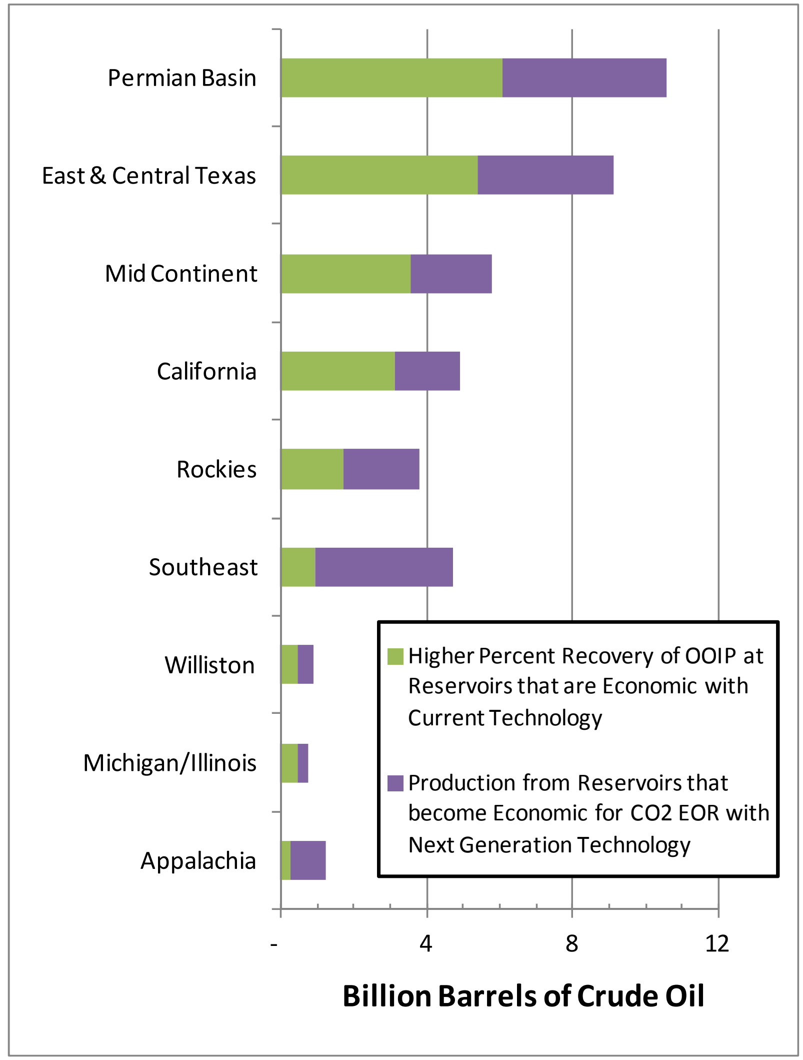
* CBP – current best practices

** Economic assessment made based on oil price of $90 per barrel, CO_2 purchase cost of $40 per metric ton CO_2 at the field gate, and a 20 % rate of return (before tax) financial hurdle rate. Economic simulations are cut off when/if the annual operating revenues turns negative. The technical simulations are continued to the target injection amount (1.0 HCPV for CBP and 1.5 HCPV for "next generation").

Results compiled from simulations of CO_2 EOR floods at 1,800 oil-bearing formations in the onshore Lower-48 United States. Reservoir characterization data drawn from the Big Oil Fields database; simulations conducted using the PROPHET stream tube model. Analysis does not include residual oil zones. Based on state-level royalty data, the 1,800 reservoirs in the big oil fields data base account for 72% of current domestic crude oil production. No adjustment is made to account for resource in un-modelled fields.

How Can "Next Generation" CO_2 EOR Recover So Much More Oil Than Current Best Practices?

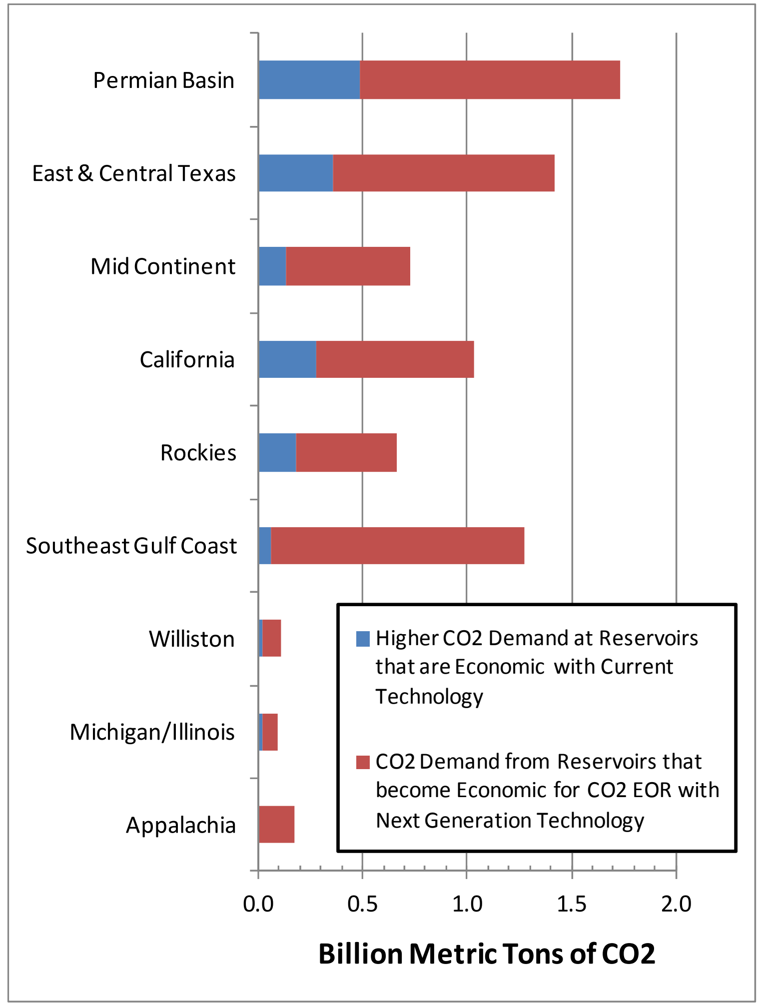
- "Next Generation" CO_2 EOR is incremental value for incremental investment. At a sample reservoir in the Permian Basin, the implementation of next generation CO_2 EOR increases the upfront capital investment by two times, from $360 MM for a current best practices flood to $680 MM for next generation. The total monies spent over the life of the project increase by a similar ratio from 2.4 B$ to 4.6 B$. Overall the project economics are improved, but the capital outlay is significant.
- The number of oil-bearing formations that are economic for CO_2 EOR increases from 511 under current best practices to 1,001 under "next generation".
- The incremental crude oil recovery from CO_2 EOR increases from an average 14% of OOIP (original-oil-in-place) under current best practices to 28% under "next generation."
- "Next Generation" gets a big boost from targeting the mobile crude oil left behind in the un-swept and poorly swept regions of a reservoir.
- We attribute to the CO_2 flood both the mobile and the trapped residual oil left after the termination of the waterflood.



Most (80%) of the Increase in CO_2 Demand from Next Generation CO_2 EOR Technology comes from Reservoirs that are not Economic to Flood with Current Technology

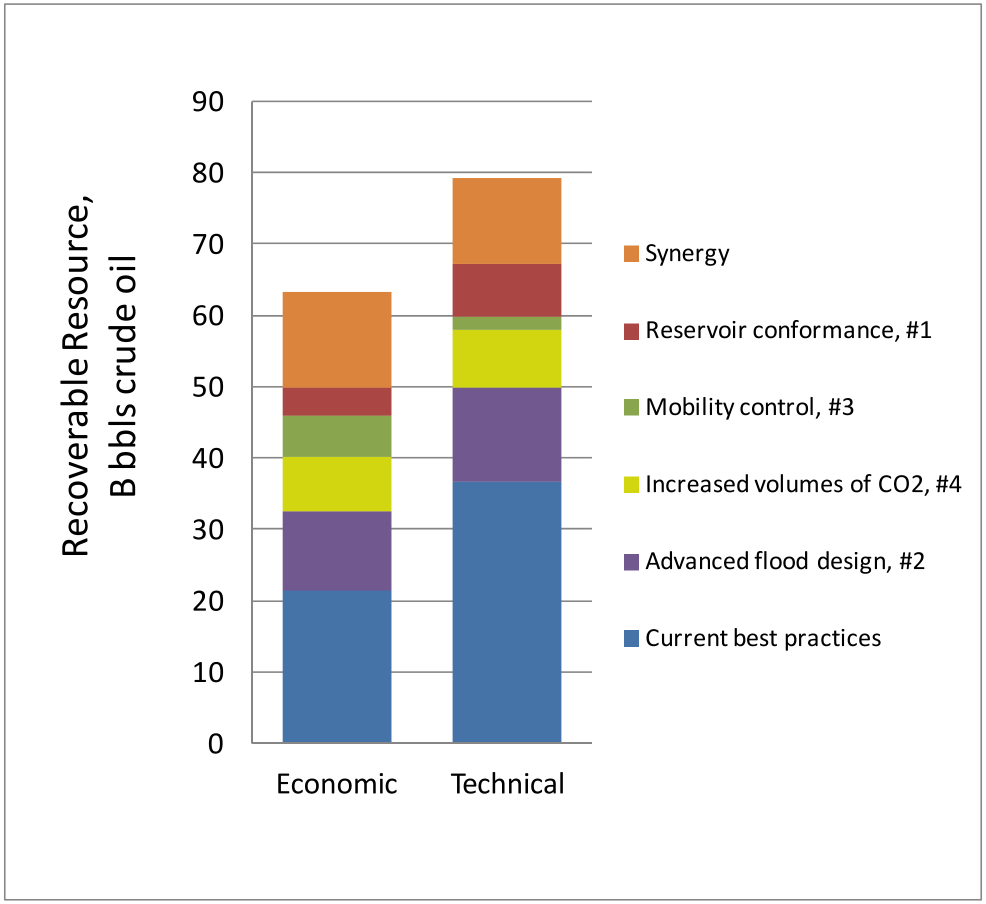
Application of next generation CO_2 EOR technology results in more efficient use of CO_2. The amount of CO_2 required at a given reservoir often increases by only a small amount compared to a current technology CO_2 EOR flood. In some cases, the amount of CO_2 required is reduced.

One billion metric tons of CO_2 demand is roughly equivalent to the CO_2 captured from 5 GW of coal-fired generation with 90% CO_2 capture operating for 30 years



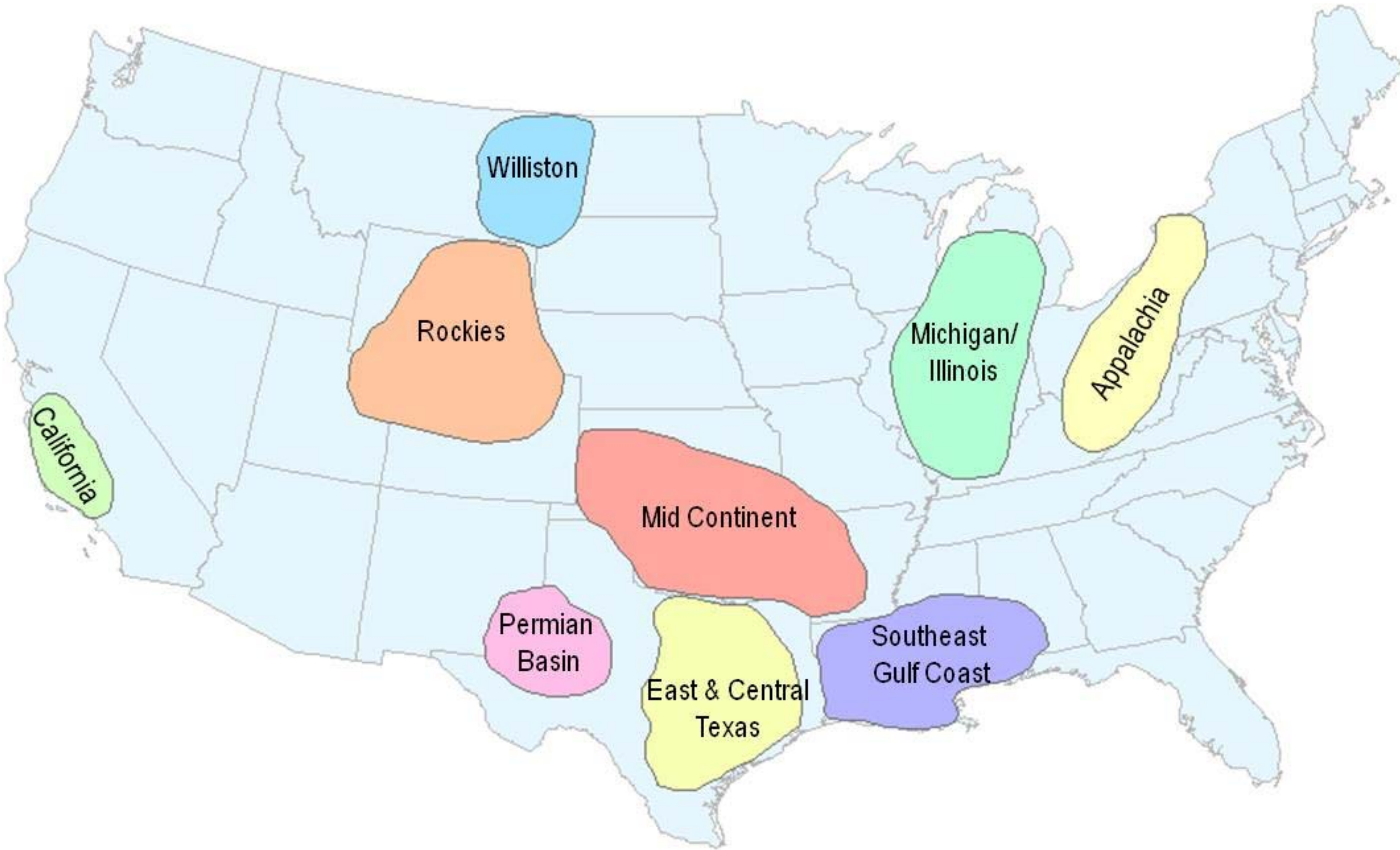
Individual Technology Area Impacts

- Each of the four primary technology areas was modeled singularly and in combination with others to evaluate impacts and synergies.
- Synergy is defined as the difference in recoverable resource between the sum of the individual technology area simulations and the simulation where all four technology areas are applied together.
- Synergy accounts for 32% of the total delta between current best practices and next generation in the economic simulations, 29% in the technical.
- "Advanced flood design" and "increased volumes of efficiently used CO_2" are the most impactful technology areas. However, conformance control and mobility control are necessary for the synergy benefit.



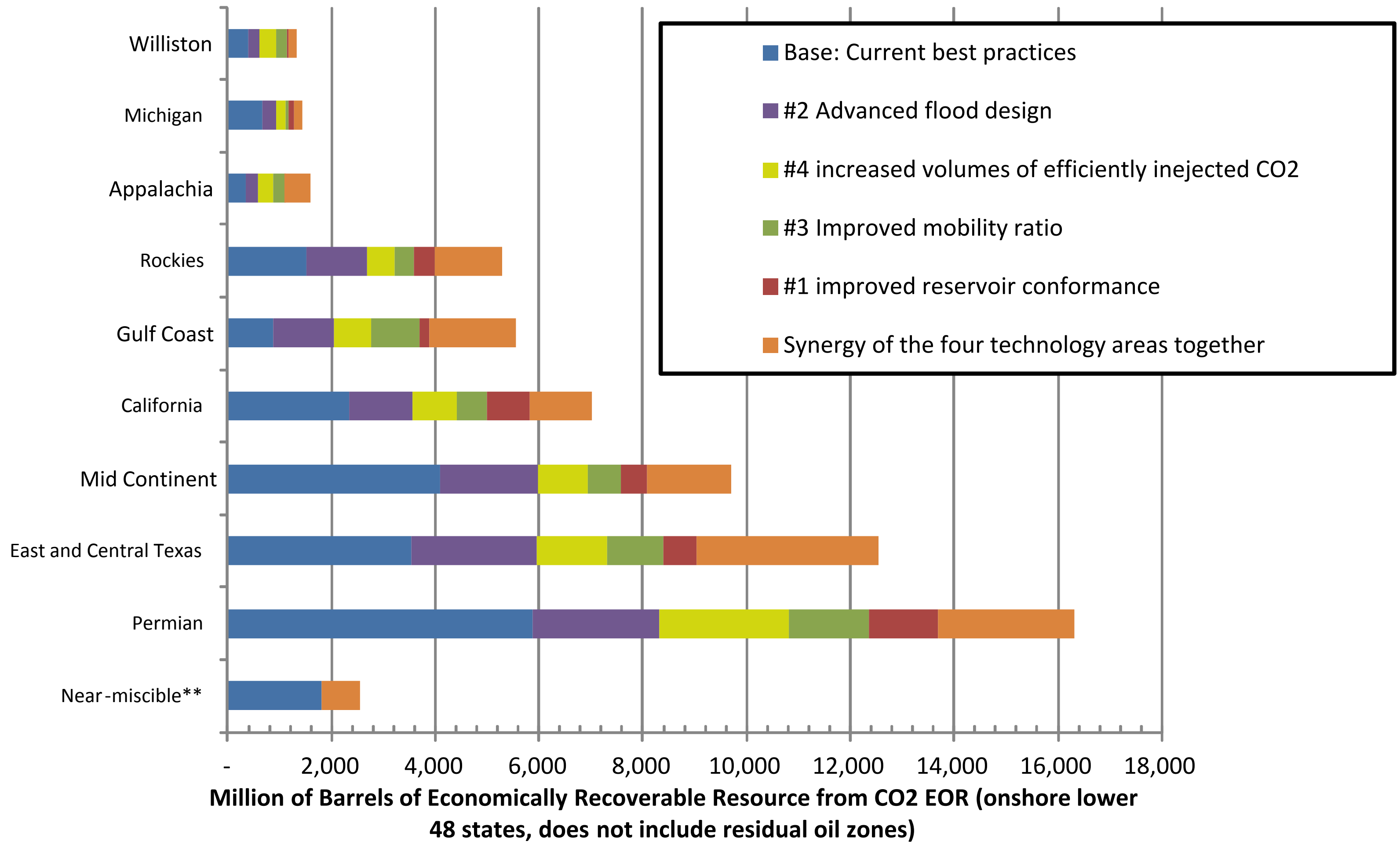
Two rules were applied in analyzing the data. (1) In cases where the sum of the increase above current best practices for technologies 1-4 applied singularly was greater than the increase in the all-in simulation, the individual cases were all reduced by the same percentage so that the sum of the increases was equivalent to the all-in case. This avoided double-counting. (2) In a small handful of cases where a singular technology simulation produced less economic crude oil than the current best practices simulation, the singular case was determined to impractical and the CO_2 demand and crude oil production was set to zero for this oil reservoir.

The CO_2 EOR technologies were individually applied to the oil reservoir in each of the geographic regions shown below.



Appendices A and B contain detailed information for each region.

Economically Recoverable Resource for CO_2 EOR in the United States, Current Best Practices and Increments from the Technology Components of "Next Generation" CO_2



*The technology area impacts are estimated by performing field-by-field CO_2 EOR flood simulations with one technology area implemented and the other three turned off.
"Synergy is the difference between the sum of the individual technology area simulations and a final set of simulations where all four technology areas are implemented together.
**Near miscible is a virtual region, includes near miscible fields all over the United States. Three states, California, Oklahoma and Texas, account for 88% of the ERR. For near miscible, synergy is the result of adding increased CO_2 and mobility control to base CO_2-EOR technology.

Closing Observations

Timely application of "next generation" CO_2-EOR technology will not come about from "business as usual".

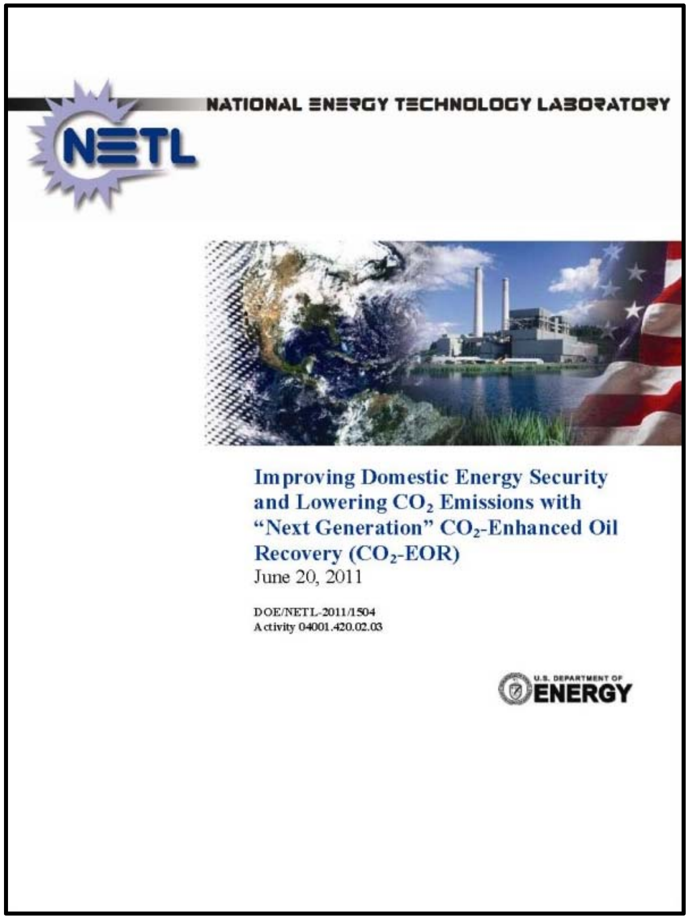
- Investing in R&D on "next generation" CO_2-EOR technology involves higher costs to an individual company, with limited potential for patenting or capturing the exclusive use of this technology. In addition, two of the additional benefits – improved energy security and an expanded domestic capacity for storing anthropogenic CO_2 – accrues to the public at large. As such, the development of "next generation" CO_2-EOR technology is constrained by the classic market imperfection - - private costs and public benefits. Forty years of only modest advances in CO_2-EOR technology and its limited geographic application so far are the evidence for this finding.

While there will be R&D costs for pursuing "next generation" CO_2-EOR technology, the costs of not doing so will be several orders of magnitude larger

- Delay in the development of "next generation" CO_2 EOR technology will lead to lost opportunities as the EOR floods implemented with current technology relegate these oil fields to lower oil recoveries and reduced opportunities for storing CO_2.

1. Introduction and Background

The DOE/NETL and ARI CO_2-EOR Assessment



http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubId=391

This analysis builds on the June 2011 CO_2 EOR Resource Assessment.

Several improvements to the data and methodology are incorporated in this study, notably the use of primary/secondary oil recovery efficiency and mobility ratio to estimate reservoir heterogeneity, the inclusion of CO_2 dissolution in the reservoir's saline waters and the incorporation of time and fluids injection for reservoir re-pressuring.

The study takes a closer look at the "next generation" CO_2 EOR concept and defines five primary technology areas that make up "next generation" CO_2 EOR.

Each technology area is modeled discreetly and the relative impacts of each is evaluated. Also evaluated are synergies that result from deploying the technology areas in combination.

The scope is limited to tertiary floods within the onshore lower 48 states (no residual oil zones).

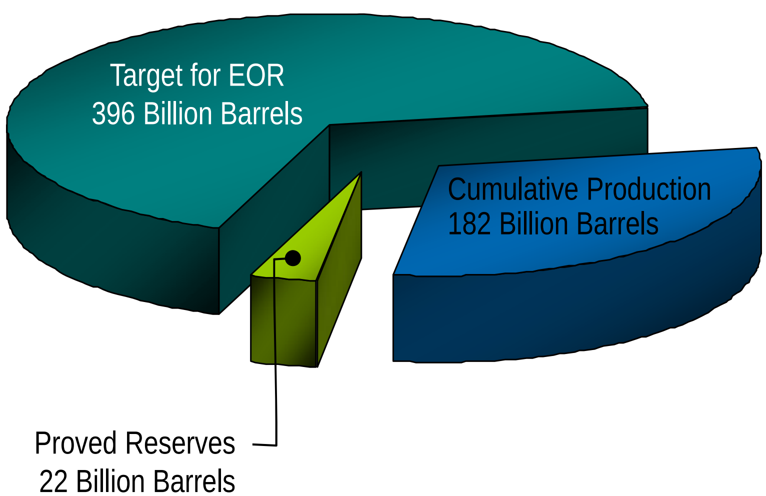
The "Size of the Prize"

Large Volumes of Oil Remain "Stranded" in U.S. Reservoirs After Traditional Recovery

400 BILLION BARRELS OF OIL
IN MAIN PAY ZONES.

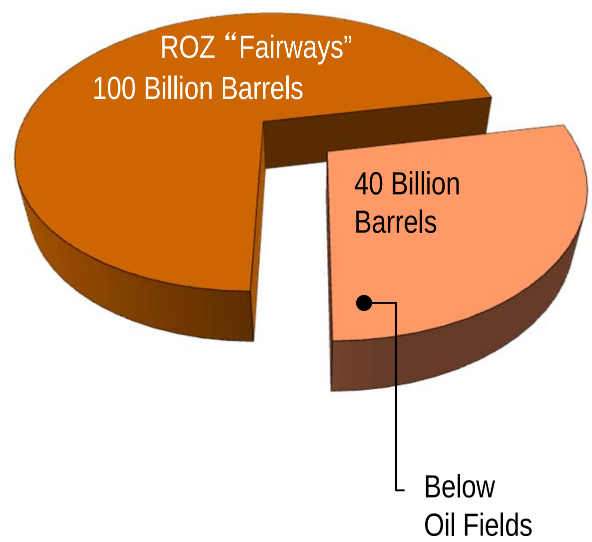
Original Oil In-Place: 600 B Barrels

"Stranded" Oil In-Place: 396 B Barrels



140 BILLION BARRELS OF OIL
IN RESIDUAL OIL ZONES (ROZs).

Oil In-Place: 140 B Barrels*



*Within ROZ "Fairways" of the Permian Basin and below oil fields in 3 U.S. basins.

Source: Advanced Resources Int'l. (2011); Melzer Consulting (2012)

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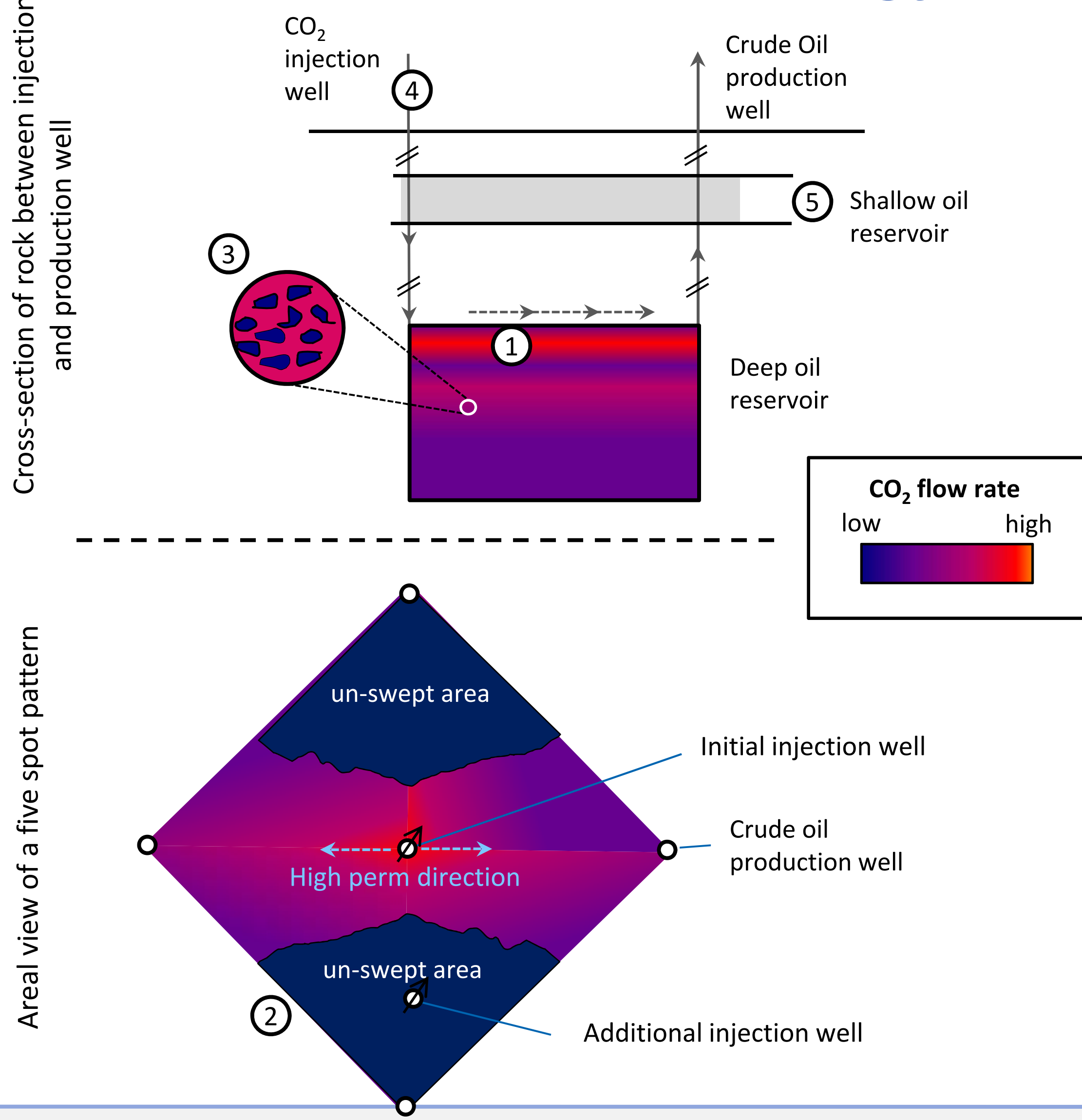
2. Technology Areas Comprising "Next Generation" CO_2-Enhanced Oil Recovery

Next Generation CO_2 Enhanced Oil Recovery: Technology Areas



1. **Improved Conformance Control.** Reduce the unproductive channeling of CO_2 through high permeability reservoir flow paths
2. **Advanced Flood Design.** Target and produce the high oil saturation reservoir segments bypassed or poorly swept by the waterflood.
3. **Enhanced Mobility Ratio.** Reduce fingering, create a more uniform and effective flow front in swept areas.
4. **Increased volumes of efficiently-injected CO_2.** Improve sweep efficiency and reduce oil saturation toward the theoretical maximum.
5. **Near-miscible CO_2 EOR**. Apply CO_2 EOR in shallow reservoirs that are close to but not above minimum miscibility pressure (MMP).

Also required for next generation CO_2 EOR are three enabling technology that cross-cut the primary technologies: **Robust reservoir characterization; Enhanced fluid injectivity via near well completion; and Extensive monitoring, diagnostics and process control.**

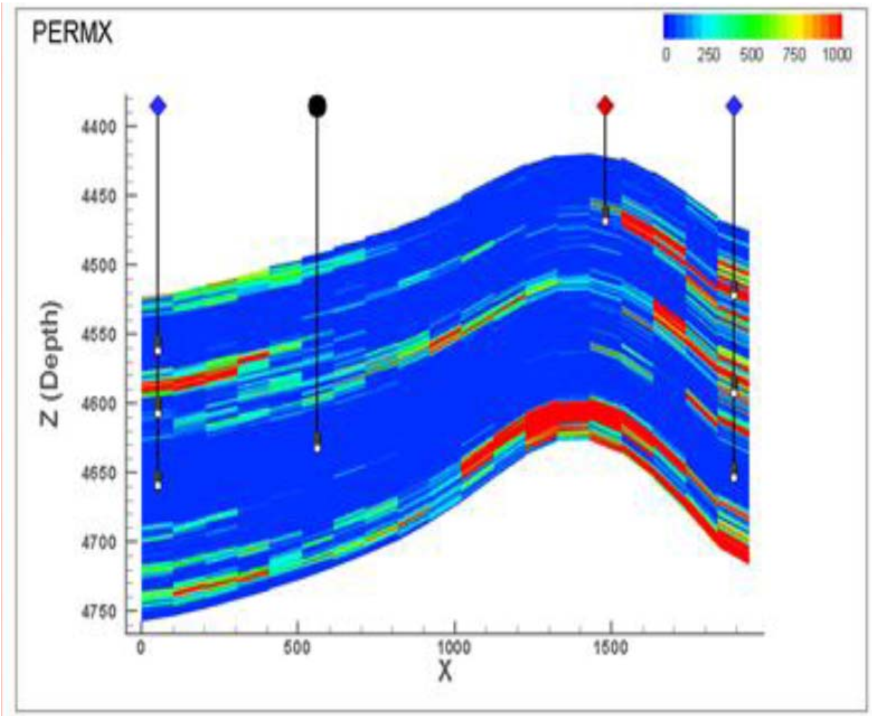
Technology #1: Improved Reservoir Conformance

- *Technology Objectives*. Reduce the unproductive channeling of CO_2 (and water) through high permeability reservoir flow paths.
- *Technology Implementation*.
  1. Reservoir characterization to identify and map reservoir flow paths:
     - Advanced core and log analyses
     - Reservoir simulation
  2. Remediation of high permeability reservoir channels:
     - Deep diversion materials (foams, polymers)
     - Plugging actions (cement, other)
  3. Reservoir monitoring, diagnostics and control:
     - Annual spinner surveys
     - Fiber optic temperature surveys
- *Technology Benefits*.
  1. More efficient utilization of CO_2; lower CO_2/oil ratio

Technology #1: Improved Reservoir Conformance

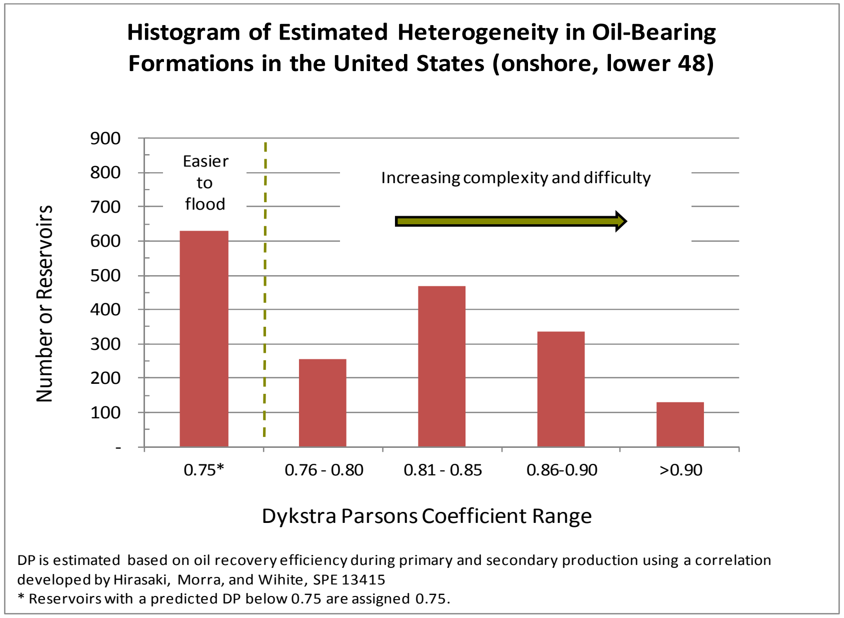
Mapping Permeability Distribution and Flow Channels

Permeability Distribution in Reservoir Cross-Section



The Reinecke carbonate reservoir in West Texas (above), illustrates its high and low permeability segments and flow channels.

Achieving improved reservoir conformance in these heterogeneous oil reservoirs represents a major technology challenge.



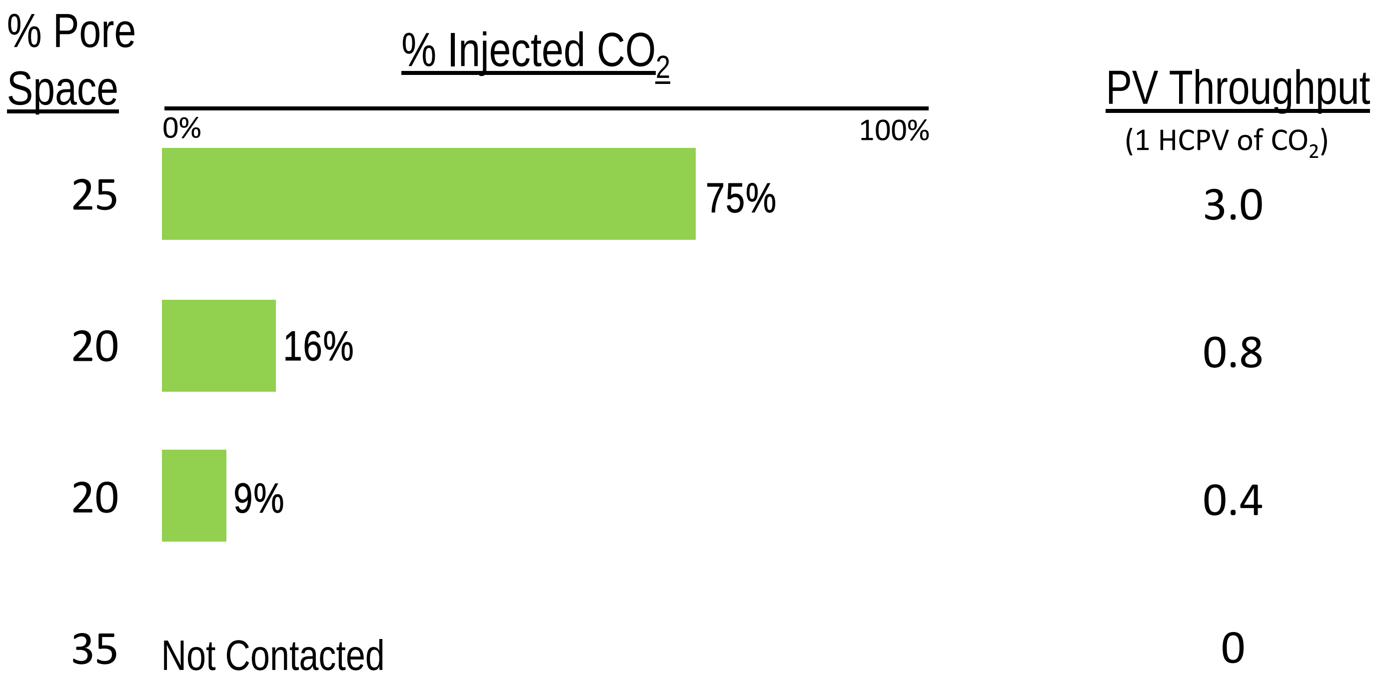
A significant number of domestic oil reservoirs are highly heterogeneous with Dykstra-Parsons coefficients of over 0.75

Source: SPE 154181, Zhou, D., Yan, M., and Calvin, W.M., “Optimization of a Mature CO2 Flood – From Continuous Injection to WAG”, prepared and presented at the Eighteenth SPE Improved Recovery Symposium, Tulsa, Oklahoma, USA, 14-18 April 2012.

Technology #1: Improved Reservoir Conformance

Reservoir Conformance Pilot at Wasson (Denver Unit) CO_2 Flood

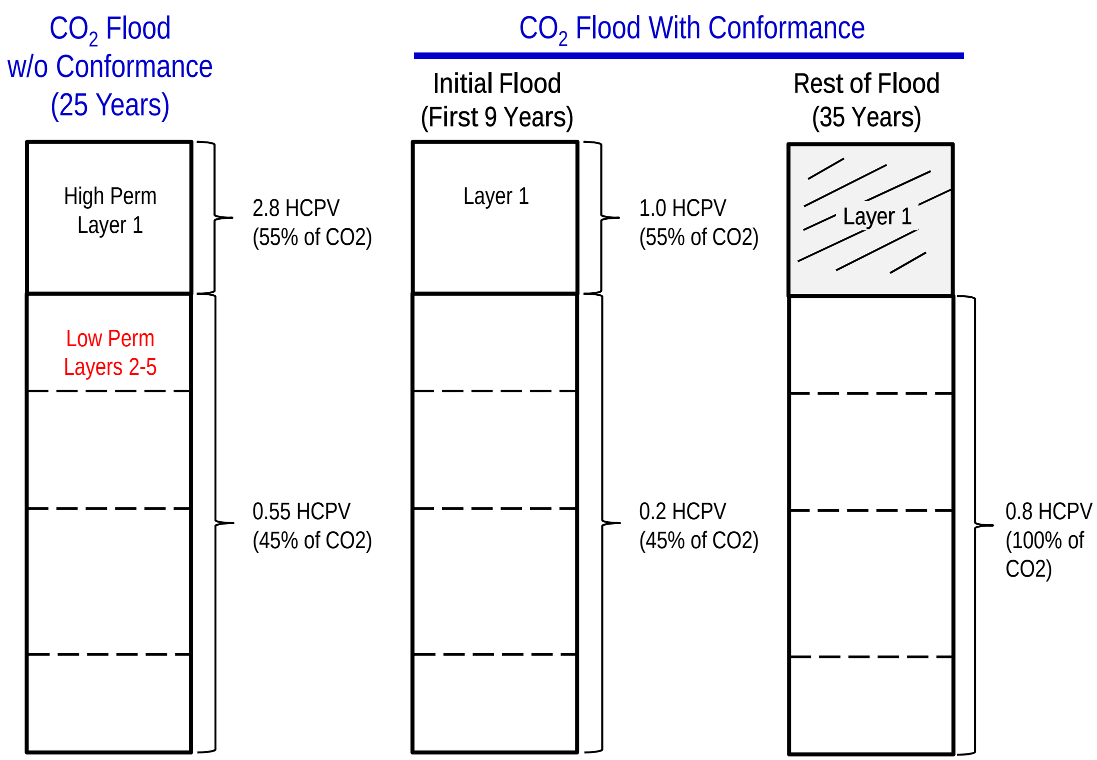
Installation of reservoir surveillance at the Wasson (Denver Unit) CO_2 flood showed high CO_2 channeling through a small portion of the reservoir's pore space.



Source: Advanced Resources International

Technology #1: Improved Reservoir Conformance

Modeling "Improved Reservoir Conformance"



- Example oil reservoir has a coarsening upward deposition; Dykstra-Parsons coefficient of 0.81.
- Objective is to efficiently flood the high- and low-permeability portions of the reservoir with 1 HCPV of CO_2.
- Conformance technology involves: (1) mapping reservoir flow paths; (2) remediating the high permeability channel; and (3) monitoring CO_2 flood performance.

Source: Advanced Resources International, Inc., 2013

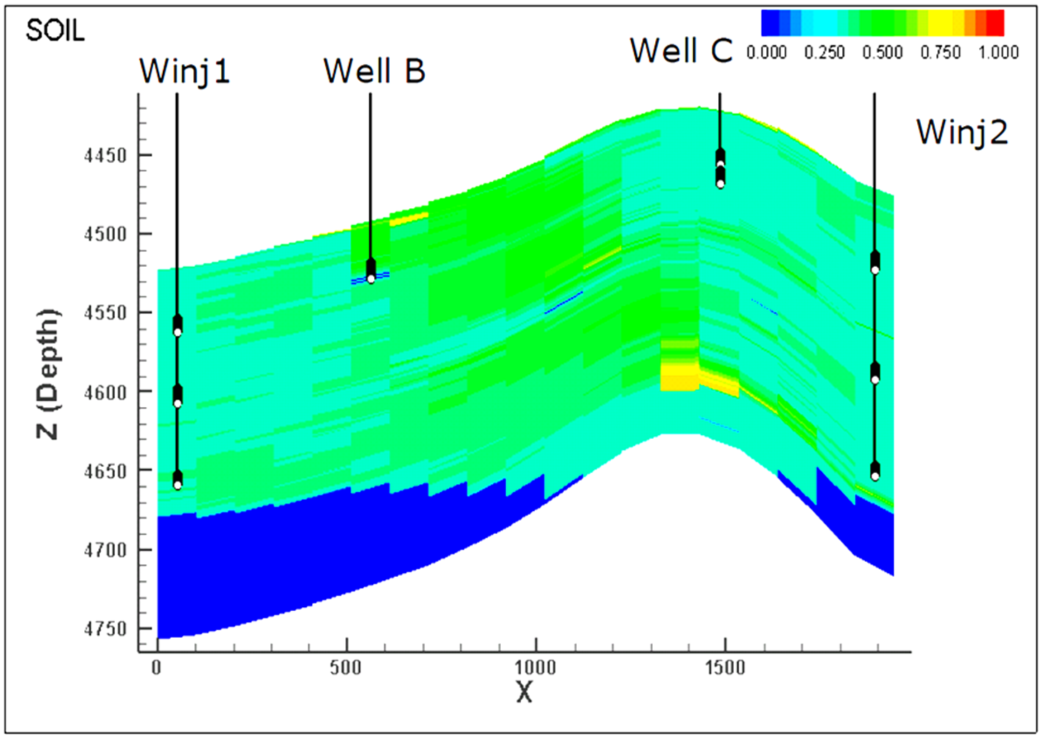
Technology #2: Advanced CO_2 Flood Design

- *Technology Objectives*. Target and produce the high oil saturation reservoir segments bypassed or poorly swept by the waterflood.
- *Technology Implementation*.
    1. Reservoir characterization to identify and map higher oil saturation, poorly swept reservoir intervals:
        - Advanced core and log analyses
        - 3-D seismic survey
        - Reservoir simulation
    2. Alternative CO_2 injection well and flood design:
        - Short lateral horizontal wells to increase reservoir contact and injectivity
        - Pattern realignment and closer spaced wells to create new fluid flow paths
        - Pressure management to increase reservoir contact by CO_2
    3. Reservoir monitoring, diagnostics and control:
        - 4-D seismic surveys
        - Annual spinner surveys
- *Technology Benefits*.
    1. Recovery of by-passed mobile oil

Technology #2: Advanced CO2 Flood Design

Mapping the Remaining Oil Saturation Distribution

Oil Saturation Distribution Prior to CO_2 Flood



Reservoir characterization is essential for mapping the location and richness of the remaining oil saturation prior to the CO_2 flood:

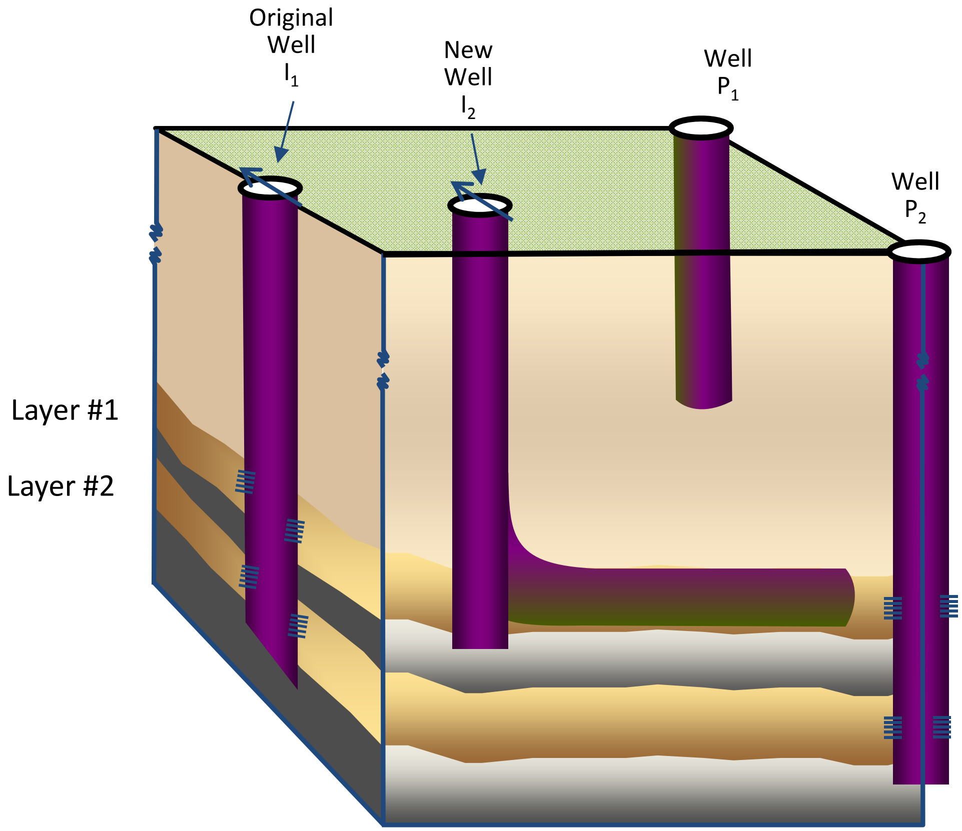
- Remaining oil saturations in reservoir intervals efficiently swept by waterflood are 25% to 35%.
- Remaining oil saturations in reservoir intervals poorly or unswept by waterflood can be over 50%.

The figure on the left, for the Reinecke oil field in West Texas, illustrates the use of detailed characterization to define the distribution of the remaining oil saturation in the reservoir.

Source: SPE 154181, Zhou, D., Yan, M., and Calvin, W.M., "Optimization of a Mature CO2 Flood – From Continuous Injection to WAG", prepared and presented at the Eighteenth SPE Improved Recovery Symposium, Tulsa, Oklahoma, USA, 14-18 April 2012.

Modeling Advanced CO_2 Flood Design

A second CO_2 injection well is used to flood low permeability Layer #1 (1/2 of 5 spot pattern).



A variety of advanced CO_2 flood and well placement designs can be used to contact more of the oil left behind after a water flood.

- The example on the left illustrates the placement of a short-lateral horizontal CO_2 injection well to target the high remaining oil saturation (Sor = 50%) Layer #1.
- Alternative flood designs can also include converting an inverted 5 spot pattern to a line drive CO_2 flood, infill drilling and/or use of horizontal production wells.

A robust program of reservoir "surveillance" is essential for determining how efficiently the advanced CO_2 flood design contacts the oil reservoir.

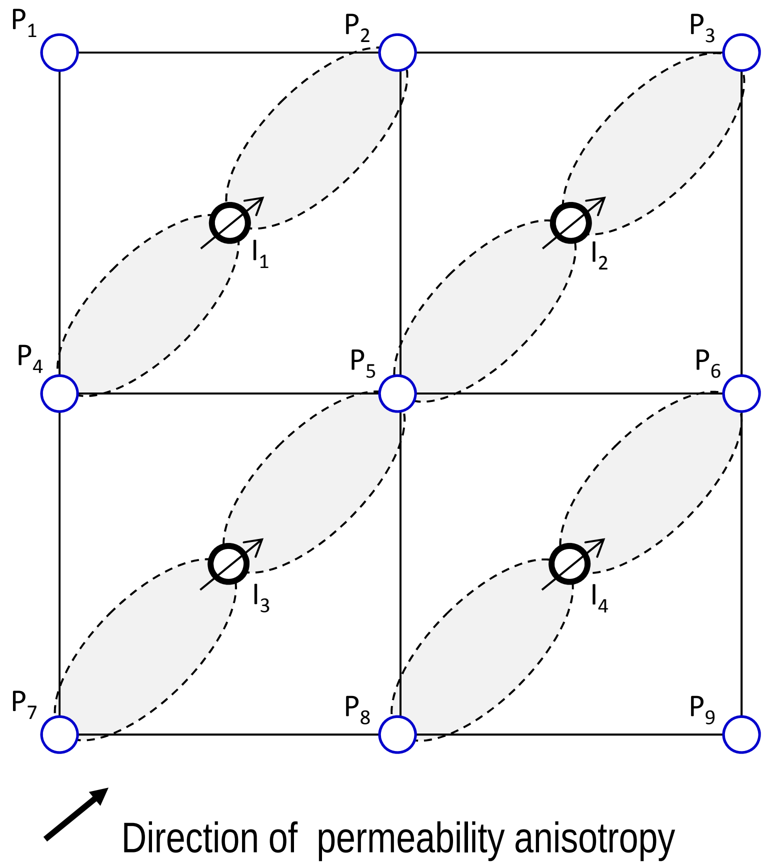
Source: Advanced Resources International, Inc., 2013

Technology #2: Advanced CO_2 Flood Design

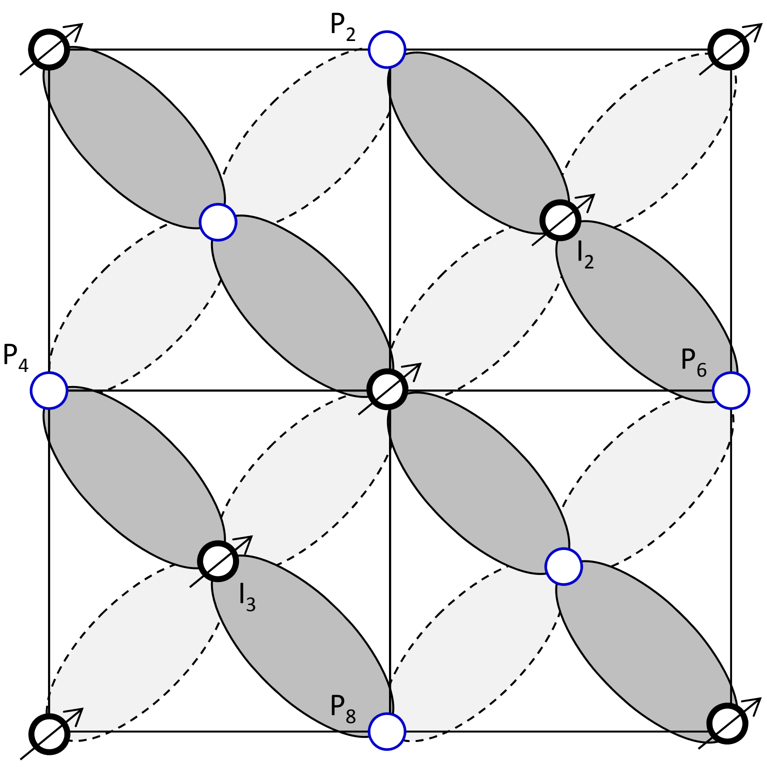
Pattern Realignment

Pattern realignment can help contact additional reservoir volume in high permeability anisotropy settings.

<u>Original Pattern</u>
(4 Injectors, 9 Producers)



<u>Pattern Realignment</u>
(7 Injectors, 6 Producers)

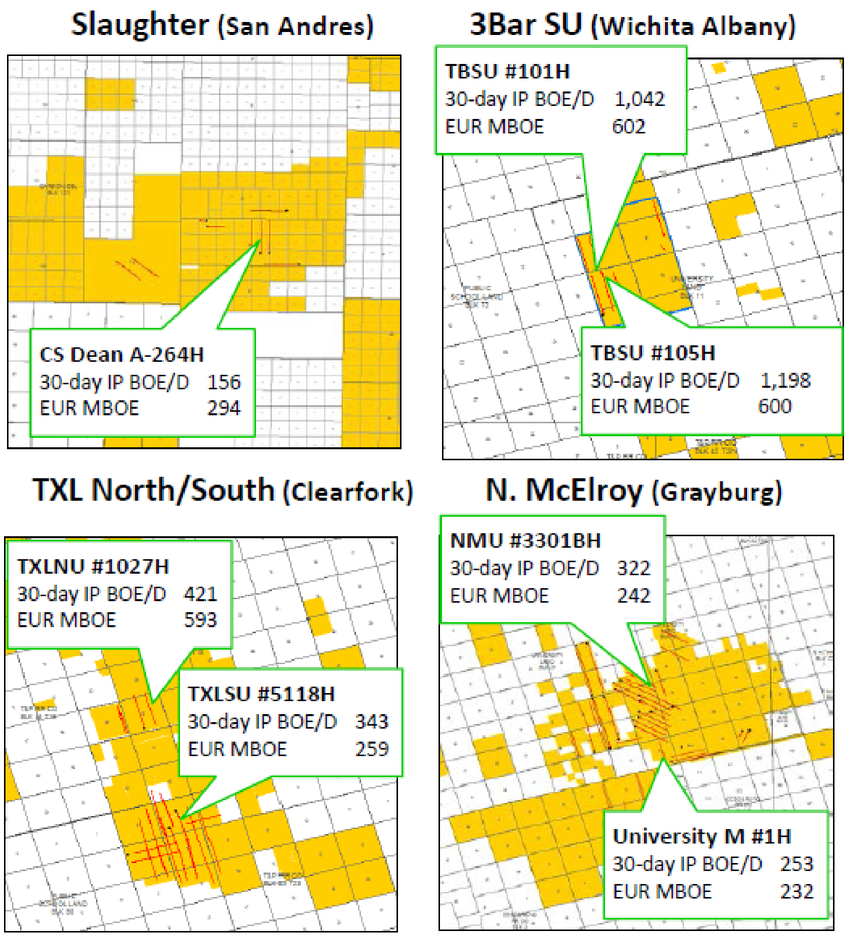


- Convert P1, P3, P7, and P9 to CO_2 injectors
- Convert I1 and I4 to oil producers

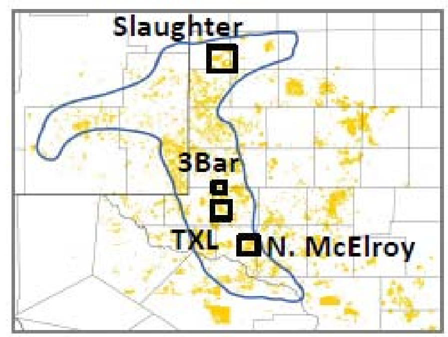
Source: Advanced Resources International, Inc., 2013

Technology #2: Advanced CO2 Flood Design

Use of Horizontal Wells



- Apache is successfully using horizontals (Hz) during waterfloods and in primary producing fields.
- Hz wells target by-passed oil zones and add new reserves.
- Apache's fields successfully produced using horizontal wells:
  - 2011: 6 fields
  - 2012: 8 additional fields



Source: Apache Energy, 2013

Technology #3: Enhanced Mobility Control

- *Technology Objectives*. Improve the mobility ratio between the injected fluid(s) and the residual oil in the reservoir.
- *Technology Implementation*.
  1. Increase the viscosity in the drive/displacement water used as part of a water-alternating-gas (WAG) CO_2 flood
     - Addition of polymers to increase water viscosity
  1. Use near-wellbore well stimulation to maintain CO_2 and water injectivity
     - Small volume "tip screen-out" frac, with x_f of about 15 ft.
- *Technology Benefits*.
  1. Increase areal sweep efficiency

Technology #3: Enhanced Mobility Control

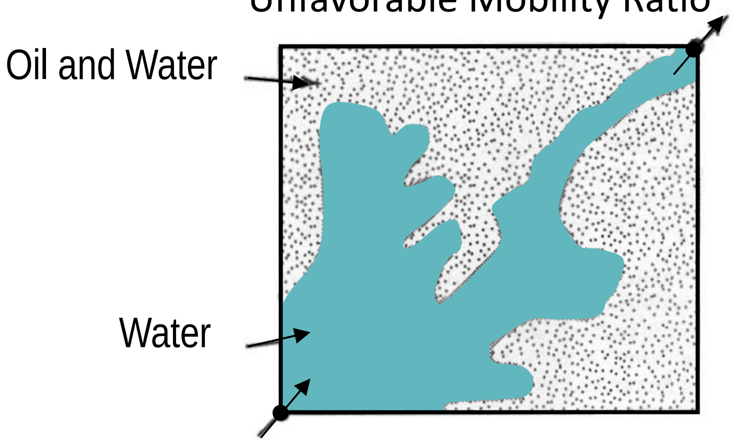
Modeling Enhanced Mobility Control

The viscosities of the injected fluids (CO_2 and water) are lower than the viscosity of the reservoir oil, leading to viscous fingering of the CO_2 through the reservoir's oil and thus inefficient sweep of the reservoir.

To model Technology #3, we raise the viscosity of the water (in the WAG process) to 2 cp. To counter the loss of fluid injectivity, Technology #3 also includes the Enabling Technology of "Enhanced Fluid Injectivity" to maintain water injectivity at SOA levels.

<u>Example A</u>

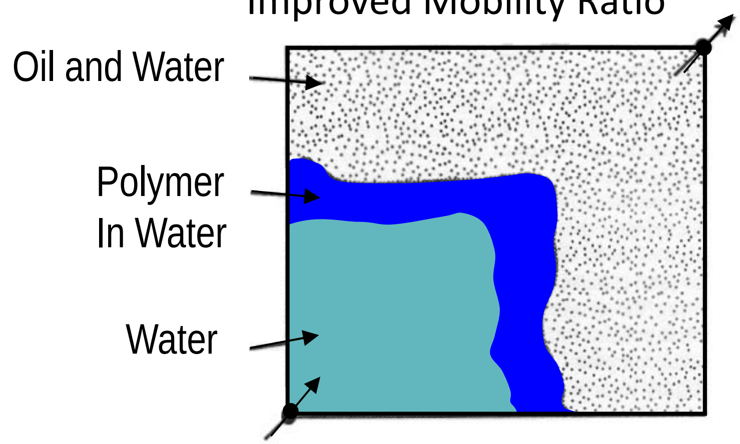
Unfavorable Mobility Ratio



Waterflood

<u>Example B</u>

Improved Mobility Ratio



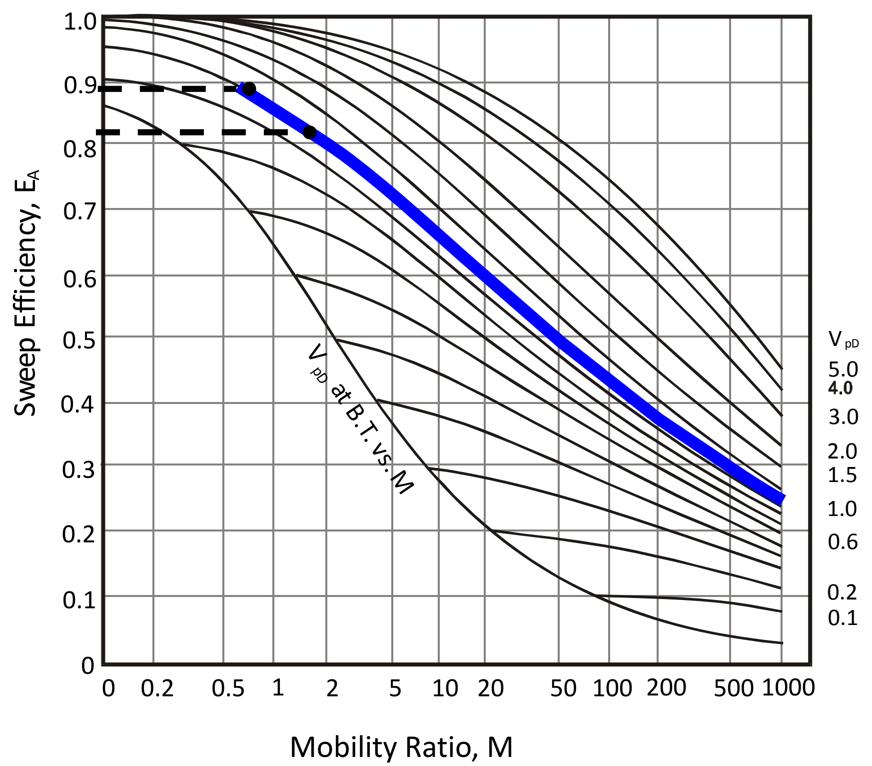
Viscosity Enhanced Flood

*Assuming equal relative permeability for oil and water.

Source: Adapted by Advanced Resources Int'l from "Enhanced Oil Recovery", D.W. Green and G. P. Willhite, SPE, 1998.

Increased Sweep Efficiency

Areal Sweep Efficiency in Miscible CO_2 Flooding as a Function of Mobility Ratio



Note: V_{pD} is hydrocarbon pore volumes of injected CO_2.

The extent of viscous fingering (and reduced sweep efficiency) is governed by the mobility ratio -- the viscosity of the reservoir oil divided by the viscosity of the displacing fluids adjusted by the relative permeabilities of the fluids.

The "example" oil reservoir has an oil/water mobility ratio of 1.8, based on an oil viscosity of 1.43 cp and a water viscosity (in the reservoir) of 0.78 cp.*

Decreasing the oil/water mobility ratio from 1.8 to 0.7 (by increasing the viscosity of the water to 2 cp) should improve the areal sweep efficiency (EA) from about 82% to about 89%.

*Assuming equal relative permeabilities for oil and water.

Source: Claridge, E.L., "Prediction of Recovery in Unstable Miscible Displacement", (J)SPE 12(2) 143-155 (April 1972).

Technology #4: Increased Volumes of Efficiently Used CO_2

- *Technology Objectives*. Increased CO_2/reservoir contact and residual oil displacement.

- *Technology Implementation*.

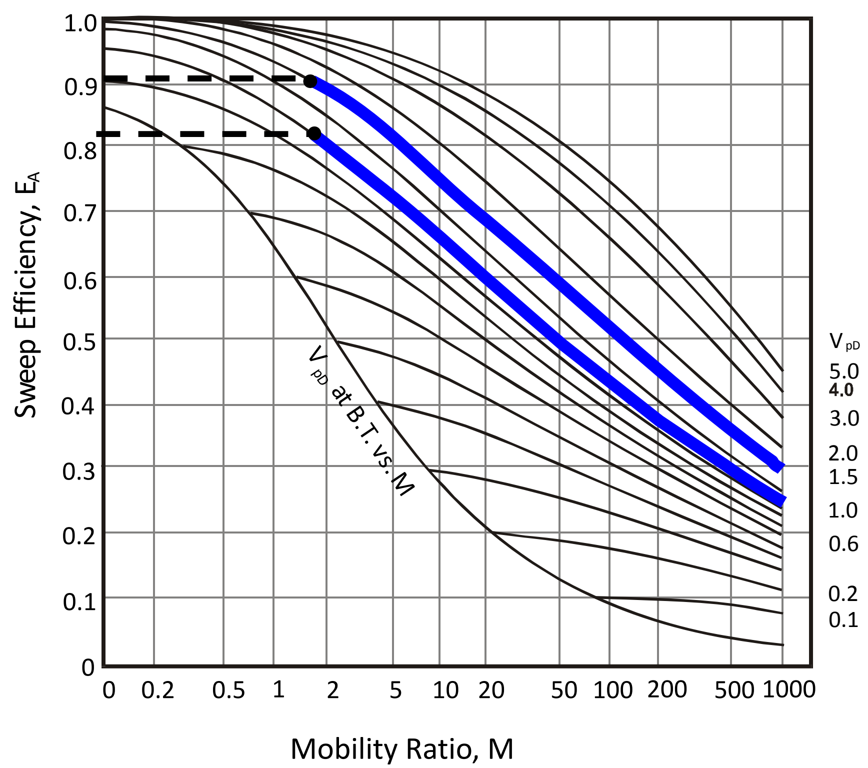
    1. Increase volume of CO_2 injected and efficiently used from 1 HCPV to 1.5 HCPV.
    2. Use near-wellbore well stimulation to maintain CO_2 and water injectivity.
        - Small volume "tip-screenout" frac with x_f of about 15 feet.
    3. Use reservoir monitoring, diagnostics and control to track CO_2/reservoir contact.
        - 4-D seismic
        - Annual spinner surveys
        - Fiber optic temperature surveys

- *Technology Benefits*.

    1. Improved sweep efficiency and more efficient oil displacement in CO_2 swept areas

Increased Sweep Efficiency

Areal Sweep Efficiency in Miscible CO_2 Flooding as a Function of HCPV CO_2



Note: V_{pD} is hydrocarbon pore volumes of injected CO_2.

Higher HCPVs of injected CO_2 enable more of the reservoir's residual oil to be contacted and displaced by the injected CO_2.

Increasing the volume of CO_2 injected (VpD), from 1.0 HCPV to 1.5 HCPV, should improve the areal sweep efficiency from about 82% to about 92% for a 1.43 mobility ratio WAG flood.

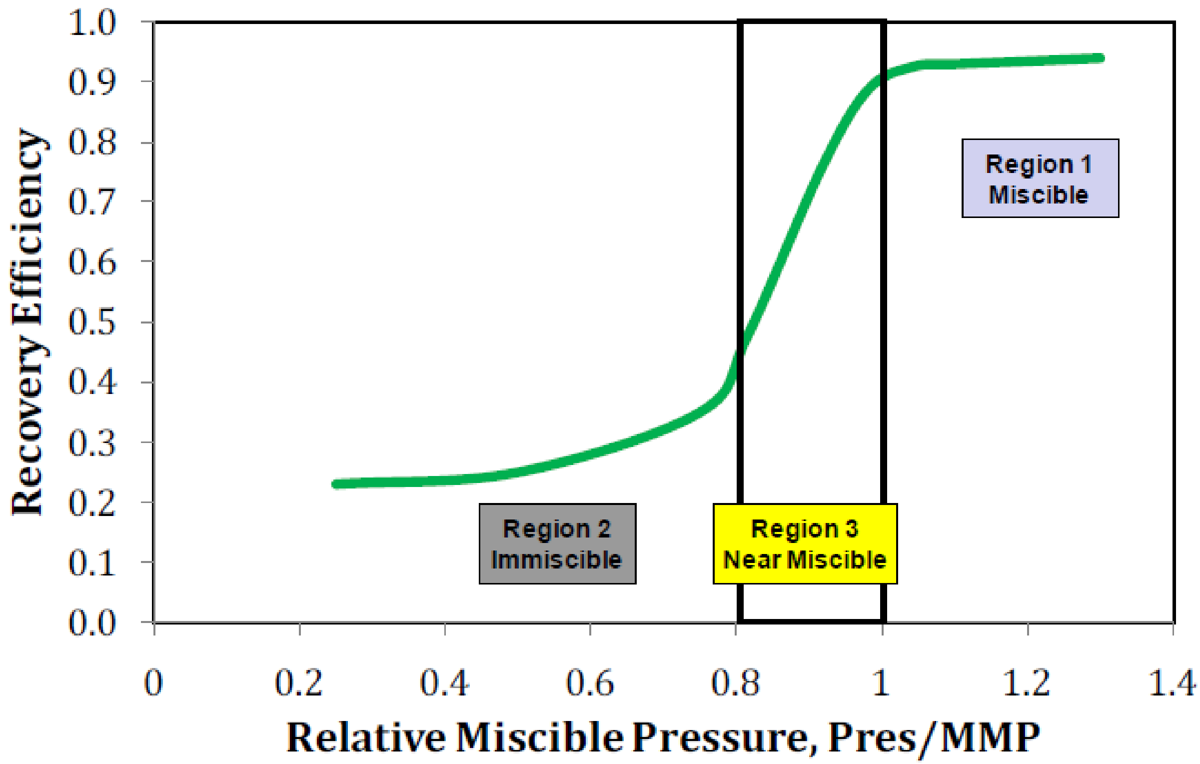
Source: Claridge, E.L., "Prediction of Recovery in Unstable Miscible Displacement", (J)SPE 12(2) 143-155 (April 1972).

Technology #5: Near-Miscible CO_2-EOR

- *Technology Objectives*. Introduce advanced EOR technology to oil reservoirs technically infeasible for miscible CO_2-EOR.
- *Technology Implementation*.
    1. Assess relationship of maximum allowable reservoir/CO_2 injection pressure to reservoir's MMP:
        - Extraction of light hydrocarbons into CO_2 phase
        - Solubility of CO_2 in oil phase
    2. Assess benefits of viscosity reduction and oil swelling on oil recovery
    3. Use reservoir monitoring, diagnostics and control to manage flood
        - 4-D seismic
        - Annual spinner surveys
        - Fiber optic temperature surveys
- *Technology Benefits*.
    1. Higher recovery of residual oil in reservoirs with pressure limits and high oil gravities.

Technology #5: Near-Miscible CO_2-EOR

As reservoir pressure enters the near-miscible range (0.8 to 0.95 of MMP), the vaporization of light hydrocarbon components from the crude oil into the CO_2 vapor phase begins, the mixing of CO_2 and oil phases progresses, and the interfacial tension (IFT) of the system is lowered, all contributing to improved oil recovery efficiency.



Source: Ly Huong Bui, Near-Miscible CO_2 Application to Improve Oil Recovery, Submitted to the graduate degree program in Chemical and Petroleum Engineering and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirement for the degree of Master of Science.

Near-Miscible CO_2-EOR

To model near-miscible reservoirs using PROPHET2, Sorm (residual oil saturation to CO_2) values are set for each field, using reservoir pressure as a percent of MMP.

Using University of Kansas near-miscible studies and near-miscible PROPHET2 test runs, Sorm values range from 0.25 for fields with reservoir pressure at 80% of MMP, to 0.1 for reservoir pressure at 100% of MMP (miscible).

Reservoir Pressure (% MMP)	Sorm
80%	0.25
85%	0.25
90%	0.20
95%	0.15
100%	0.10

Of the 77 near-miscible candidate reservoirs:

- 32 have reservoir pressure of 80% to 89% of MMP.
- 23 have reservoir pressure of 90% to 94% of MMP.
- 22 have reservoir pressure of 95%+ of MMP.

Enabling Technology #1:
Robust Reservoir Characterization

Reservoir characterization is essential for ensuring that the reservoir and CO_2 flood design engineers have sound data on the flow patterns, heterogeneity, and oil saturation distribution in the reservoir by:

- Mapping the remaining oil saturation to ensure that well placement and CO_2 injected are optimized to contact the reservoir's mobile and residual oil.
- Developing a rigorous understanding of areal and vertical reservoir heterogeneity to ensure that the increased volumes of injected CO_2 contact additional reservoir volume and do not merely circulate through high permeability reservoir intervals or directions.

Robust reservoir characterization is an essential Enabling Technology for Technologies #1 (Improving Reservoir Conformance) and #2 (Advanced CO_2 Flood Design).

Enabling Technology #2: Enhanced Fluid Injectivity

Enhanced fluid injectivity methods allow reservoir engineers to design CO_2 floods with higher injectivity (processing rates). Enhanced fluid injectivity also allows the use of higher viscosity fluids by increasing near-wellbore injectivity. Enhanced injectivity methods:

- Allow higher viscosity fluids to be injected at a favorable "processing" rate.
- Enable increased volumes of CO_2 are to be injected during the finite lifetime of a CO_2 flood.

Enhanced fluid injectivity is an essential Enabling Technology for Technologies #3 (Enhanced Mobility Control) and #4 (Increased Volumes of Efficiently Used CO_2).

Enabling Technology #2: Enhanced Fluid Injectivity

A small, "tip screen-out" near-wellbore type of hydraulic stimulation can provide enhanced CO_2 and water injectivity, particularly when using higher viscosity injection fluids.

We calculated that a small hydraulic fracture, with a wing length (x_f) of 15 feet (wellbore skin of about -3) is sufficient, to raise injectivity by a factor of 1.5 to 2.

$X_f = 2r_{ws}$

$r_{ws} = r_w (e^{-s})$

$- l_n (r_{ws}/r_w) = s$

Where: $r_w = 0.33$ feet

$X_f = 15$ feet

$r_{ws} = 7.5$ feet

$S = -3$

Enabling Technology #3:
Monitoring, Diagnostics and Process Control

Enhanced CO_2 flood monitoring, diagnostics and process control ("reservoir surveillance") are essential for ensuring that field operators gain process performance data from within the reservoir (and not just from the producing wells). Monitoring and control systems:

- Enable tracking the location and stability of CO_2 flood front to assess the performance of reservoir conformance and mobility control technologies.
- Provide real-time information that increased injected CO_2 contacts additional reservoir volume and does not merely circulate through already swept reservoir intervals.

Monitoring, diagnostics and process control are an essential Enabling Technology for Technologies #1 (Improved Reservoir Conformance), #2 (Advanced CO_2 Flood Design), and #4 (Increased Volumes of Efficiently Used CO_2).

Primary and Enabling "Next Generation" Technology Areas

		Technologies	Technology Implementation	Use of Enabling Technologies
I.	Primary Technologies			
	1.	Improved Reservoir Conformance	Divert CO_2 from high permeability reservoir channels.	Reservoir Characterization and MDC
	2.	Advanced CO_2 Flood Design	Realign CO_2 flood pattern; drill additional wells to flood poorly swept zone(s).	Reservoir Characterization and MDC
	3.	Enhanced Mobility Control	Increase viscosity of drive water (WAG) to 2 cp.	Enhanced Fluid Injectivity
	4.	Increased Volumes of Efficiently Used CO_2	Increase CO_2 injection from 1 HCPV to 1.5 HCPV; reduce Sorm from 0.1 to 0.08.	MDC and Enhanced Fluid Injectivity
	5.	Near-Miscible CO_2-EOR	Apply CO_2-EOR to oil reservoirs with max. pressure within 80% of MMP; reduce Sorm based on reservoir pressure.	-
II.	Enabling Technologies			
	1.	Robust Reservoir Characterization	Advanced logging, seismic monitoring and core analysis.	Essential for Technologies #1 and #2
	2.	Enhanced Fluid Injectivity	Effective near-wellbore stimulation methods.	Essential for Technologies #3 and #4
	3.	Monitoring, Diagnostics and Control (MDC)	Downhole monitoring systems, real-time diagnostics, smart wells, etc.	Essential for Technologies #1, #2, and #4

Methodology

Study Methodology Summary

(1) Assemble and update the Big Oil Fields Database (contains characterization data for 1,824 onshore reservoirs representing 353 Bbbls OOIP, 70% of domestic resources)

(2) Screen out reservoirs that are not amenable to CO_2 EOR (1,274 reservoirs with 293 billion barrels of OOIP are technically favorable for CO_2 enhanced oil recovery)

(3) Define five technology areas that make up "next generation" CO_2 EOR. Develop methodologies to characterize each technology area singularly in PROPHET

(4) Technology Areas 1-4: for each "screened in" reservoir, exercise PROPHET to conduct a series of simulations of CO_2 EOR floods that model each technology area deployed singularly and in all the possible combinations with the other three technology areas.

(5) Technology Area 5 (near miscible CO_2 EOR): reevaluate the screened out reservoirs and define a subset that would be amenable to CO2 EOR if near-miscible technology was developed. Conduct reservoir simulations for these reservoirs.

(6) Using the annual fluid flows (CO_2, crude oil, etc.) from PROPHET, conduct cash flow analyses of each of the CO_2 EOR flood simulations and to determine reservoirs that are economically viable.

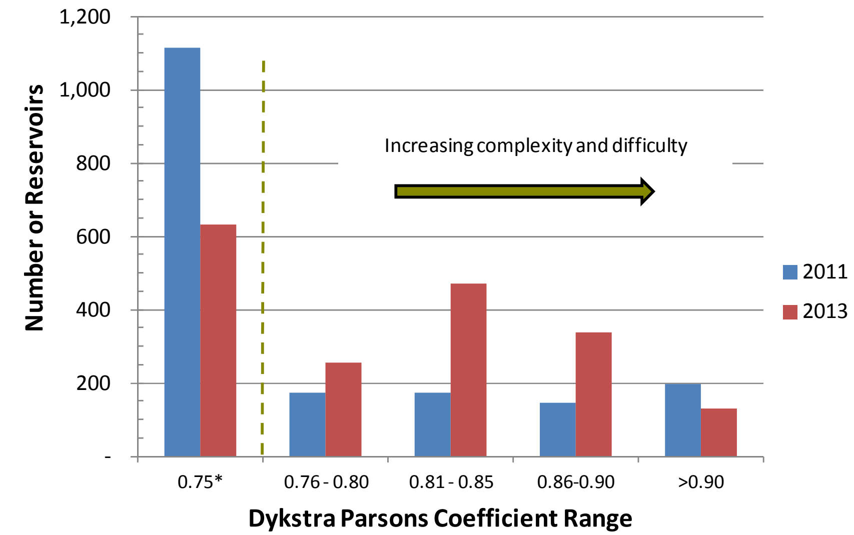
(7) Sum up the crude oil production and CO_2 demand from all of the economic CO_2 floods and report these volumes under economically recoverable resource (ERR) and economically viable CO_2 demand.

(8) Analyze the results.

Progression from the June 2011 Resource Assessment

- **More robust modeling of CO_2 storage**
  - PROPHET was altered to characterize CO_2 dissolution in brine using methodology derived from Mansoori (1982).
  - Loss factor reduced from a flat 25% to 10% for first HCPV declining to zero with subsequent CO2 injection.
- **Improved methodology for estimating reservoir heterogeneity**
  - Dykstra Parsons derived from mobility ratio and sweep efficiency during primary and secondary recovery based on method developed by Hirisaki, Morra, and Wilhite (SPE 13415)
- **Added conformance control as a discreet technology area**
  - Modeled as follows. Operate injection well until high permeability channel has seen 1 HCPV. Plug that layer and resume injection. CO_2 now directed to lower permeability layers within the target zone.
- **Calculate percentage of un-swept area in each reservoir based on values of residual oil saturation, initial oil saturation, and cumulative production**
- **Added re-pressurization algorithm**
  - Exercised GEM to develop a re-pressure algorithm based on well spacing, horizontal permeability, and the degree to which current pressure falls below calculated minimum miscibiity pressure. Typically presents as a 1 year lag between investment and crude oil production.
- **Revised capital and operating cost of "next generation" CO_2 EOR**
  - Includes more detailed monitoring and diagnostics for reservoir characterization and process control and well workovers for scheduled maintenance.

Histogram of Estimated Heterogeneity in Oil-Bearing Formations in the United States (onshore, lower 48)



In 2013, DP is estimated based on oil recovery efficiency during primary and secondary production using a correlation developed by Hirasaki, Morra, and Wihite, SPE 13415
* In both the 2011 and 2013 methodology, reservoirs with a predicted DP below 0.75 are assigned 0.75.

Key Inputs And Assumptions Of The Economic Model

- *Oil Price* - - $90 per barrel (WTI reference price). This oil price is consistent with EIA's Annual Energy Outlook oil price for years 2012 and 2013.
- *CO_2 Purchase Price* - - $40 per metric ton; $2.13 Mcf (delivered at pressure to the oil field), equal to 2.5% of oil price.
- *Financial Hurdle Rate* - - 20% ROR (before tax).
- *Royalties* - - 20%
- *State Severance/Ad Valorem Taxes* - - State specific.
- *CO_2 Reinjection Cost* - - $6 per metric ton; $0.30/Mcf (for dehydration and compression).
- *CAPEX and OPEX* - - State and reservoir depth specific.

Modeling Next Generation Technologies

Improved Reservoir Conformance – The CO_2 flood is run through all reservoir layers until 1 HCPV has cycled through the high-perm streak. The high-perm streak is then shut off, and the CO_2 flood is continued in the remaining layers. The high perm streak flood time is calculated based on the Dykstra-Parsons value for the reservoir.

Advanced CO_2 Flood Design – An additional PROPHET2 run simulates a second well drilled into the poorly swept reservoir zone. The recoveries from the two PROPHET2 runs are merged to simulate recovery from two wells.

Enhanced Mobility Control – The viscosity of the drive water in the PROPHET2 run is increased to 2 cp, and a single reservoir frac is modeled to maintain injectivity (the costs for which are added to the cashflow). The single frac allows for an increased CO_2 injectivity rate by 1.5 times.

Increased Volumes of Efficiently Used CO_2 – The injected HCPV is increased from 1.0 to 1.5, water and CO_2 injectivity rates are increased 1.5 times, and the Sorm is adjusted from 10% to 8% to account for the increased volumes of injected CO_2.

Cost Estimation Methodology

To illustrate the methodology for estimating the cost of"Next Generation" CO_2-EOR Technology, we selected a "representative" Permian Basin oil field/reservoir and modeled its Capital, CO_2 and O&M costs as well as its oil recovery, using a variety of CO_2-EOR technology options:

- ***Current Technology***: involving standard high quality CO_2-EOR operating practices and injecting 1 HPCV of CO_2.
- ***"Next Generation" Technology:**** examining each of the four advanced CO_2-EOR management practices singly and then in combination.

*The detailed description of the "Next Generation" set of CO_2-EOR technologies has been provided in previous materials.

The "Representative" Permian Basin Oil Field/Reservoir

The description of the "representative" Permian Basin oil field/reservoir selected for this analysis is as follows:

- **Technically Favorable for Miscible CO2-EOR**. The reservoir has light oil (38º API), sufficient depth (5,600') and original pressure (2,330 psi) to exceed the minimum miscible pressure (MMP) of 1,282 psi.
- **Moderate Primary and Secondary Oil Recovery**. The oil reservoir has projected oil recovery of 27% of OOIP, following an active 160 acre/well spaced waterflood.
- **Challenging Reservoir Properties**. The carbonate oil reservoir is heterogeneous, with a Dykstra-Parsons coefficient of 0.80, and has a moderately viscous oil (4.5 cp), limiting the sweep efficiency of the waterflood to 56% of gross reservoir volume.
- **Attractive Volumes of "Stranded Oil".** Primary/secondary recovery is projected to recovery about 210 million of the 768 million barrels of OOIP, leaving behind a large, 558 million barrel remaining oil in-place target.

Implementing Current Technology CO_2-EOR in the "Representative" Oil Field/Reservoirs

Given the significant size of the "representative" oil field/reservoir, covering nearly 30,000 acres and holding a substantial volume of remaining oil in-place, implementing field-wide CO_2-EOR entails considerable capital investment, CO_2 injection volumes and operating costs.

- **Capital Investment (CAPEX)**. With an extensive set of existing waterflood injection and production wells, the Capex of $361 million is primarily for well workovers, the CO_2 recycle plant and other CO_2-EOR facilities.
- **CO_2 Supply Costs**. CO_2 supply costs, for purchasing 729 Bcf (39 MMmt) and recycling 413 Bcf (22 MMmt) of CO_2 are $1,677 million.
- **O&M Costs**. Operating the CO_2 flood for 16 years, including lifting fluids and maintaining the field, costs $368 million.
- **Total Costs.** Including Capex, costs for CO_2 supplies and O&M, the total cost of the CO_2-EOR project in the "representative" oil field (under Current Technology) is $2,406 million.

Implementing Current Technology CO_2-EOR in the "Representative" Oil Field/Reservoirs

Constrained by the heterogeneous nature of the reservoir and its somewhat higher oil viscosity, the performance of Current Technology CO_2-EOR is moderate:

- Cumulative oil recovery is 60 million barrels, equal to about 8% of the OOIP. Project life and thus oil production are limited based on the "representative" reservoir reaching an economic limit in 16 years under Current Technology.
- The net (purchased) CO_2 to oil ratio is relatively high at 12 Mcf of CO_2 per barrel of recovered oil. Much of the injected CO_2 channels through a higher permeability ("thief zone") reservoir interval.

However, despite the lower oil recovery and higher net CO_2 to oil ratio, the project provides a 19.7% (before tax) return on investment (IRR), just below our minimum threshold of 20% (before tax) IRR.

Implementing “Next Generation” CO_2-EOR in the “Representative” Oil Field/Reservoirs

Given the challenging characteristics of the oil field/reservoir but a large target of “stranded” oil, the application of the “Next Generation” CO_2-EOR Technologies is appropriate for overcoming these reservoir challenges.

- **Reservoir Conformance** is designed to mitigate unproductive CO_2 channeling,
- **Advanced Flood Design** is designed to target the high volumes of mobile oil remaining in the unswept portion of the reservoir,
- **Mobility Control** is designed to improve the injection fluid mobility ratio for this moderately viscous oil, and
- **Increased Volumes of Efficiently Used CO_2**, particularly in combination with Reservoir Conformance and the other two “Next Generation” technologies enable much more of the reservoir to be efficiently contacted with CO_2, thus substantially extending the economic limit of the “representative” oil field.

Implementing "Next Generation" CO_2-EOR in the "Representative" Oil Field/Reservoirs

Implementing "Next Generation" CO_2-EOR Technology is not "free".

Significant additional capital investment, CO_2 purchase and recycle costs and higher O&M costs from more rigorous reservoir characterization and CO_2 flood.

Monitoring/management significantly increase total project costs.

Compared to $2,406 million under "Current Technology" the "Next Generation" CO_2 flood costs of $4,647 million.

	Current Technology	Integrated Application of Next Generation Technology
CAPEX Total ($M)	$ (361,293)	$ (677,769)
Total CO2 Costs ($M)	$ (1,676,753)	$ (2,743,723)
O&M Total ($M)	$ (368,296)	$ (1,225,102)
Total Project Costs ($M)	$ (2,406,342)	$ (4,646,594)

However, the higher oil recovery of 213 million barrels (versus 60 million for Current Technology) reduces unit costs to $18/barrel (versus $40/barrel for Current Technology) and improves return on investment.

Capital Costs for Implementing "Next Generation" CO_2-EOR Technology

Each of the "Next Generation" Technologies requires additional capital expenditures (Capex) compared to using Current CO_2-EOR Technology.

- **Reservoir Conformance** requires an additional $10 million of Capex for "thief zone" plugging, plus $56 million for the enabling technologies of reservoir characterization and monitoring. ($73 million total)*.
- **Advanced Flood Design** requires an additional $215 million of Capex for CO_2 injection wells and expanded CO2 recycling facilities, plus $56 million for the enabling technologies of reservoir characterization and monitoring. ($298 million total)*.
- **CO_2 Flood Mobility Control** requires an additional $30 million of Capex for a larger CO_2 recycling plant, plus $9 million for the enabling technology of improved reservoir injectivity. ($43 million total)*.
- **Increased CO_2 Injection** requires an additional $37 million for a larger CO_2 recycling plant, plus $88 million for the enabling technologies of reservoir characterization, enhanced reservoir injectivity, and reservoir monitoring. ($138 million total)*.

*After 10% Capex G&A

Capital Costs for Implementing "Next Generation" CO_2-EOR Technology

	Current Technology	"Next Generation" Technologies			
	Base Case	#1- Reservoir Conformance	#2- Advanced Flood Design	#3- CO2 Flood Mobility Control	#4- Increased Injection of CO2
Capital Costs ($M)					
Wells & Surface Eqpt	$ (123,037)	$ (123,037)	$ (334,627)	$ (123,037)	$ (123,037)
CO2 Recycling Plant	$ (53,564)	$ (53,564)	$ (57,150)	$ (83,474)	$ (90,397)
CO2 Trunkline/Gathering System	$ (19,172)	$ (19,172)	$ (19,172)	$ (19,172)	$ (19,172)
Plugging Costs	$ (132,675)	$ (132,675)	$ (132,675)	$ (132,675)	$ (132,675)
Workover Rig/Materials	$ -	$ (10,050)	$ -	$ -	$ -
Spinner Surveys	$ -	$ (24,569)	$ -	$ -	$ (40,364)
Fiber Optics	$ -	$ (15,000)	$ -	$ -	$ -
Coring	$ -	$ (11,250)	$ (11,250)	$ -	$ -
Logging	$ -	$ (5,625)	$ (5,625)	$ -	$ -
Stimulation	$ -	$ -	$ -	$ (9,000)	$ (9,000)
Seismic Survey	$ -	$ -	$ (39,000)	$ -	$ (39,000)
CAPEX Subtotal	$ (328,448)	$ (394,942)	$ (599,499)	$ (367,359)	$ (453,646)
CAPEX G&A	$ (32,845)	$ (39,494)	$ (59,950)	$ (36,736)	$ (45,365)
CAPEX Total	$ (361,293)	$ (434,437)	$ (659,449)	$ (404,095)	$ (499,010)

Capital Costs for Implementing "Next Generation" CO_2-EOR Technology

	Current Technology		Integrated Application of Next Generation Technologies	
Capital Costs ($M)				
Wells & Surface Eqpt	$	(123,037)	$	(178,927)
CO2 Recycling Plant	$	(53,564)	$	(90,297)
CO2 Trunkline/Gathering System	$	(19,172)	$	(19,172)
Plugging Costs	$	(132,675)	$	(132,675)
Workover Rig	$	-	$	(20,100)
Spinner Surveys	$	-	$	(71,953)
Fiber Optics	$	-	$	(15,000)
Coring	$	-	$	(11,250)
Logging	$	-	$	(5,625)
Stimulation	$	-	$	(18,000)
Seismic Survey	$	-	$	(39,000)
CAPEX Subtotal	$	(328,448)	$	(601,999)
CAPEX G&A	$	(32,845)	$	(75,770)
CAPEX Total	$	(361,293)	$	(677,769)

Other Costs for Implementing "Next Generation" CO_2-EOR Technology

Each of the "Next Generation" Technologies also requires additional CO_2 supply, lease operating and fluid lifting costs compared to using Current CO_2-EOR Technology.

- **Reservoir Conformance and Advanced CO_2 Flood Design** entailed higher volumes of fluid lifting and longer CO_2 flood operations, each adding $627 million and $1,762 million respectively to costs.
- **CO_2 Flood Mobility Control** entails purchase and use of polymers with the injection fluid, higher fluid lifting costs and longer CO_2 flood operations, adding $1,300 million to costs.
- **Increased CO2 Injection** entails higher purchases of CO_2 and longer flood operations, adding $1,578 million to costs

Other Costs for Implementing "Next Generation" CO2-EOR Technology

	Current Technology	#1- Conformance	#2- Flood Design	#3- Mobility Control	#4- Increased CO2
CO2 Costs ($M)					
Purchased CO2	$ (1,552,722)	$ (1,803,327)	$ (2,270,864)	$ (2,263,955)	$ (2,569,109)
Recycled CO2	$ (124,031)	$ (207,710)	$ (422,296)	$ (413,517)	$ (418,701)
Total CO2 Costs	$ (1,676,753)	$ (2,011,037)	$ (2,693,159)	$ (2,677,472)	$ (2,987,810)
O&M Costs ($M)					
Well O&M	$ (126,900)	$ (296,100)	$ (592,200)	$ (194,580)	$ (194,580)
Lifting Costs	$ (174,734)	$ (243,632)	$ (325,013)	$ (263,654)	$ (327,055)
CO2 Gathering System O&M	$ (5,280)	$ (10,838)	$ (10,838)	$ (7,503)	$ (7,503)
Polymer Costs	$ -	$ -	$ -	$ (90,811)	$ -
O&M Subtotal	$ (306,913)	$ (550,569)	$ (928,050)	$ (556,547)	$ (529,138)
O&M G&A	$ (61,383)	$ (110,114)	$ (185,610)	$ (111,310)	$ (105,828)
O&M Total	$ (368,296)	$ (660,683)	$ (1,113,660)	$ (667,857)	$ (634,965)
Total CO2 Costs and O&M	$ (2,045,049)	$ (2,671,720)	$ (3,806,820)	$ (3,345,329)	$ (3,622,775)
Flood Duration (Years)	16	36	29	22	23

Other Costs for Implementing “Next Generation” CO2-EOR Technology

	Current Technology	Integrated Application of Next Generation Technologies
CO2 Costs ($M)		
Purchased CO2	$ (1,552,722)	$ (2,330,898)
Recycled CO2	$ (124,031)	$ (412,824)
Total CO2 Costs	$ (1,676,753)	$ (2,743,723)
O&M Costs ($M)		
Well O&M	$ (126,900)	$ (693,720)
Lifting Costs	$ (174,734)	$ (295,300)
CO2 Gathering System O&M	$ (5,280)	$ (12,505)
Polymer Costs	$ -	$ -
O&M Subtotal	$ (306,913)	$ (1,001,525)
O&M G&A	$ (61,383)	$ (223,577)
O&M Total	$ (368,296)	$ (1,225,102)
Total CO2 Costs and O&M	$ (2,045,049)	$ (3,968,824)
Flood Duration (Years)	16	45

Results

An In-depth Look at "Next Generation" CO_2-Enhanced Oil Recovery: Summary Results

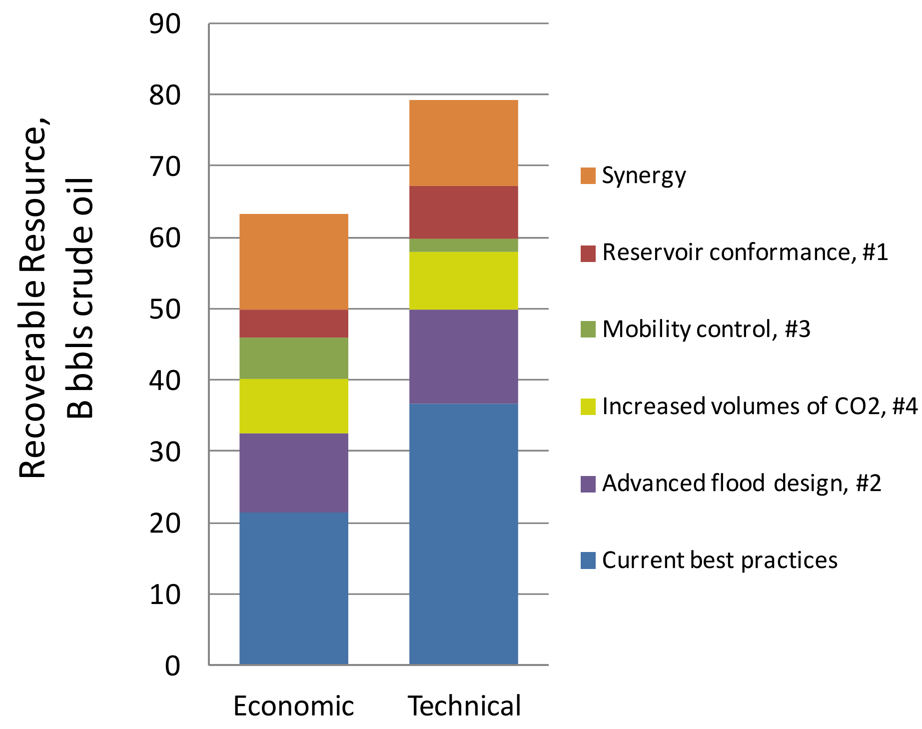
Under a "next generation" technology scenario – with all technologies applied in combination - the economically recoverable resource for CO_2 EOR increases from 21.4 Bbbls to 63.3 Bbbls (onshore lower 48, no residual oil zones). The demand for CO_2 increases from 8.9 BmtCO2 to to 16.2 B mt CO_2.

Resource Area	Economic Oil Recovery (BBbls)*		Demand for CO_2 (Billion Metric Tons)		Average CO_2 Utilization (bbls/mtCO_2)	
	SOA	Next Gen.	SOA	Next Gen.	SOA	Next Gen.
Miscible	19.6	60.8	8.4	15.4	2.3	3.9
Near Miscible	1.8	2.6	0.5	0.8	3.9	3.3
Total	21.4	63.3	8.9	16.2	2.4	3.9

*At $90 per barrel oil price and $40 per metric ton CO_2 price, with 20 % rate of return (before tax).
Results compiled from simulations of CO2 EOR floods at 1,800 oil-bearing formations in the onshore continental United States. Reservoir characterization data drawn from the Big Oil Fields database; simulations conducted using the PROPHET stream tube model.

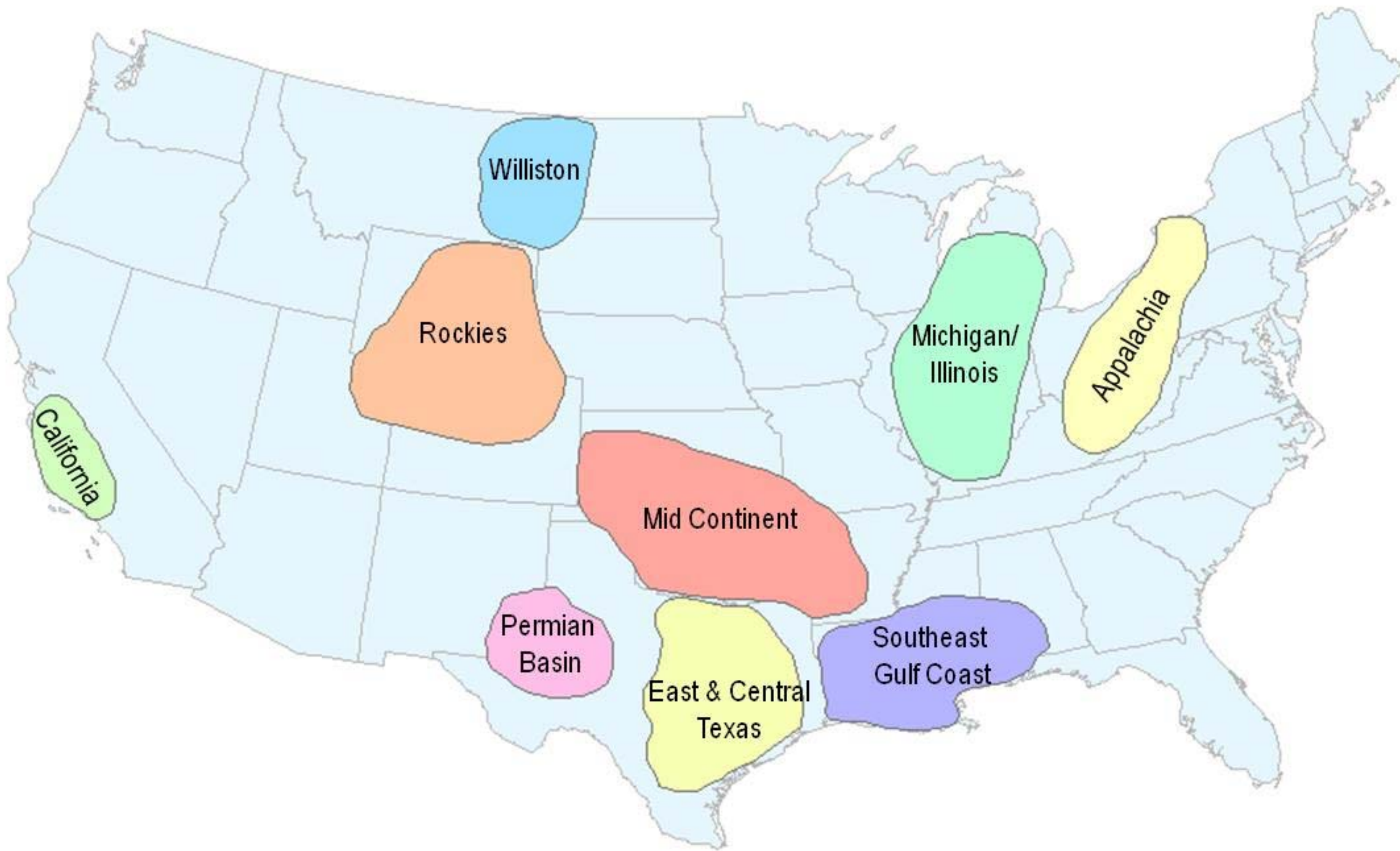
Individual Technology Area Impacts

- Each of the four primary technology areas was modeled singularly and in combination with others to evaluate impacts and synergies.
- Synergy is defined as the difference in recoverable resource between the sum of the individual technology area simulations and the simulation where all four technology areas are applied together.
- Synergy accounts for 32% of the total delta between current best practices and next generation in the economic simulations, 29% in the technical.
- "Advanced flood design" and "increased volumes of efficiently used CO_2" are the most impactful technology areas. However, conformance control and mobility control are necessary for the synergy benefit.



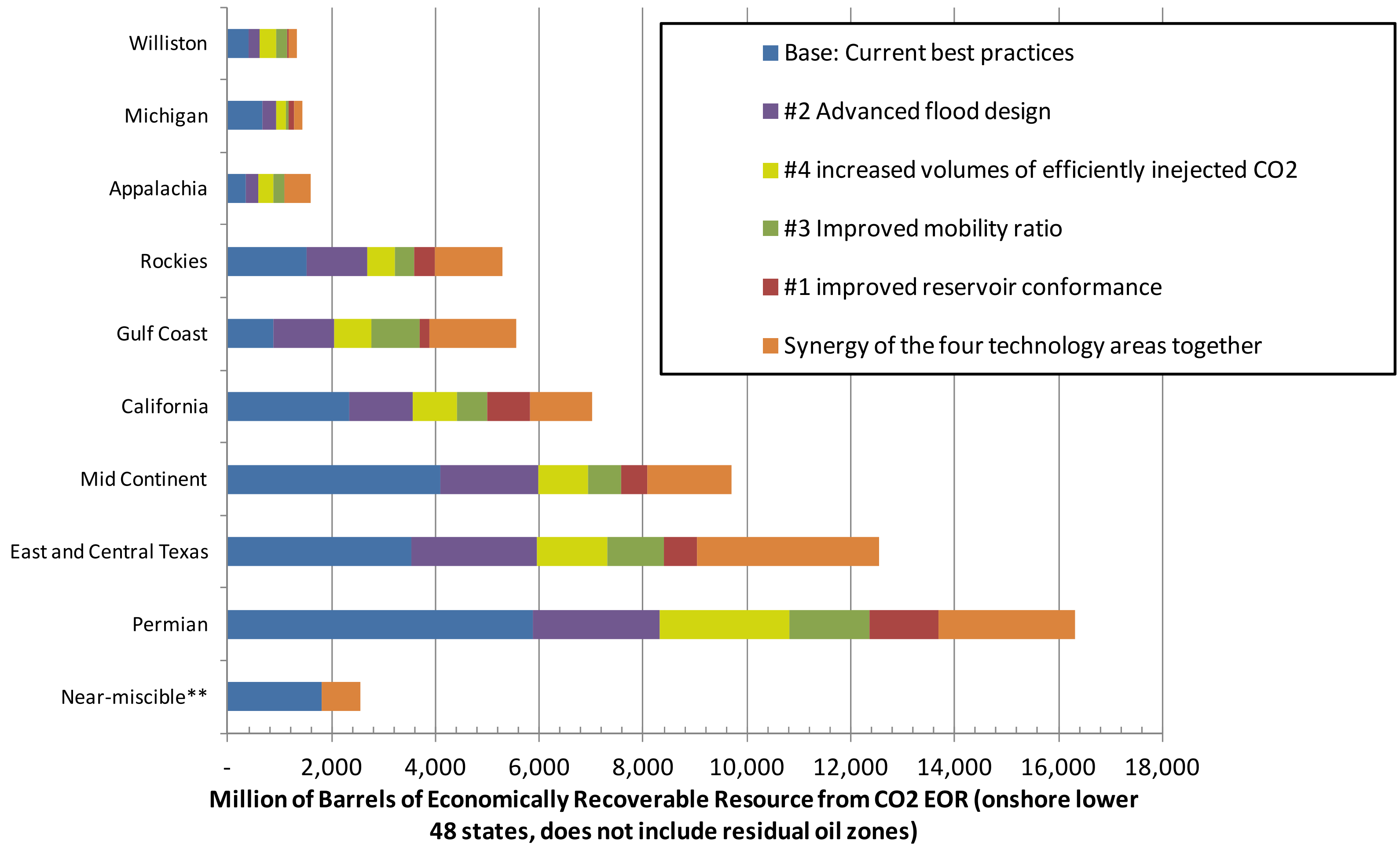
Two rules were applied in analyzing the data. (1) In cases where the sum of the increase above current best practices for technologies 1-4 applied singularly was greater than the increase in the all-in simulation, the individual cases were all reduced by the same percentage so that the sum of the increases was equivalent to the all-in case. This avoided double-counting. (2) In a small handful of cases where a singular technology simulation produced less economic crude oil than the current best practices simulation, the singular case was determined to impractical and the CO_2 demand and crude oil production was set to zero for this oil reservoir.

The CO_2 EOR technologies were individually applied to the oil reservoir in each of the geographic regions shown below.



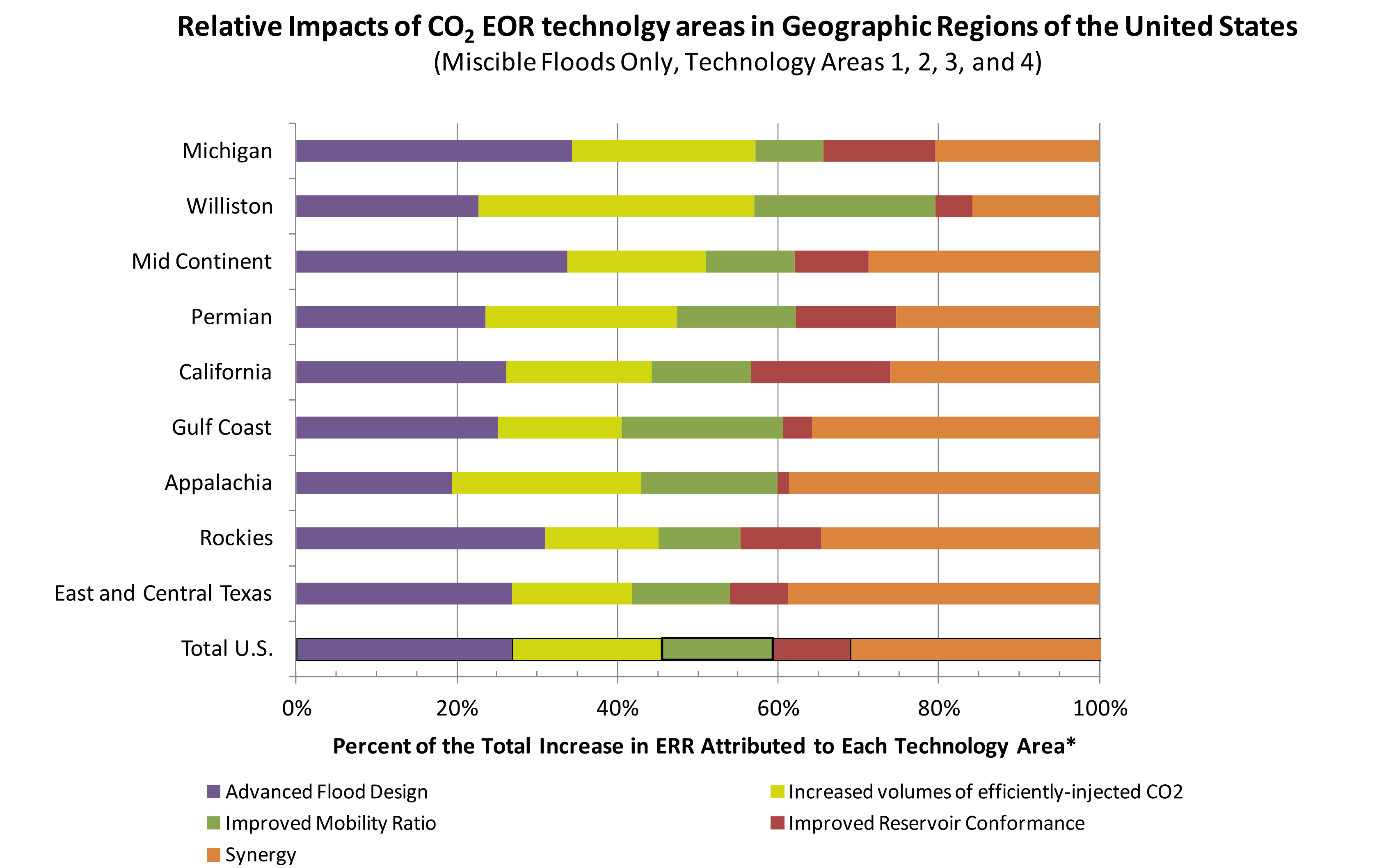
Appendices A and B contain detailed information for each region.

Economically Recoverable Resource for CO_2 EOR in the United States, Current Best Practices and Increments from the Technology Components of Next Generation CO_2



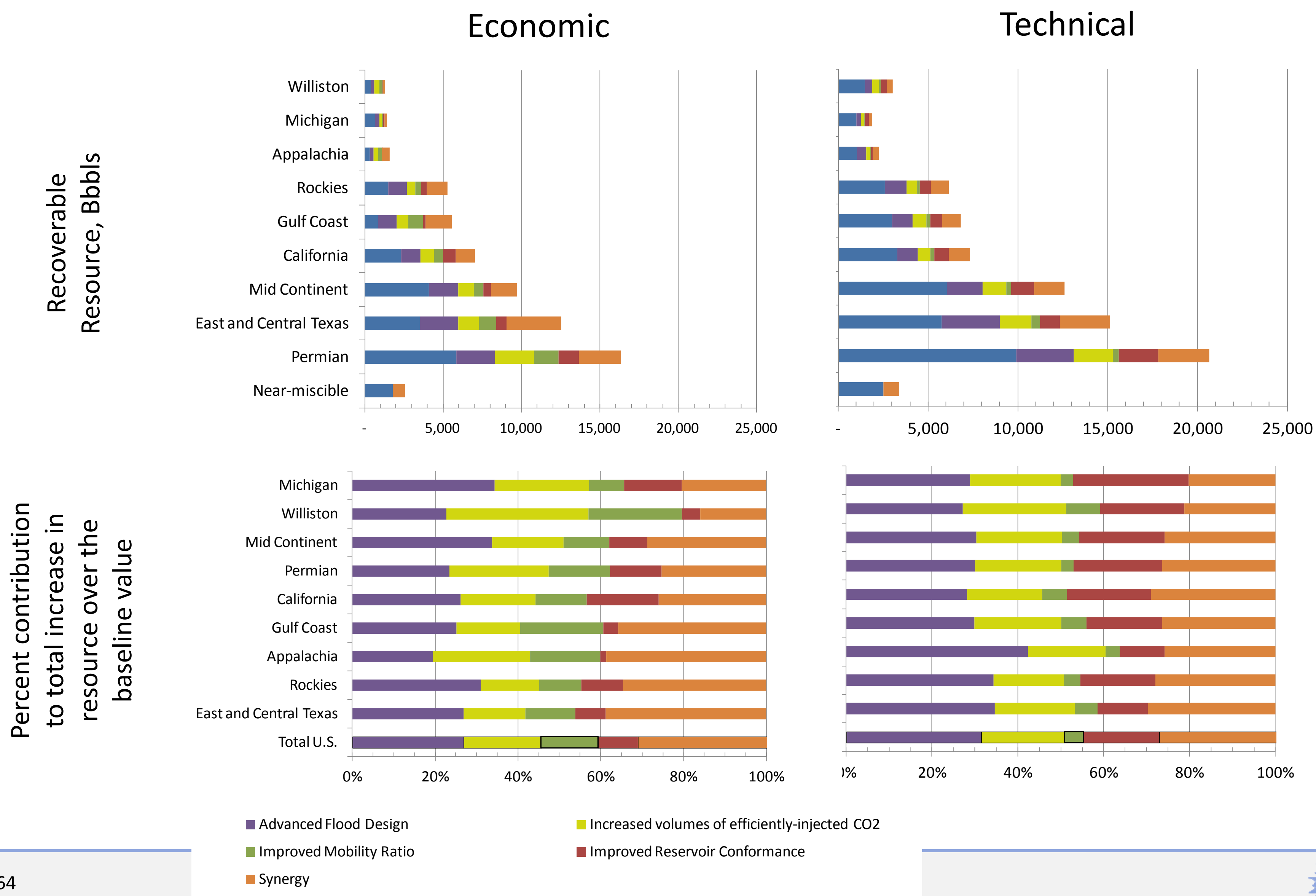
* The technology area impacts are estimated by performing field-by-field CO2 EOR flood simulation s with one technology area implemented and the other three turned off. "Synergy" is the difference between the sum of the individual technology area simulations and a final set of simulations where all four technology areas are implemented together.

** Near miscible is a virtual region, includes near miscible fields all over the United States. 3 states, California, Oklahoma, and Texas, acccount for 88% of the ERR. For near miscible, synergy is the base technology combined with increased CO2 and mobility control.



* The technology area impacts are estimated by performing field-by-field CO2 EOR flood simulation s with one technology area implemented and the other four turned off. "Synergy" is the difference between the sum of the individual technology area simulations and a final set of simulations where all four technology areas are implemented together.

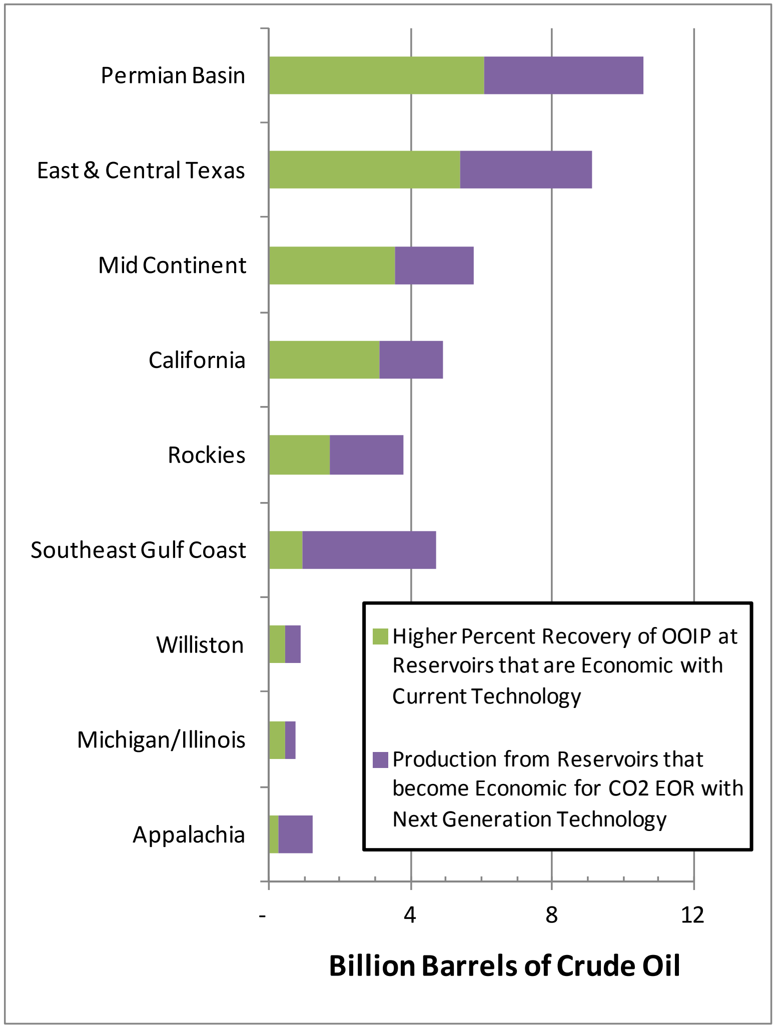
Technical Resource Shows Large Increase in Current Best Practices Resource. The impact of Advanced Flood Design (contacting unswept areas) increase relative to economic. Conformance control shows bigger impact also as delay in initial oil production is not a factor.



Next Generation CO_2 EOR Technology makes good fields better and makes challenging fields economically viable

Overall 53% of the ERR impact of Next Generation CO_2 EOR technology comes from higher crude oil recovery at reservoirs that are economic to flood with current technology.

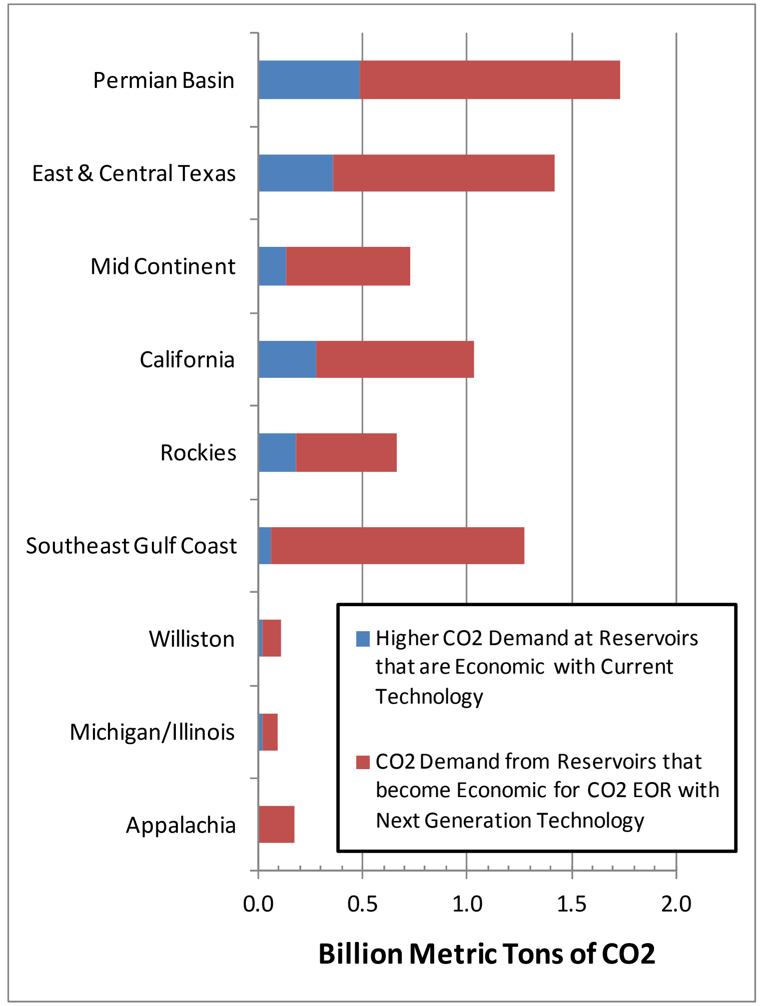
The Southeast Gulf Coast and Appalachia are atypical; most of the impact in those regions are from reservoirs that become economic with Next Generation CO_2 EOR



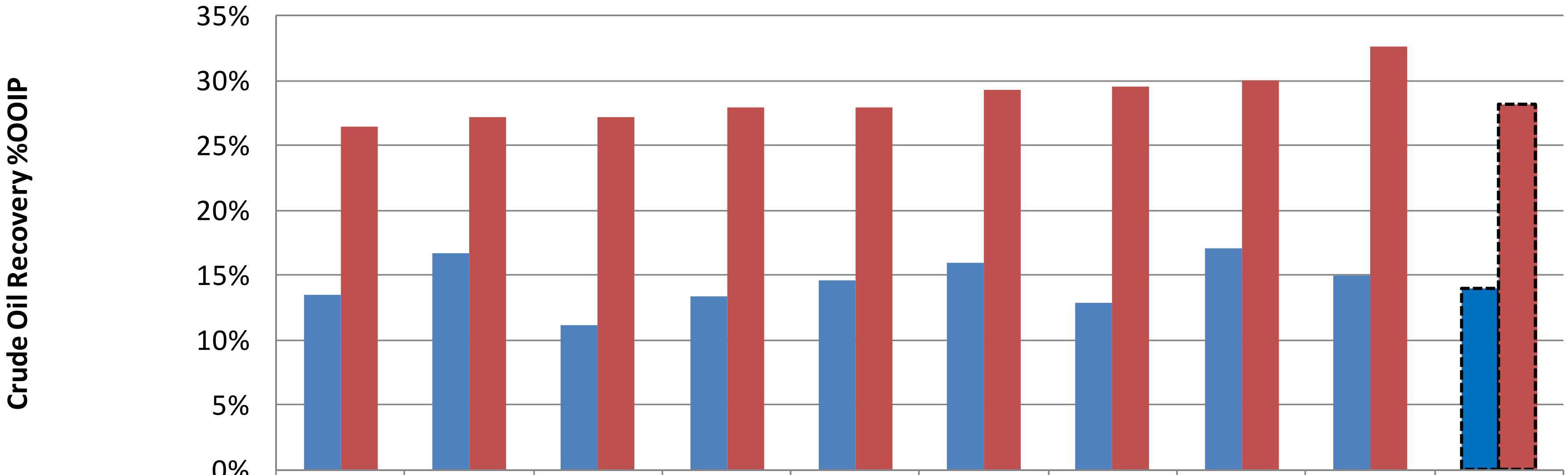
Most (80%) of the Increase in CO_2 Demand from Next Generation CO_2 EOR Technology comes from Reservoirs that are not Economic to Flood with Current Technology

Application of next generation CO_2 EOR technology results in more efficient use of CO_2. The amount of CO_2 required at a given reservoir often increases by only a small amount compared to a current technology CO_2 EOR flood. In some cases, the amount of CO_2 required is reduced.

One billion metric tons of CO_2 demand is roughly equivalent to the CO_2 captured from 5 GW of coal-fired generation with 90% CO_2 capture operating for 30 years



Resource Conservation: Next Generation CO_2 EOR Provides a Significant Shift Upward in Crude Oil Recovery



	Southeast Gulf Coast	Michigan/ Illinois Basin	East and Central Texas	Rockies	Permian Basin	Appalachia	California	Mid Continent	Williston	U.S. Average
Current Best Practices	14%	17%	11%	13%	15%	16%	13%	17%	15%	14%
Next Generation	26%	27%	27%	28%	28%	29%	30%	30%	33%	28%

Near-Miscible CO_2-EOR

- *Significant Recovery Using Near-Miscible Technology*. This study identified a resource base of nearly 30 billion barrels of oil in place in 77 fields that are viable for CO2-EOR floods using Near-Miscible technology. A total of 1.8 billion barrels is recoverable under economic conditions* using Base Case Near-Miscible technology. The Near-Miscible "Next Generation" Case (more favorable mobility ratio and increased volumes of injected CO_2) adds 760 million barrels of incremental oil to the Base Case, for a total of 2.6 billion barrels of oil economically viable oil recovery.

Technology	Technical Recovery				Economic Recovery			
	OOIP (MMBbl)	Oil Recovery (MMBbl)	RE %	# Fields	OOIP (MMBbl)	Oil Recovery (MMBbl)	RE %	# Fields
Base Case	29,491	2,531	8.6%	77	12,913	1,798	13.9%	31
Upside Case	29,491	3,402	11.5%	77	16,556	2,558	15.5%	40

* $85/bbl; $2.13/Mcf purchased CO_2

Reservoir Quality Groupings

Reservoir Category	# reservoirs	OOIP, Bbbls	Current Best Practices			Next Generation		
			Economically Recoverable Resource	Technical increment	Technically Recoverable Resource	Economically Recoverable Resource	Technical increment	Technically Recoverable Resource
Economic, current best practices	511	140.6	19.6	0.9	20.5	41.2	3.0	44.2
Economic, next generation	451	74.5	-	9.1	9.1	19.6	2.6	22.2
Economic, CBP near miscible	31	12.9	1.8	-	1.8	2.2	0.0	2.2
Economic, next generation, near misc	9	3.6	-	-	-	0.3	-	0.3
Technical	231	28.0	-	4.5	4.5	-	9.3	9.3
Technical, near miscible	37	12.9	-	0.5	0.5	-	0.8	0.8
Not amenable to CO2 EOR	554	80.4	-	-	-	-	-	-
Total	**1824**	**353**	**21.4**	**15.1**	**36.5**	**63.3**	**15.8**	**79.2**

- **40% of the OOIP in the database is economic to flood under current best practices technology.**
- **23% of the OOIP is not amenable to CO_2 EOR regardless of economics, technology**
- **Introduction of next generation technology doubles the estimated recovery from reservoirs already economic and opens up an additional 21% of the OOIP to CO_2 EOR flood.**

Closing Observations

Timely application of "next generation" CO_2-EOR technology will not come about from "business as usual".

- Pursuing "next generation" CO_2-EOR technology involves higher costs to an individual company, with limited potential for patenting or capturing the use of this technology. In addition, two of the primary benefits – improved energy security and an expanded domestic capacity for storing anthropogenic CO_2 – accrues to the public at large. The development of "next generation" CO_2-EOR technology is constrained by the classic market imperfection - - private costs and public benefits. Forty years of only modest advances in CO_2-EOR technology and its limited geographic application are the evidence for this.

While there will be R&D costs for pursuing "next generation" CO_2-EOR technology, the costs of not doing so will be several orders of magnitude larger

- Delay in the development of next generation CO_2 EOR technology will lend to lost opportunities as EOR operations designed and implemented with current technology relegate these oil fields to lower oil recoveries and reduced opportunities for storing CO_2.

Appendix A:
Reports for Miscible Next Generation CO_2 EOR from the Nine Geographic Regions

Appendix A:
Reports from the Nine Geographic Regions

The following nine sections outline of the performance of "Next Generation" Technologies vs State of the Art CO2-EOR by Region and by State.

1. Appalachia- KY, OH, PA, WV
2. California
3. East & Central Texas
4. Michigan/Illinois Basin- IL, IN, KY, MI
5. Mid Continent- AR, KS, NE, OK
6. Permian Basin- NM, TX
7. Rockies- CO, UT, WY
8. Southeast Gulf Coast- AL, LA, MS
9. Williston Basin- MT, ND, SD

Appalachia

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 56 Appalachia oil reservoirs technically favorable for miscible CO_2-EOR:

- The 56 Appalachia reservoirs have 6.1 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 1.0 billion barrels (B bbls), with remaining P/S reserves of 0.01 billion barrels (end of 2010).
- With P/S oil recovery efficiency of only 16%, a large 5.1 billion barrel target remains for CO_2-EOR.

CO_2-EOR operations in the Appalachian region have not yet begun on a large scale.

Appalachia Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 56 Appalachia oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection and a tapered WAG.

- The oil recovery and economic models showed that 16 of the 56 Appalachia oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 16 oil reservoirs is 0.3 billion, with the following performance measures:
  - Oil Recovery Efficiency: 15.9% OOIP
  - Purchased CO2/Oil Ratio: 5.9 Mcf/B
- Another 0.7 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Appalachia (All Formations) Oil Reservoirs

The application of “next generation” CO_2-EOR technologies to the 56 Appalachia oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #4 (Increased Volumes of CO_2) provides 0.4 billion barrels of additional, economically viable oil recovery (EVOR). Increasing volumes of injected CO_2 improves oil recovery efficiency (+4.0%) and also enables an additional 17 Appalachia reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design) and Technology #4 (Increased Volumes of CO_2) provide 0.8 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+11.0%) and also enables an additional 25 Appalachia reservoirs to become economic.

Application of Next Generation CO_2-EOR on Appalachia (All Formations) Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 0.9 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+12.4%) and also enables an additional 26 Appalachia reservoirs to become economic.

Combined Technologies

The combination of all four "Next Generation" Technologies provides 1.2 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+13.4%), and enables an additional 30 Appalachia reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Appalachia (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	337	16	15.9%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	345	13	17.1%	8	+1.2%
Tech #2. Advanced CO_2 Flood Design	598	33	19.7%	261	+3.8%
Tech #3. Enhanced Mobility Control	672	30	17.9%	335	+1.9%
Tech #4. Increased Volumes of Efficiently Used CO_2	778	33	20.0%	441	+4.0%

Dual Application of Next Generation CO_2-EOR on Appalachia (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	337	16	15.9%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	653	31	22.4%	316	+6.4%
Technologies #1 and #3	632	28	18.3%	295	+2.4%
Technologies #1 and #4	795	32	20.7%	458	+4.8%
Technologies #2 and #3	815	39	23.2%	478	+7.3%
Technologies #2 and #4	1,129	41	26.9%	792	+11.0%
Technologies #3 and #4	805	36	20.2%	468	+4.3%

*For reservoirs economically feasible for CO_2-EOR.

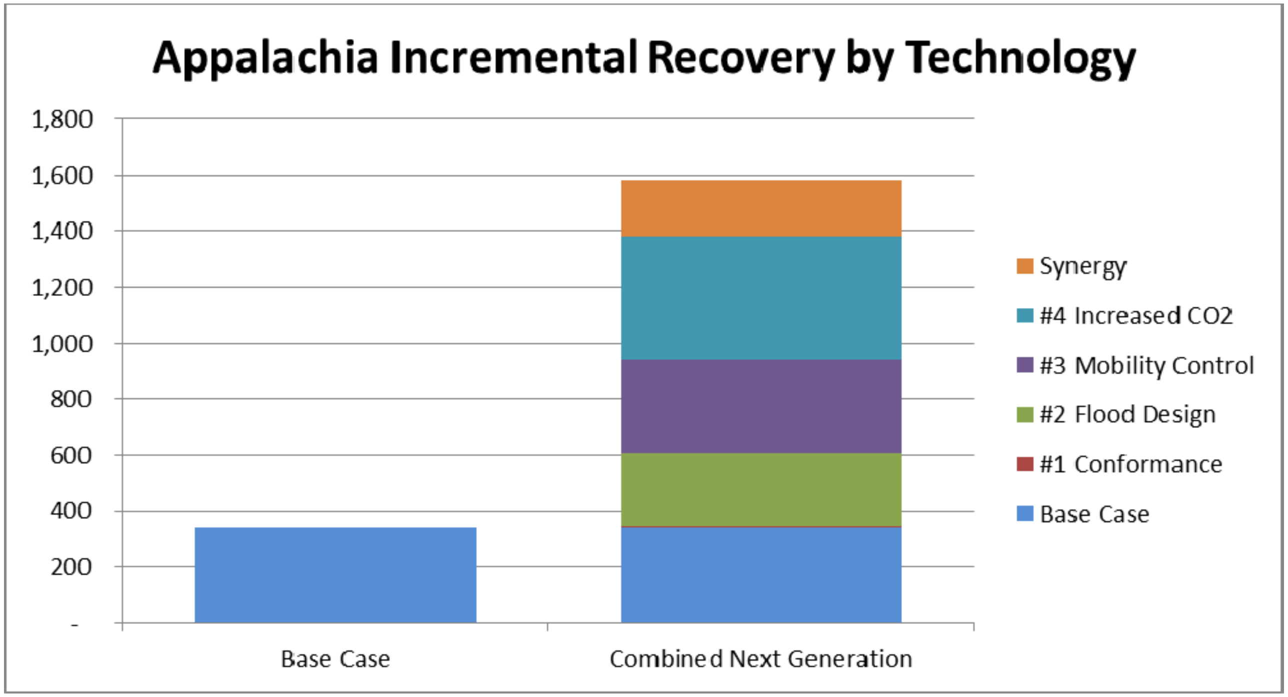
Combined Application of Three and Four Next Generation CO_2-EOR on Appalachia (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	337	16	15.9%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	875	39	24.9%	538	+9.0%
Technologies # 1, #2 and #4	1,193	42	28.3%	856	+12.4%
Technologies # 1, #3 and #4	832	36	20.8%	495	+4.8%
Technologies # 2, #3 and #4	1,474	45	28.2%	1,137	+12.3%
Technologies # 1, #2, #3 and #4	1,582	46	29.3%	1,245	+13.4%

Appalachia Next Generation Technology Case Results

Appalachia Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	1,049	6,120	17.1%	-	337	2,115	15.9%	-
Tech 1	1,187	6,120	19.4%	2.3%	345	2,015	17.1%	1.2%
Tech 2	1,593	6,120	26.0%	8.9%	598	3,034	19.7%	3.8%
Tech 3	1,078	6,120	17.6%	0.5%	672	3,762	17.9%	1.9%
Tech 4	1,290	6,120	21.1%	3.9%	778	3,894	20.0%	4.0%
Tech 1,2	1,859	6,120	30.4%	13.2%	653	2,921	22.4%	6.4%
Tech 1,3	1,323	6,120	21.6%	4.5%	632	3,454	18.3%	2.4%
Tech 1,4	1,502	6,120	24.5%	7.4%	795	3,841	20.7%	4.8%
Tech 2,3	1,579	6,120	25.8%	8.7%	815	3,511	23.2%	7.3%
Tech 2,4	1,806	6,120	29.5%	12.4%	1,129	4,193	26.9%	11.0%
Tech 3,4	1,308	6,120	21.4%	4.2%	805	3,978	20.2%	4.3%
Tech 1,2,3	1,944	6,120	31.8%	14.6%	875	3,511	24.9%	9.0%
Tech 1,2,4	2,192	6,120	35.8%	18.7%	1,193	4,215	28.3%	12.4%
Tech 1,3,4	1,526	6,120	24.9%	7.8%	832	4,007	20.8%	4.8%
Tech 2,3,4	1,861	6,120	30.4%	13.3%	1,474	5,219	28.2%	12.3%
Tech 1,2,3,4	2,260	6,120	36.9%	19.8%	1,582	5,396	29.3%	13.4%

Appalachia Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	337	337
#1 Conformance	-	8
#2 Flood Design	-	261
#3 Mobility Control	-	335
#4 Increased CO2	-	441
Synergy	-	200
Total	337	1,582

Appalachia—West Virginia Production Totals

West Virginia Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	243	2,008	12.1%	-	30	107	846	12.6%	-	10
Tech 1	270	2,008	13.5%	1.4%	30	101	767	13.2%	0.6%	8
Tech 2	478	2,008	23.8%	11.7%	30	330	1,640	20.1%	7.5%	22
Tech 3	278	2,008	13.8%	1.8%	30	198	1,442	13.7%	1.1%	17
Tech 4	341	2,008	17.0%	4.9%	30	249	1,574	15.8%	3.2%	20
Tech 1,2	582	2,008	29.0%	16.9%	30	326	1,527	21.3%	8.7%	20
Tech 1,3	336	2,008	16.7%	4.6%	30	206	1,353	15.2%	2.6%	16
Tech 1,4	404	2,008	20.1%	8.0%	30	258	1,521	17.0%	4.3%	19
Tech 2,3	472	2,008	23.5%	11.4%	30	393	1,806	21.8%	9.1%	26
Tech 2,4	546	2,008	27.2%	15.1%	30	448	1,806	24.8%	12.1%	26
Tech 3,4	348	2,008	17.3%	5.3%	30	265	1,639	16.2%	3.5%	22
Tech 1,2,3	574	2,008	28.6%	16.5%	30	442	1,806	24.5%	11.8%	26
Tech 1,2,4	662	2,008	33.0%	20.9%	30	499	1,828	27.3%	14.7%	27
Tech 1,3,4	413	2,008	20.6%	8.5%	30	282	1,633	17.3%	4.6%	22
Tech 2,3,4	564	2,008	28.1%	16.0%	30	496	1,966	25.2%	12.6%	29
Tech 1,2,3,4	683	2,008	34.0%	21.9%	30	559	1,966	28.4%	15.8%	29

Appalachia—Pennsylvania Production Totals

Pennsylvania Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	203	1,257	16.1%	-	8	184	1,077	17.1%	-	4
Tech 1	250	1,257	19.9%	3.8%	8	183	1,056	17.3%	0.3%	3
Tech 2	281	1,257	22.3%	6.2%	8	224	1,237	18.1%	1.1%	7
Tech 3	204	1,257	16.2%	0.1%	8	192	1,182	16.2%	-0.8%	6
Tech 4	241	1,257	19.2%	3.0%	8	216	1,182	18.3%	1.3%	6
Tech 1,2	351	1,257	27.9%	11.8%	8	277	1,237	22.4%	5.4%	7
Tech 1,3	255	1,257	20.3%	4.1%	8	197	1,182	16.7%	-0.4%	6
Tech 1,4	300	1,257	23.9%	7.7%	8	223	1,182	18.8%	1.8%	6
Tech 2,3	287	1,257	22.8%	6.7%	8	281	1,237	22.7%	5.7%	7
Tech 2,4	318	1,257	25.3%	9.2%	8	295	1,237	23.8%	6.8%	7
Tech 3,4	244	1,257	19.4%	3.3%	8	227	1,202	18.9%	1.9%	7
Tech 1,2,3	359	1,257	28.6%	12.4%	8	288	1,237	23.3%	6.3%	7
Tech 1,2,4	396	1,257	31.5%	15.4%	8	304	1,237	24.6%	7.5%	7
Tech 1,3,4	303	1,257	24.1%	8.0%	8	236	1,237	19.0%	2.0%	7
Tech 2,3,4	334	1,257	26.6%	10.4%	8	316	1,237	25.5%	8.5%	7
Tech 1,2,3,4	416	1,257	33.1%	17.0%	8	323	1,237	26.1%	9.1%	7

Appalachia—Ohio Production Totals

Ohio Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	600	2,814	21.3%	-	16	47	192	24.3%	-	2
Tech 1	663	2,814	23.6%	2.2%	16	61	192	31.7%	7.4%	2
Tech 2	826	2,814	29.4%	8.1%	16	42	145	29.1%	4.9%	3
Tech 3	592	2,814	21.0%	-0.3%	16	282	1,138	24.8%	0.5%	7
Tech 4	704	2,814	25.0%	3.7%	16	313	1,138	27.5%	3.2%	7
Tech 1,2	916	2,814	32.5%	11.2%	16	48	145	33.4%	9.1%	3
Tech 1,3	729	2,814	25.9%	4.6%	16	229	920	24.9%	0.6%	6
Tech 1,4	793	2,814	28.2%	6.9%	16	314	1,138	27.6%	3.3%	7
Tech 2,3	812	2,814	28.8%	7.5%	16	140	456	30.6%	6.4%	5
Tech 2,4	932	2,814	33.1%	11.8%	16	385	1,138	33.9%	9.6%	7
Tech 3,4	709	2,814	25.2%	3.9%	16	313	1,138	27.5%	3.2%	7
Tech 1,2,3	1,000	2,814	35.5%	14.2%	16	142	456	31.2%	6.9%	5
Tech 1,2,4	1,121	2,814	39.8%	18.5%	16	387	1,138	34.0%	9.8%	7
Tech 1,3,4	799	2,814	28.4%	7.1%	16	314	1,138	27.6%	3.3%	7
Tech 2,3,4	953	2,814	33.9%	12.5%	16	661	2,004	33.0%	8.7%	8
Tech 1,2,3,4	1,147	2,814	40.8%	19.4%	16	697	2,181	32.0%	7.7%	9

Appalachia—Kentucky Production Totals

Kentucky Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	4	41	9.2%	-	2	-	-	0.0%	-	-
Tech 1	4	41	9.2%	0.0%	2	-	-	0.0%	0.0%	-
Tech 2	9	41	20.9%	11.7%	2	2	12	13.5%	13.5%	1
Tech 3	4	41	9.2%	0.0%	2	-	-	0.0%	0.0%	-
Tech 4	4	41	10.1%	0.9%	2	-	-	0.0%	0.0%	-
Tech 1,2	11	41	26.1%	16.9%	2	2	12	13.5%	13.5%	1
Tech 1,3	4	41	9.2%	0.0%	2	-	-	0.0%	0.0%	-
Tech 1,4	4	41	10.1%	0.9%	2	-	-	0.0%	0.0%	-
Tech 2,3	9	41	21.2%	12.1%	2	2	12	14.3%	14.3%	1
Tech 2,4	10	41	25.0%	15.8%	2	2	12	14.8%	14.8%	1
Tech 3,4	8	41	19.1%	9.9%	2	-	-	0.0%	0.0%	-
Tech 1,2,3	11	41	26.5%	17.4%	2	3	12	20.2%	20.2%	1
Tech 1,2,4	13	41	31.2%	22.1%	2	3	12	20.6%	20.6%	1
Tech 1,3,4	10	41	23.8%	14.7%	2	-	-	0.0%	0.0%	-
Tech 2,3,4	11	41	26.5%	17.4%	2	2	12	15.6%	15.6%	1
Tech 1,2,3,4	14	41	33.1%	24.0%	2	3	12	22.9%	22.9%	1

California

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 77 California oil reservoirs technically favorable for miscible CO_2-EOR:

- The 77 California reservoirs have 24.3 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 7.2 billion barrels (B bbls), with remaining P/S reserves of 0.2 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 30.5%, a large 16.8 billion barrel target remains for CO_2-EOR.

CO_2-EOR operations in California have not yet begun on a large scale.

California Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 77 California oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with “State of Art” (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection and a tapered WAG.

- The oil recovery and economic models showed that 46 of the 77 California oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 46 oil reservoirs is 2.3 billion, with the following performance measures:
  - Oil Recovery Efficiency: 12.9% OOIP
  - Purchased CO2/Oil Ratio: 11.3 Mcf/B
- An additional 0.9 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on California (All Formations) Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 77 California oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #2 (Advanced CO_2 Flood Design) provides 1.4 billion barrels of additional, economically viable oil recovery (EVOR). Improving contact with unswept oil zones improves oil recovery efficiency (+4.9%) and also enables an additional 14 California reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 2.3 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+9.2%) and also enables an additional 18 California reservoirs to become economic.

Application of Next Generation CO_2-EOR on California (All Formations) Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 3.8 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+13.2%) and also enables an additional 23 California reservoirs to become economic.

Combined Technologies

The combination of all four "Next Generation" Technologies provides 4.7 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+16.7%), and enables an additional 24 California reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on California (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	2,347	46	12.9%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	3,452	54	16.6%	1,105	+3.7%
Tech #2. Advanced CO_2 Flood Design	3,709	60	17.8%	1,362	+4.9%
Tech #3. Enhanced Mobility Control	3,248	63	14.5%	901	+1.6%
Tech #4. Increased Volumes of Efficiently Used CO_2	3,544	62	15.8%	1,197	+2.9%

Dual Application of Next Generation CO_2-EOR on California (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	2,347	46	12.9%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	4,667	64	22.1%	2,320	+9.2%
Technologies #1 and #3	4,025	64	18.0%	1,678	+5.1%
Technologies #1 and #4	4,436	64	19.8%	2,089	+6.9%
Technologies #2 and #3	4,884	70	20.5%	2,537	+7.6%
Technologies #2 and #4	4,814	69	20.8%	2,467	+7.9%
Technologies #3 and #4	3,683	63	16.4%	1,336	+3.5%

*For reservoirs economically feasible for CO2-EOR.

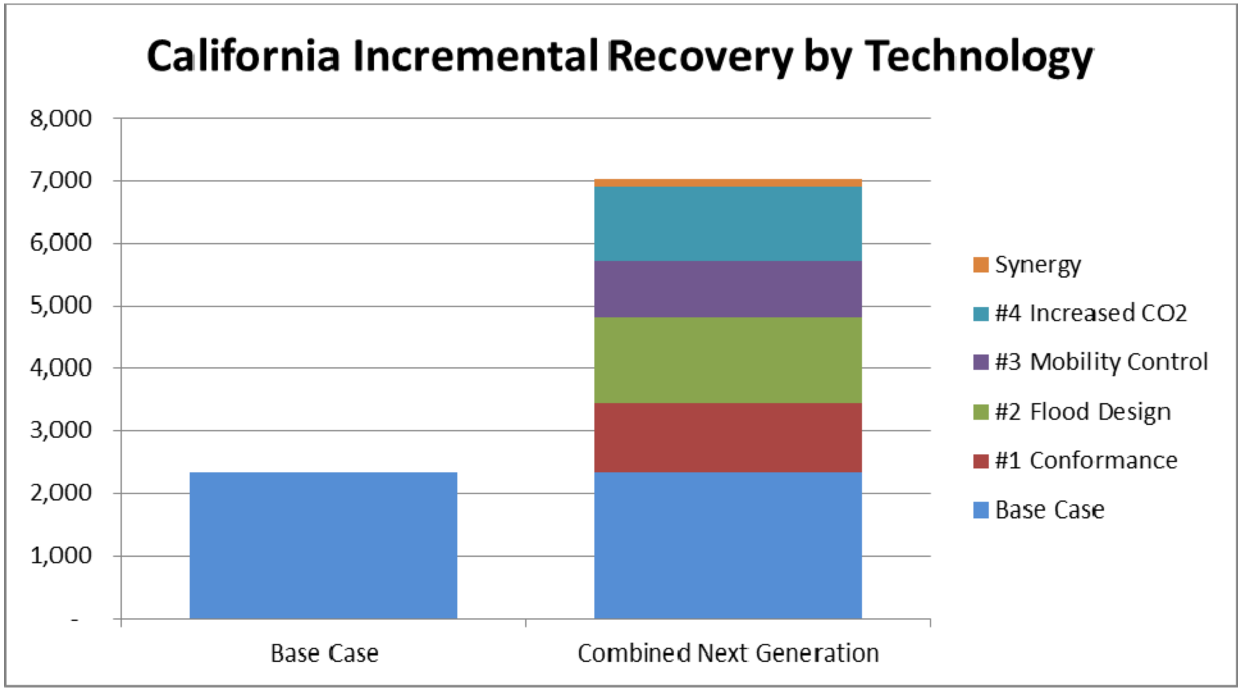
Combined Application of Three and Four Next Generation CO_2-EOR on California (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	2,347	46	12.9%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	6,147	70	25.9%	3,800	+13.0%
Technologies # 1, #2 and #4	6,034	69	26.1%	3,687	+13.2%
Technologies # 1, #3 and #4	4,795	65	21.4%	2,448	+8.5%
Technologies # 2, #3 and #4	5,533	70	23.3%	3,186	+10.4%
Technologies # 1, #2, #3 and #4	7,029	70	29.6%	4,682	+16.7%

California Next Generation Technology Case Results

California Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	3,285	24,268	13.5%	-	2,347	18,203	12.9%	-
Tech 1	4,100	24,268	16.9%	3.4%	3,452	20,797	16.6%	3.7%
Tech 2	4,445	24,268	18.3%	4.8%	3,709	20,875	17.8%	4.9%
Tech 3	3,522	24,268	14.5%	1.0%	3,248	22,400	14.5%	1.6%
Tech 4	4,006	24,268	16.5%	3.0%	3,544	22,375	15.8%	2.9%
Tech 1,2	5,546	24,268	22.9%	9.3%	4,667	21,123	22.1%	9.2%
Tech 1,3	4,394	24,268	18.1%	4.6%	4,025	22,412	18.0%	5.1%
Tech 1,4	4,941	24,268	20.4%	6.8%	4,436	22,412	19.8%	6.9%
Tech 2,3	5,066	24,268	20.9%	7.3%	4,884	23,777	20.5%	7.6%
Tech 2,4	5,212	24,268	21.5%	7.9%	4,814	23,152	20.8%	7.9%
Tech 3,4	4,266	24,268	17.6%	4.0%	3,683	22,400	16.4%	3.5%
Tech 1,2,3	6,324	24,268	26.1%	12.5%	6,147	23,777	25.9%	13.0%
Tech 1,2,4	6,431	24,268	26.5%	13.0%	6,034	23,152	26.1%	13.2%
Tech 1,3,4	5,266	24,268	21.7%	8.2%	4,795	22,444	21.4%	8.5%
Tech 2,3,4	5,944	24,268	24.5%	11.0%	5,533	23,777	23.3%	10.4%
Tech 1,2,3,4	7,338	24,268	30.2%	16.7%	7,029	23,777	29.6%	16.7%

California Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	2,347	2,347
#1 Conformance	-	1,105
#2 Flood Design	-	1,362
#3 Mobility Control	-	901
#4 Increased CO2	-	1,197
Synergy	-	117
Total	2,347	7,029

East & Central Texas

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 165 East & Central Texas oil reservoirs technically favorable for miscible CO_2-EOR:

- The 165 reservoirs have 51.7 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 18.5 billion barrels (B bbls), with remaining P/S reserves of 0.3 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 36.4%, a large 33.2 billion barrel target remains for CO_2-EOR.

Several large CO_2-EOR projects are operating in East & Central Texas.

East & Central Texas Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 165 East & Central Texas oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection and a tapered WAG.

- The oil recovery and economic models showed that 87 of the 165 East & Central Texas oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 87 oil reservoirs is 3.5 billion, with the following performance measures:
  - Oil Recovery Efficiency: 11.1% OOIP
  - Purchased CO2/Oil Ratio: 8.8 Mcf/B
- An additional 2.0 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on East & Central Texas (All Formations) Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 165 East & Central Texas oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #2 (Advanced CO_2 Flood Design) provides 2.6 billion barrels of additional, economically viable oil recovery (EVOR). Improving contact with unswept oil zones improves oil recovery efficiency (+5.6%) and also enables an additional 40 reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 5.1 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+7.7%) and also enables an additional 54 East & Central Texas reservoirs to become economic.

Application of Next Generation CO_2-EOR on East & Central Texas (All Formations) Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 6.7 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+12.0%) and also enables an additional 51 East & Central Texas reservoirs to become economic.

Combined Technologies

The combination of all four “Next Generation” Technologies provides 9.0 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+16.0%), and enables an additional 56 East & Central Texas reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on East & Central Texas (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	3,536	87	11.2%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	4,275	96	13.3%	739	+2.1%
Tech #2. Advanced CO_2 Flood Design	6,150	127	16.7%	2,614	+5.6%
Tech #3. Enhanced Mobility Control	5,115	121	11.7%	1,579	+0.6%
Tech #4. Increased Volumes of Efficiently Used CO_2	5,059	110	14.2%	1,523	+3.0%

Dual Application of Next Generation CO_2-EOR on East & Central Texas (All Formations) Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	3,536	87	11.2%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	7,286	128	19.8%	3,750	+8.6%
Technologies #1 and #3	5,869	130	13.3%	2,333	+2.1%
Technologies #1 and #4	6,140	118	16.4%	2,604	+5.3%
Technologies #2 and #3	8,596	141	18.8%	5,060	+7.7%
Technologies #2 and #4	8,423	138	19.0%	4,887	+7.9%
Technologies #3 and #4	6,592	126	14.9%	3,056	+3.7%

*For reservoirs economically feasible for CO2-EOR.

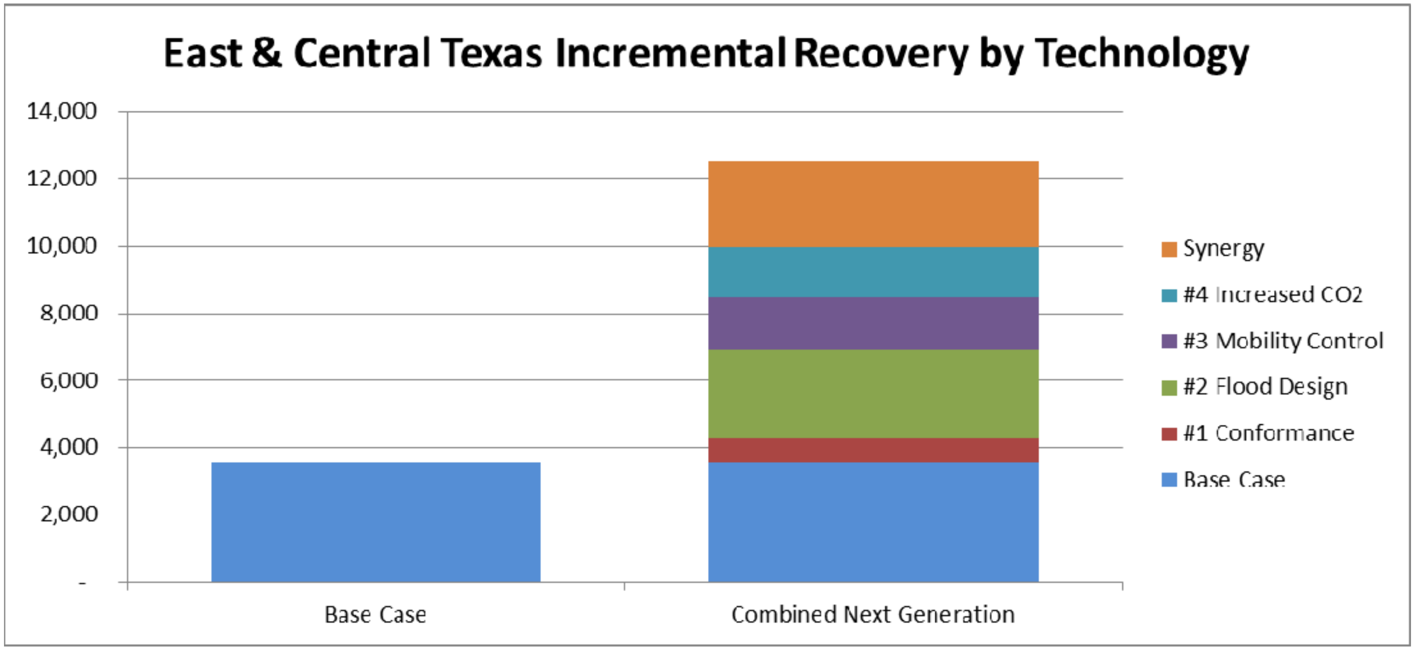
Combined Application of Three and Four Next Generation CO_2-EOR on East & Central Texas Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	3,536	87	11.2%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	10,065	141	22.1%	6,529	+10.9%
Technologies # 1, #2 and #4	10,235	138	23.1%	6,699	+12.0%
Technologies # 1, #3 and #4	8,547	132	19.0%	5,011	+7.8%
Technologies # 2, #3 and #4	10,019	143	21.7%	6,483	+10.6%
Technologies # 1, #2, #3 and #4	12,539	143	27.2%	9,003	+16.0%

East & Central Texas Next Generation Technology Case Results

East & Central Texas Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	5,775	51,697	11.2%	-	3,536	31,684	11.2%	-
Tech 1	6,880	51,697	13.3%	2.1%	4,275	32,229	13.3%	2.1%
Tech 2	9,315	51,697	18.0%	6.8%	6,150	36,768	16.7%	5.6%
Tech 3	6,440	51,697	12.5%	1.3%	5,115	43,581	11.7%	0.6%
Tech 4	7,757	51,697	15.0%	3.8%	5,059	35,745	14.2%	3.0%
Tech 1,2	11,293	51,697	21.8%	10.7%	7,286	36,868	19.8%	8.6%
Tech 1,3	7,696	51,697	14.9%	3.7%	5,869	44,197	13.3%	2.1%
Tech 1,4	9,264	51,697	17.9%	6.7%	6,140	37,337	16.4%	5.3%
Tech 2,3	10,142	51,697	19.6%	8.4%	8,596	45,609	18.8%	7.7%
Tech 2,4	11,143	51,697	21.6%	10.4%	8,423	44,266	19.0%	7.9%
Tech 3,4	8,620	51,697	16.7%	5.5%	6,592	44,293	14.9%	3.7%
Tech 1,2,3	12,462	51,697	24.1%	12.9%	10,065	45,609	22.1%	10.9%
Tech 1,2,4	13,640	51,697	26.4%	15.2%	10,235	44,266	23.1%	12.0%
Tech 1,3,4	10,483	51,697	20.3%	9.1%	8,547	45,054	19.0%	7.8%
Tech 2,3,4	12,351	51,697	23.9%	12.7%	10,019	46,100	21.7%	10.6%
Tech 1,2,3,4	15,131	51,697	29.3%	18.1%	12,539	46,100	27.2%	16.0%

East & Central Texas Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	3,536	3,536
#1 Conformance	-	739
#2 Flood Design	-	2,614
#3 Mobility Control	-	1,579
#4 Increased CO2	-	1,523
Synergy	-	2,548
Total	3,536	12,539

Michigan/Illinois Basin

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 117 East & Central Texas oil reservoirs technically favorable for miscible CO_2-EOR:

- The 117 reservoirs have 6.1 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 2.3 billion barrels (B bbls), with remaining P/S reserves of 0.01 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 38.8%, a 3.8 billion barrel target remains for CO_2-EOR.

Several large CO_2-EOR pilot projects have been conducted in the Silurian Reef formations in the Michigan/Illinois Basin.

Michigan/Illinois Basin Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 117 East & Central Texas oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection and a tapered WAG, and a production delay of two years to allow for reservoir repressurization.

- The oil recovery and economic models showed that 55 of the 117 Michigan/Illinois Basin oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 55 oil reservoirs is 0.7 billion, with the following performance measures:
  - Oil Recovery Efficiency: 16.7% OOIP
  - Purchased CO2/Oil Ratio: 7.6 Mcf/B
- An additional total of 0.4 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Michigan/Illinois Basin Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 117 Michigan/Illinois Basin oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #2 (Advanced CO_2 Flood Design) provides 0.3 billion barrels of additional, economically viable oil recovery (EVOR). Improving contact with unswept oil zones improves oil recovery efficiency (+3.0%) and also enables an additional 38 reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 0.6 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+6.8%) and also enables an additional 43 Michigan/Illinois Basin reservoirs to become economic.

Application of Next Generation CO_2-EOR on Michigan/Illinois Basin Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 0.7 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+9.6%) and also enables an additional 45 Michigan/Illinois Basin reservoirs to become economic.

Combined Technologies

The combination of all four “Next Generation” Technologies provides 0.8 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+10.4%), and enables an additional 48 Michigan/Illinois Basin reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Michigan/Illinois Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	666	55	16.7%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	778	61	19.3%	112	+2.5%
Tech #2. Advanced CO_2 Flood Design	1,006	93	19.8%	340	+3.0%
Tech #3. Enhanced Mobility Control	783	69	17.1%	117	+0.3%
Tech #4. Increased Volumes of Efficiently Used CO_2	927	71	19.9%	261	+3.1%

Dual Application of Next Generation CO_2-EOR on Michigan/Illinois Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	666	55	16.7%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	1,193	93	23.5%	527	+6.7%
Technologies #1 and #3	983	79	20.2%	317	+3.5%
Technologies #1 and #4	1,073	78	22.3%	407	+5.5%
Technologies #2 and #3	1,076	98	20.8%	410	+4.0%
Technologies #2 and #4	1,219	98	23.5%	553	+6.8%
Technologies #3 and #4	977	77	20.3%	311	+3.6%

*For reservoirs economically feasible for CO2-EOR.

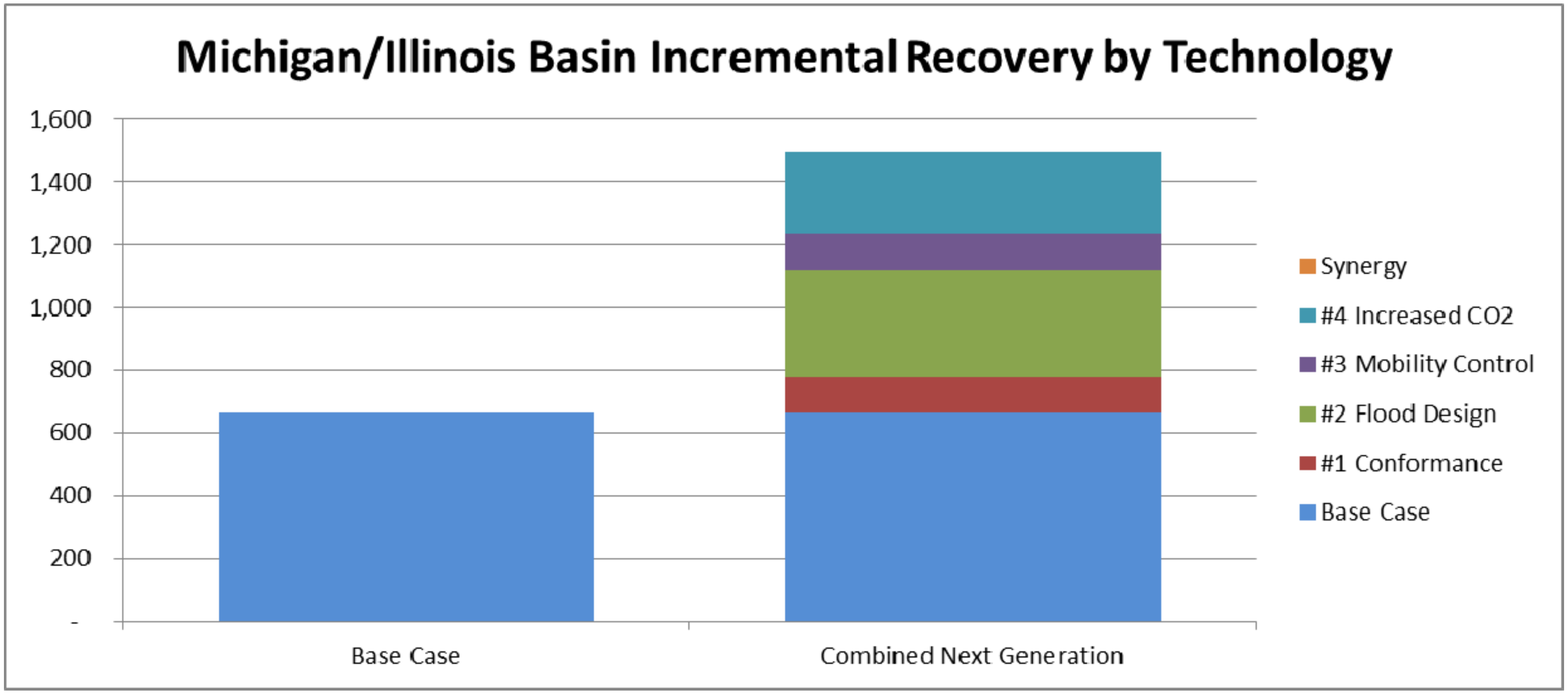
Combined Application of Three and Four Next Generation CO_2-EOR on Michigan/Illinois Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	666	55	16.7%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	1,284	101	24.6%	618	+7.8%
Technologies # 1, #2 and #4	1,372	100	26.3%	706	+9.6%
Technologies # 1, #3 and #4	1,086	81	22.1%	420	+5.4%
Technologies # 2, #3 and #4	1,304	103	24.7%	638	+8.0%
Technologies # 1, #2, #3 and #4	1,435	103	27.2%	769	+10.4%

Michigan/Illinois Basin Next Generation Technology Case Results

Region 1 Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	1,013	6,134	16.5%	-	666	3,977	16.7%	-
Tech 1	1,257	6,134	20.5%	4.0%	778	4,033	19.3%	2.5%
Tech 2	1,288	6,134	21.0%	4.5%	1,006	5,082	19.8%	3.0%
Tech 3	1,032	6,134	16.8%	0.3%	783	4,589	17.1%	0.3%
Tech 4	1,217	6,134	19.8%	3.3%	927	4,662	19.9%	3.1%
Tech 1,2	1,604	6,134	26.1%	9.6%	1,193	5,082	23.5%	6.7%
Tech 1,3	1,276	6,134	20.8%	4.3%	983	4,867	20.2%	3.5%
Tech 1,4	1,486	6,134	24.2%	7.7%	1,073	4,818	22.3%	5.5%
Tech 2,3	1,298	6,134	21.2%	4.6%	1,076	5,183	20.8%	4.0%
Tech 2,4	1,480	6,134	24.1%	7.6%	1,219	5,183	23.5%	6.8%
Tech 3,4	1,229	6,134	20.0%	3.5%	977	4,806	20.3%	3.6%
Tech 1,2,3	1,607	6,134	26.2%	9.7%	1,284	5,221	24.6%	7.8%
Tech 1,2,4	1,844	6,134	30.1%	13.5%	1,372	5,211	26.3%	9.6%
Tech 1,3,4	1,440	6,134	23.5%	7.0%	1,086	4,906	22.1%	5.4%
Tech 2,3,4	1,535	6,134	25.0%	8.5%	1,304	5,278	24.7%	8.0%
Tech 1,2,3,4	1,917	6,134	31.3%	14.7%	1,435	5,278	27.2%	10.4%

Michigan/Illinois Basin Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	666	666
#1 Conformance	-	112
#2 Flood Design	-	340
#3 Mobility Control	-	117
#4 Increased CO2	-	261
Synergy	-	-
Total	666	*1,435

*The combination of four Next Generation technologies includes an overlapping benefit of 61 million barrels compared to the sum of the individual technologies.

Michigan/Illinois Basin—Illinois Production Totals

Illinois Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	661	4,084	16.2%	-	66	482	3,046	15.8%	-	30
Tech 1	820	4,084	20.1%	3.9%	66	531	2,950	18.0%	2.2%	31
Tech 2	841	4,084	20.6%	4.4%	66	753	3,933	19.2%	3.3%	60
Tech 3	672	4,084	16.5%	0.3%	66	590	3,595	16.4%	0.6%	42
Tech 4	790	4,084	19.3%	3.2%	66	694	3,618	19.2%	3.3%	43
Tech 1,2	1,051	4,084	25.7%	9.6%	66	885	3,933	22.5%	6.7%	60
Tech 1,3	830	4,084	20.3%	4.2%	66	731	3,723	19.6%	3.8%	47
Tech 1,4	957	4,084	23.4%	7.3%	66	786	3,690	21.3%	5.5%	47
Tech 2,3	848	4,084	20.8%	4.6%	66	819	4,021	20.4%	4.5%	64
Tech 2,4	963	4,084	23.6%	7.4%	66	927	4,021	23.0%	7.2%	64
Tech 3,4	794	4,084	19.5%	3.3%	66	735	3,728	19.7%	3.9%	47
Tech 1,2,3	1,049	4,084	25.7%	9.5%	66	974	4,037	24.1%	8.3%	65
Tech 1,2,4	1,200	4,084	29.4%	13.2%	66	1,027	4,037	25.4%	9.6%	65
Tech 1,3,4	907	4,084	22.2%	6.0%	66	794	3,767	21.1%	5.2%	49
Tech 2,3,4	1,000	4,084	24.5%	8.3%	66	984	4,037	24.4%	8.5%	65
Tech 1,2,3,4	1,250	4,084	30.6%	14.4%	66	1,064	4,037	26.4%	10.5%	65

Michigan/Illinois Basin—Indiana Production Totals

Indiana Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	77	388	19.8%	-	15	77	388	19.8%	-	15
Tech 1	96	388	24.7%	4.9%	15	92	388	23.7%	3.9%	15
Tech 2	91	388	23.4%	3.6%	15	91	388	23.4%	3.6%	15
Tech 3	77	388	19.7%	0.0%	15	77	388	19.7%	0.0%	15
Tech 4	89	388	22.9%	3.1%	15	89	388	22.9%	3.1%	15
Tech 1,2	113	388	29.2%	9.4%	15	109	388	28.0%	8.2%	15
Tech 1,3	96	388	24.7%	4.9%	15	87	388	22.4%	2.6%	15
Tech 1,4	111	388	28.6%	8.8%	15	99	388	25.5%	5.7%	15
Tech 2,3	92	388	23.8%	4.0%	15	92	388	23.8%	4.0%	15
Tech 2,4	104	388	26.7%	6.9%	15	103	388	26.7%	6.9%	15
Tech 3,4	90	388	23.2%	3.4%	15	90	388	23.1%	3.3%	15
Tech 1,2,3	115	388	29.7%	9.9%	15	105	388	27.0%	7.3%	15
Tech 1,2,4	129	388	33.3%	13.6%	15	115	388	29.7%	9.9%	15
Tech 1,3,4	112	388	28.9%	9.2%	15	100	388	25.8%	6.0%	15
Tech 2,3,4	107	388	27.6%	7.8%	15	107	388	27.5%	7.7%	15
Tech 1,2,3,4	134	388	34.5%	14.7%	15	119	388	30.7%	10.9%	15

Michigan/Illinois Basin—Kentucky Production To

Kentucky Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	55	385	14.4%	-	18	27	142	18.8%	-	7
Tech 1	68	385	17.7%	3.3%	18	50	257	19.4%	0.6%	11
Tech 2	79	385	20.6%	6.3%	18	61	293	20.9%	2.1%	13
Tech 3	58	385	15.1%	0.8%	18	30	160	18.5%	-0.4%	8
Tech 4	67	385	17.4%	3.0%	18	34	173	19.4%	0.6%	8
Tech 1,2	93	385	24.2%	9.9%	18	74	293	25.3%	6.5%	13
Tech 1,3	72	385	18.8%	4.4%	18	55	273	20.0%	1.2%	12
Tech 1,4	78	385	20.3%	5.9%	18	57	257	22.0%	3.2%	11
Tech 2,3	80	385	20.9%	6.5%	18	65	306	21.2%	2.4%	14
Tech 2,4	90	385	23.3%	8.9%	18	71	306	23.1%	4.2%	14
Tech 3,4	68	385	17.7%	3.3%	18	41	208	19.9%	1.0%	10
Tech 1,2,3	100	385	25.9%	11.6%	18	85	329	25.8%	6.9%	16
Tech 1,2,4	110	385	28.5%	14.1%	18	87	318	27.5%	8.6%	15
Tech 1,3,4	81	385	21.0%	6.6%	18	59	268	22.1%	3.3%	12
Tech 2,3,4	92	385	23.8%	9.5%	18	82	340	24.2%	5.4%	17
Tech 1,2,3,4	112	385	29.2%	14.8%	18	95	340	28.0%	9.2%	17

Michigan/Illinois Basin—Michigan Production Totals

Michigan Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	221	1,277	17.3%	-	18	80	401	19.8%	-	3
Tech 1	273	1,277	21.4%	4.1%	18	105	437	24.1%	4.3%	4
Tech 2	277	1,277	21.7%	4.5%	18	100	467	21.4%	1.6%	5
Tech 3	225	1,277	17.6%	0.3%	18	87	446	19.6%	-0.2%	4
Tech 4	271	1,277	21.3%	4.0%	18	110	482	22.9%	3.0%	5
Tech 1,2	347	1,277	27.2%	9.9%	18	125	467	26.8%	7.0%	5
Tech 1,3	278	1,277	21.7%	4.5%	18	110	482	22.8%	3.0%	5
Tech 1,4	339	1,277	26.6%	9.3%	18	131	482	27.2%	7.3%	5
Tech 2,3	278	1,277	21.7%	4.5%	18	99	467	21.2%	1.4%	5
Tech 2,4	324	1,277	25.4%	8.1%	18	118	467	25.2%	5.4%	5
Tech 3,4	277	1,277	21.7%	4.4%	18	111	482	23.1%	3.2%	5
Tech 1,2,3	342	1,277	26.8%	9.6%	18	120	467	25.6%	5.8%	5
Tech 1,2,4	405	1,277	31.7%	14.4%	18	142	467	30.4%	10.6%	5
Tech 1,3,4	340	1,277	26.7%	9.4%	18	133	482	27.5%	7.6%	5
Tech 2,3,4	336	1,277	26.3%	9.0%	18	132	513	25.7%	5.8%	6
Tech 1,2,3,4	420	1,277	32.9%	15.6%	18	156	513	30.5%	10.7%	6

Mid Continent

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 147 Mid Continent oil reservoirs technically favorable for miscible CO_2-EOR:

- The 147 reservoirs have 37.0 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 9.8 billion barrels (B bbls), with remaining P/S reserves of 0.3 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 27.2%, a large 26.9 billion barrel target remains for CO_2-EOR.

A number of mature CO_2-EOR projects have been underway in the Mid Continent.

Mid Continent Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 147 Mid Continent oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection, a tapered WAG, and a production delay of two years to allow for reservoir repressurization.

- The oil recovery and economic models showed that 83 of the 147 Mid Continent oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 83 oil reservoirs is 4.1 billion, with the following performance measures:
  - Oil Recovery Efficiency: 17.2% OOIP
  - Purchased CO2/Oil Ratio: 7.5 Mcf/B
- An additional total of 2.0 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Mid Continent Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 147 Mid Continent oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #2 (Advanced CO_2 Flood Design) provides 2.0 billion barrels of additional, economically viable oil recovery (EVOR). Improving contact with unswept oil zones improves oil recovery efficiency (+4.1%) and also enables an additional 19 reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 3.5 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+7.3%) and also enables an additional 27 Mid Continent reservoirs to become economic.

Application of Next Generation CO_2-EOR on Mid Continent Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 4.9 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+11.3%) and also enables an additional 29 Mid Continent reservoirs to become economic.

Combined Technologies

The combination of all four "Next Generation" Technologies provides 5.6 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+12.9%), and enables an additional 32 Mid Continent reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Mid Continent Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	4,091	83	17.1%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	4,691	87	19.4%	600	+2.3%
Tech #2. Advanced CO_2 Flood Design	6,074	102	21.2%	1,983	+4.1%
Tech #3. Enhanced Mobility Control	5,110	98	17.6%	1,019	+0.5%
Tech #4. Increased Volumes of Efficiently Used CO_2	5,497	94	20.6%	1,406	+3.5%

Dual Application of Next Generation CO_2-EOR on Mid Continent Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	4,091	83	17.1%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	7,204	103	25.1%	3,113	+8.0%
Technologies #1 and #3	6,299	109	19.9%	2,208	+2.8%
Technologies #1 and #4	6,704	103	22.0%	2,613	+4.9%
Technologies #2 and #3	7,105	111	22.9%	3,014	+5.8%
Technologies #2 and #4	7,578	110	24.4%	3,487	+7.3%
Technologies #3 and #4	6,198	105	20.7%	2,107	+3.6%

*For reservoirs economically feasible for CO2-EOR.

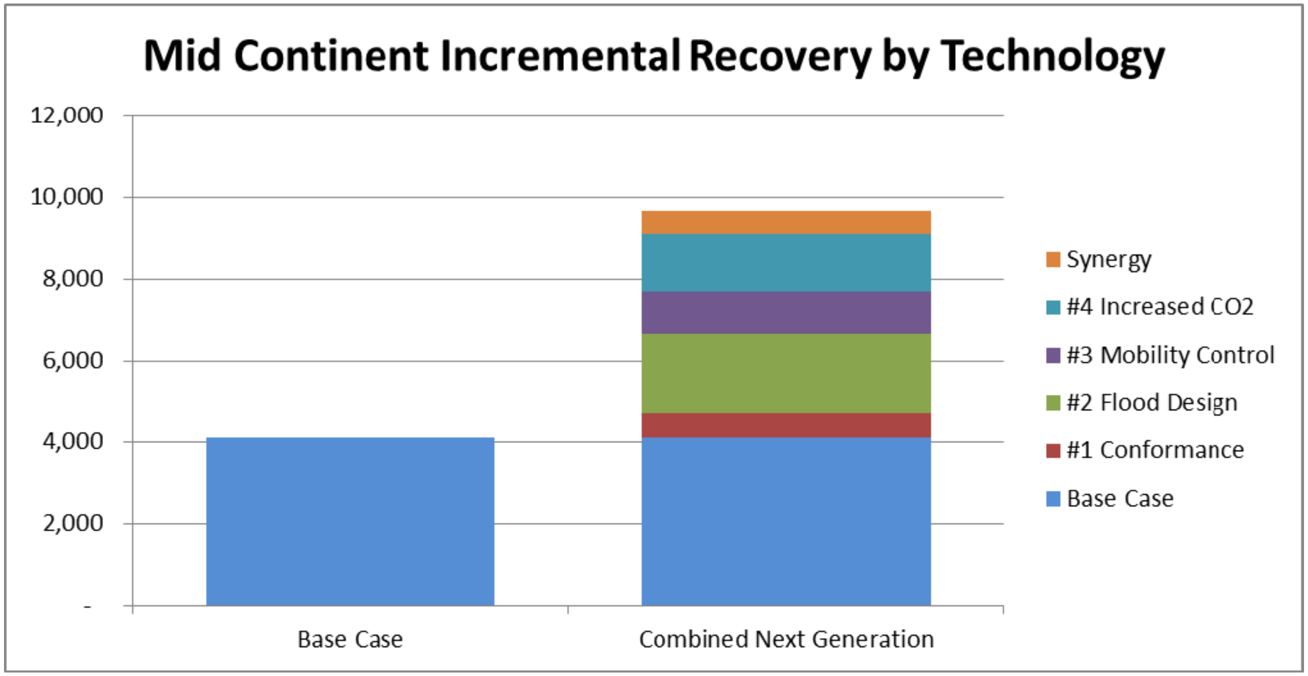
Combined Application of Three and Four Next Generation CO_2-EOR on Mid Continent Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	4,091	83	17.1%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	8,401	112	26.6%	4,310	+9.5%
Technologies # 1, #2 and #4	8,975	112	28.4%	4,884	+11.3%
Technologies # 1, #3 and #4	7,448	111	23.1%	3,357	+6.0%
Technologies # 2, #3 and #4	8,617	115	26.7%	4,526	+9.6%
Technologies # 1, #2, #3 and #4	9,689	115	30.0%	5,598	+12.9%

Mid Continent Next Generation Technology Case Results

Mid Continent Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	6,061	37,015	16.4%	-	4,091	23,924	17.1%	-
Tech 1	7,371	37,015	19.9%	3.5%	4,691	24,209	19.4%	2.3%
Tech 2	8,091	37,015	21.9%	5.5%	6,074	28,626	21.2%	4.1%
Tech 3	6,320	37,015	17.1%	0.7%	5,110	28,961	17.6%	0.5%
Tech 4	7,398	37,015	20.0%	3.6%	5,497	26,730	20.6%	3.5%
Tech 1,2	10,046	37,015	27.1%	10.8%	7,204	28,678	25.1%	8.0%
Tech 1,3	7,753	37,015	20.9%	4.6%	6,299	31,585	19.9%	2.8%
Tech 1,4	9,048	37,015	24.4%	8.1%	6,704	30,452	22.0%	4.9%
Tech 2,3	8,619	37,015	23.3%	6.9%	7,105	31,080	22.9%	5.8%
Tech 2,4	9,421	37,015	25.5%	9.1%	7,578	31,060	24.4%	7.3%
Tech 3,4	7,663	37,015	20.7%	4.3%	6,198	29,895	20.7%	3.6%
Tech 1,2,3	10,637	37,015	28.7%	12.4%	8,401	31,555	26.6%	9.5%
Tech 1,2,4	11,671	37,015	31.5%	15.2%	8,975	31,555	28.4%	11.3%
Tech 1,3,4	9,384	37,015	25.4%	9.0%	7,448	32,231	23.1%	6.0%
Tech 2,3,4	10,191	37,015	27.5%	11.2%	8,617	32,257	26.7%	9.6%
Tech 1,2,3,4	12,614	37,015	34.1%	17.7%	9,689	32,257	30.0%	12.9%

Mid Continent Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	4,091	4,091
#1 Conformance	-	600
#2 Flood Design	-	1,983
#3 Mobility Control	-	1,019
#4 Increased CO_2	-	1,406
Synergy	-	590
Total	4,091	9,689

Mid Continent—Arkansas Production Totals

Arkansas Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	197	1,573	12.6%	-	14	49	349	13.9%	-	4
Tech 1	246	1,573	15.6%	3.1%	14	76	555	13.6%	-0.3%	6
Tech 2	280	1,573	17.8%	5.3%	14	154	837	18.4%	4.5%	9
Tech 3	205	1,573	13.1%	0.5%	14	108	785	13.8%	-0.1%	9
Tech 4	244	1,573	15.5%	2.9%	14	84	555	15.1%	1.2%	6
Tech 1,2	350	1,573	22.3%	9.7%	14	181	837	21.6%	7.6%	9
Tech 1,3	256	1,573	16.3%	3.7%	14	169	1,086	15.5%	1.6%	11
Tech 1,4	304	1,573	19.3%	6.8%	14	107	596	17.9%	4.0%	7
Tech 2,3	311	1,573	19.8%	7.2%	14	305	1,535	19.8%	5.9%	13
Tech 2,4	331	1,573	21.0%	8.5%	14	320	1,514	21.2%	7.2%	12
Tech 3,4	261	1,573	16.6%	4.0%	14	149	866	17.2%	3.2%	10
Tech 1,2,3	389	1,573	24.7%	12.2%	14	352	1,535	22.9%	9.0%	13
Tech 1,2,4	407	1,573	25.9%	13.3%	14	372	1,535	24.2%	10.3%	13
Tech 1,3,4	317	1,573	20.1%	7.6%	14	216	1,086	19.9%	5.9%	11
Tech 2,3,4	379	1,573	24.1%	11.5%	14	371	1,535	24.2%	10.2%	13
Tech 1,2,3,4	467	1,573	29.7%	17.1%	14	410	1,535	26.7%	12.8%	13

Mid Continent—Kansas Production Totals

Kansas Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	1,378	8,113	17.0%	-	36	1,178	6,695	17.6%	-	24
Tech 1	1,645	8,113	20.3%	3.3%	36	1,366	6,695	20.4%	2.8%	24
Tech 2	1,734	8,113	21.4%	4.4%	36	1,394	6,750	20.6%	3.1%	26
Tech 3	1,538	8,113	19.0%	2.0%	36	1,410	7,607	18.5%	0.9%	27
Tech 4	1,761	8,113	21.7%	4.7%	36	1,575	7,607	20.7%	3.1%	27
Tech 1,2	2,160	8,113	26.6%	9.6%	36	1,760	6,750	26.1%	8.5%	26
Tech 1,3	1,915	8,113	23.6%	6.6%	36	1,786	7,636	23.4%	5.8%	28
Tech 1,4	2,182	8,113	26.9%	9.9%	36	1,817	7,636	23.8%	6.2%	28
Tech 2,3	1,901	8,113	23.4%	6.5%	36	1,654	7,000	23.6%	6.0%	28
Tech 2,4	2,060	8,113	25.4%	8.4%	36	1,663	7,000	23.8%	6.2%	28
Tech 3,4	1,831	8,113	22.6%	5.6%	36	1,761	7,707	22.8%	5.3%	29
Tech 1,2,3	2,377	8,113	29.3%	12.3%	36	2,025	7,000	28.9%	11.3%	28
Tech 1,2,4	2,558	8,113	31.5%	14.6%	36	1,955	7,000	27.9%	10.3%	28
Tech 1,3,4	2,240	8,113	27.6%	10.6%	36	1,932	7,707	25.1%	7.5%	29
Tech 2,3,4	2,231	8,113	27.5%	10.5%	36	2,104	7,701	27.3%	9.7%	31
Tech 1,2,3,4	2,781	8,113	34.3%	17.3%	36	2,298	7,701	29.8%	12.2%	31

Mid Continent—Nebraska Production Totals

Nebraska Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	73	552	13.2%	-	14	50	404	12.5%	-	8
Tech 1	91	552	16.5%	3.3%	14	52	404	12.8%	0.3%	8
Tech 2	116	552	21.0%	7.9%	14	103	495	20.9%	8.4%	11
Tech 3	74	552	13.4%	0.2%	14	57	442	12.9%	0.4%	9
Tech 4	89	552	16.1%	2.9%	14	69	442	15.6%	3.1%	9
Tech 1,2	145	552	26.3%	13.1%	14	116	495	23.4%	10.9%	11
Tech 1,3	92	552	16.6%	3.4%	14	74	495	15.1%	2.6%	11
Tech 1,4	106	552	19.2%	6.1%	14	75	466	16.0%	3.6%	10
Tech 2,3	123	552	22.2%	9.1%	14	110	495	22.2%	9.7%	11
Tech 2,4	134	552	24.2%	11.1%	14	119	495	24.1%	11.6%	11
Tech 3,4	93	552	16.9%	3.7%	14	76	466	16.4%	3.9%	10
Tech 1,2,3	153	552	27.7%	14.5%	14	134	495	27.2%	14.7%	11
Tech 1,2,4	167	552	30.3%	17.1%	14	132	495	26.7%	14.3%	11
Tech 1,3,4	111	552	20.1%	7.0%	14	85	495	17.3%	4.8%	11
Tech 2,3,4	145	552	26.4%	13.2%	14	130	495	26.3%	13.8%	11
Tech 1,2,3,4	179	552	32.5%	19.4%	14	145	495	29.3%	16.8%	11

Mid Continent—Oklahoma Production Totals

Oklahoma Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	4,413	26,779	16.5%	-	83	2,814	16,476	17.1%	-	47
Tech 1	5,389	26,779	20.1%	3.6%	83	3,198	16,555	19.3%	2.2%	49
Tech 2	5,961	26,779	22.3%	5.8%	83	4,423	20,544	21.5%	4.4%	56
Tech 3	4,503	26,779	16.8%	0.3%	83	3,536	20,128	17.6%	0.5%	53
Tech 4	5,305	26,779	19.8%	3.3%	83	3,768	18,127	20.8%	3.7%	52
Tech 1,2	7,390	26,779	27.6%	11.1%	83	5,148	20,596	25.0%	7.9%	57
Tech 1,3	5,491	26,779	20.5%	4.0%	83	4,270	22,368	19.1%	2.0%	59
Tech 1,4	6,457	26,779	24.1%	7.6%	83	4,706	21,754	21.6%	4.6%	58
Tech 2,3	6,284	26,779	23.5%	7.0%	83	5,037	22,051	22.8%	5.8%	59
Tech 2,4	6,897	26,779	25.8%	9.3%	83	5,475	22,051	24.8%	7.8%	59
Tech 3,4	5,477	26,779	20.5%	4.0%	83	4,212	20,856	20.2%	3.1%	56
Tech 1,2,3	7,719	26,779	28.8%	12.3%	83	5,890	22,526	26.1%	9.1%	60
Tech 1,2,4	8,539	26,779	31.9%	15.4%	83	6,516	22,526	28.9%	11.8%	60
Tech 1,3,4	6,716	26,779	25.1%	8.6%	83	5,214	22,942	22.7%	5.6%	60
Tech 2,3,4	7,436	26,779	27.8%	11.3%	83	6,013	22,526	26.7%	9.6%	60
Tech 1,2,3,4	9,187	26,779	34.3%	17.8%	83	6,836	22,526	30.3%	13.3%	60

Permian Basin

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 214 Permian Basin oil reservoirs technically favorable for miscible CO_2-EOR:

- The 214 reservoirs have 66.4 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 20.2 billion barrels (B bbls), with remaining P/S reserves of 1.5 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 32.8%, a large 44.6 billion barrel target remains for CO_2-EOR.

The majority of mature CO_2-EOR projects in the U.S. are located in the Permian Basin.

Permian Basin Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 214 Permian Basin oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection, and a tapered WAG.

- The oil recovery and economic models showed that 91 of the 214 Permian Basin oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 91 oil reservoirs is 5.9 billion, with the following performance measures:
  - Oil Recovery Efficiency: 14.6% OOIP
  - Purchased CO_2/Oil Ratio: 8.3 Mcf/B
- An additional total of 4.0 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Permian Basin Oil Reservoirs

The application of “next generation” CO_2-EOR technologies to the 214 Permian Basin oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #4 (Increased Volumes of Efficiently Used CO_2) provides 2.7 billion barrels of additional, economically viable oil recovery (EVOR). Increasing volumes of injected CO_2 improves oil recovery efficiency (+3.7%) and also enables an additional 15 reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 5.9 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+7.4%) and also enables an additional 52 Permian Basin reservoirs to become economic.

Application of Next Generation CO_2-EOR on Permian Basin Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #4 (Increased Volumes of CO_2) provide 8.2 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+11.8%) and also enables an additional 52 Permian Basin reservoirs to become economic.

Combined Technologies

The combination of all four “Next Generation” Technologies provides 10.5 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+13.4%), and enables an additional 72 Permian Basin reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Permian Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	5,862	91	14.6%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	7,456	91	18.2%	1,594	+3.7%
Tech #2. Advanced CO_2 Flood Design	8,607	106	18.3%	2,745	+3.7%
Tech #3. Enhanced Mobility Control	8,011	133	15.3%	2,149	+0.7%
Tech #4. Increased Volumes of Efficiently Used CO_2	9,182	128	17.9%	3,320	+3.3%

Dual Application of Next Generation CO_2-EOR on Permian Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	5,862	91	14.6%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	10,662	105	22.7%	4,800	+8.1%
Technologies #1 and #3	9,684	137	18.2%	3,822	+3.6%
Technologies #1 and #4	10,924	129	21.2%	5,062	+6.7%
Technologies #2 and #3	11,259	147	20.7%	5,397	+6.1%
Technologies #2 and #4	11,752	143	22.0%	5,890	+7.4%
Technologies #3 and #4	9,715	151	17.4%	3,853	+2.8%

*For reservoirs economically feasible for CO2-EOR.

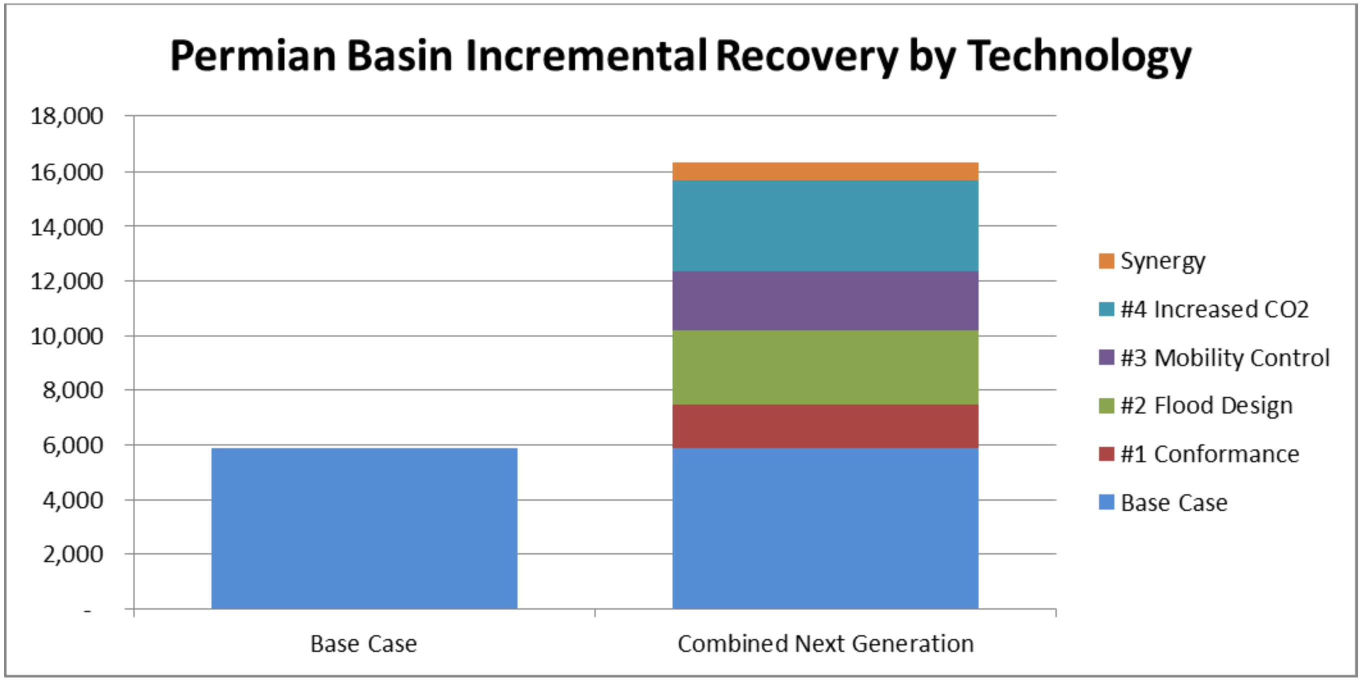
Combined Application of Three and Four Next Generation CO_2-EOR on Permian Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	5,862	91	14.6%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	13,531	148	24.7%	7,669	+10.1%
Technologies # 1, #2 and #4	14,068	143	26.3%	8,206	+11.8%
Technologies # 1, #3 and #4	12,213	153	21.7%	6,351	+7.1%
Technologies # 2, #3 and #4	13,680	163	23.4%	7,818	+8.8%
Technologies # 1, #2, #3 and #4	16,330	163	28.0%	10,468	+13.4%

Permian Basin Next Generation Technology Case Results

Permian Basin Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	9,911	66,366	14.9%	-	5,862	40,239	14.6%	-
Tech 1	12,138	66,366	18.3%	3.4%	7,456	40,887	18.2%	3.7%
Tech 2	13,203	66,366	19.9%	5.0%	8,607	47,047	18.3%	3.7%
Tech 3	10,235	66,366	15.4%	0.5%	8,011	52,411	15.3%	0.7%
Tech 4	12,125	66,366	18.3%	3.3%	9,182	51,305	17.9%	3.3%
Tech 1,2	16,207	66,366	24.4%	9.5%	10,662	46,949	22.7%	8.1%
Tech 1,3	12,619	66,366	19.0%	4.1%	9,684	53,205	18.2%	3.6%
Tech 1,4	14,906	66,366	22.5%	7.5%	10,924	51,414	21.2%	6.7%
Tech 2,3	13,940	66,366	21.0%	6.1%	11,259	54,351	20.7%	6.1%
Tech 2,4	15,487	66,366	23.3%	8.4%	11,752	53,433	22.0%	7.4%
Tech 3,4	12,625	66,366	19.0%	4.1%	9,715	55,908	17.4%	2.8%
Tech 1,2,3	17,254	66,366	26.0%	11.1%	13,531	54,752	24.7%	10.1%
Tech 1,2,4	19,119	66,366	28.8%	13.9%	14,068	53,433	26.3%	11.8%
Tech 1,3,4	15,529	66,366	23.4%	8.5%	12,213	56,322	21.7%	7.1%
Tech 2,3,4	16,771	66,366	25.3%	10.3%	13,680	58,425	23.4%	8.8%
Tech 1,2,3,4	20,651	66,366	31.1%	16.2%	16,330	58,425	28.0%	13.4%

Permian Basin Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	5,862	5,862
#1 Conformance	-	1,594
#2 Flood Design	-	2,745
#3 Mobility Control	-	2,149
#4 Increased CO2	-	3,320
Synergy	-	660
Total	5,862	16,330

Permian Basin—New Mexico Production Totals

New Mexico Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	1,810	12,894	14.0%	-	65	765	6,395	12.0%	-	19
Tech 1	2,173	12,894	16.9%	2.8%	65	1,049	6,411	16.4%	4.4%	20
Tech 2	2,582	12,894	20.0%	6.0%	65	1,392	7,239	19.2%	7.3%	24
Tech 3	1,883	12,894	14.6%	0.6%	65	1,140	7,813	14.6%	2.6%	28
Tech 4	2,213	12,894	17.2%	3.1%	65	1,298	7,410	17.5%	5.6%	27
Tech 1,2	3,146	12,894	24.4%	10.4%	65	1,602	7,239	22.1%	10.2%	24
Tech 1,3	2,294	12,894	17.8%	3.8%	65	1,382	8,000	17.3%	5.3%	28
Tech 1,4	2,689	12,894	20.9%	6.8%	65	1,504	7,317	20.6%	8.6%	26
Tech 2,3	2,750	12,894	21.3%	7.3%	65	2,032	9,691	21.0%	9.0%	38
Tech 2,4	3,016	12,894	23.4%	9.4%	65	2,071	9,254	22.4%	10.4%	37
Tech 3,4	2,333	12,894	18.1%	4.1%	65	1,568	9,334	16.8%	4.8%	36
Tech 1,2,3	3,383	12,894	26.2%	12.2%	65	2,451	10,092	24.3%	12.3%	39
Tech 1,2,4	3,700	12,894	28.7%	14.7%	65	2,362	9,254	25.5%	13.6%	37
Tech 1,3,4	2,854	12,894	22.1%	8.1%	65	1,854	9,584	19.3%	7.4%	36
Tech 2,3,4	3,307	12,894	25.7%	11.6%	65	2,674	11,269	23.7%	11.8%	47
Tech 1,2,3,4	4,008	12,894	31.1%	17.0%	65	3,001	11,269	26.6%	14.7%	47

Permian Basin—Texas Production Totals

Texas Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	8,102	53,472	15.2%	-	149	5,097	33,844	15.1%	-	72
Tech 1	9,965	53,472	18.6%	3.5%	149	6,406	34,476	18.6%	3.5%	71
Tech 2	10,621	53,472	19.9%	4.7%	149	7,215	39,808	18.1%	3.1%	82
Tech 3	8,352	53,472	15.6%	0.5%	149	6,871	44,599	15.4%	0.3%	105
Tech 4	9,912	53,472	18.5%	3.4%	149	7,884	43,895	18.0%	2.9%	101
Tech 1,2	13,061	53,472	24.4%	9.3%	149	9,060	39,710	22.8%	7.8%	81
Tech 1,3	10,325	53,472	19.3%	4.2%	149	8,303	45,204	18.4%	3.3%	109
Tech 1,4	12,218	53,472	22.8%	7.7%	149	9,419	44,097	21.4%	6.3%	103
Tech 2,3	11,189	53,472	20.9%	5.8%	149	9,227	44,660	20.7%	5.6%	109
Tech 2,4	12,471	53,472	23.3%	8.2%	149	9,681	44,179	21.9%	6.9%	106
Tech 3,4	10,293	53,472	19.2%	4.1%	149	8,146	46,573	17.5%	2.4%	115
Tech 1,2,3	13,871	53,472	25.9%	10.8%	149	11,081	44,660	24.8%	9.8%	109
Tech 1,2,4	15,419	53,472	28.8%	13.7%	149	11,706	44,179	26.5%	11.4%	106
Tech 1,3,4	12,675	53,472	23.7%	8.6%	149	10,358	46,737	22.2%	7.1%	117
Tech 2,3,4	13,464	53,472	25.2%	10.0%	149	11,007	47,156	23.3%	8.3%	116
Tech 1,2,3,4	16,643	53,472	31.1%	16.0%	149	13,329	47,156	28.3%	13.2%	116

Rockies

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 133 Rockies oil reservoirs technically favorable for miscible CO_2-EOR:

- The 133 reservoirs have 30.0 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 6.3 billion barrels (B bbls), with remaining P/S reserves of 0.6 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 23.0%, a large 23.1 billion barrel target remains for CO_2-EOR.

Several large CO_2-EOR operations are located in the Rockies, with CO_2 pipelines in the region currently under construction.

Rockies Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 133 Rockies oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection, and a tapered WAG.

- The oil recovery and economic models showed that 70 of the 133 Rockies oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 70 oil reservoirs is 1.5 billion, with the following performance measures:
  - Oil Recovery Efficiency: 13.3% OOIP
  - Purchased CO_2/Oil Ratio: 7.6 Mcf/B
- As additional total of 1.1 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Rockies Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 133 Rockies oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #2 (Advanced CO_2 Flood Design) provides 1.4 billion barrels of additional, economically viable oil recovery (EVOR). Contacting unswept portions of the reservoir improves oil recovery efficiency (+4.0%) and also enables an additional 27 reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 2.2 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+6.5%) and also enables an additional 37 Rockies reservoirs to become economic.

Application of Next Generation CO_2-EOR on Rockies Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 3.1 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+11.1%) and also enables an additional 37 Rockies reservoirs to become economic.

Combined Technologies

The combination of all four “Next Generation” Technologies provides 3.8 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+14.6%), and enables an additional 37 Rockies reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Rockies Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	1,515	70	13.3%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	1,945	73	15.7%	430	+2.4%
Tech #2. Advanced CO_2 Flood Design	2,896	97	17.4%	1,381	+4.0%
Tech #3. Enhanced Mobility Control	2,023	93	13.4%	508	+0.1%
Tech #4. Increased Volumes of Efficiently Used CO_2	2,186	87	15.4%	671	+2.0%

Dual Application of Next Generation CO_2-EOR on Rockies Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	1,515	70	13.3%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	3,545	97	21.3%	2,030	7.9%
Technologies #1 and #3	2,515	97	16.2%	1,000	2.8%
Technologies #1 and #4	2,666	91	18.1%	1,151	4.8%
Technologies #2 and #3	3,748	107	19.8%	2,233	6.5%
Technologies #2 and #4	3,504	103	20.3%	1,989	7.0%
Technologies #3 and #4	2,350	94	15.5%	835	2.2%

*For reservoirs economically feasible for CO2-EOR.

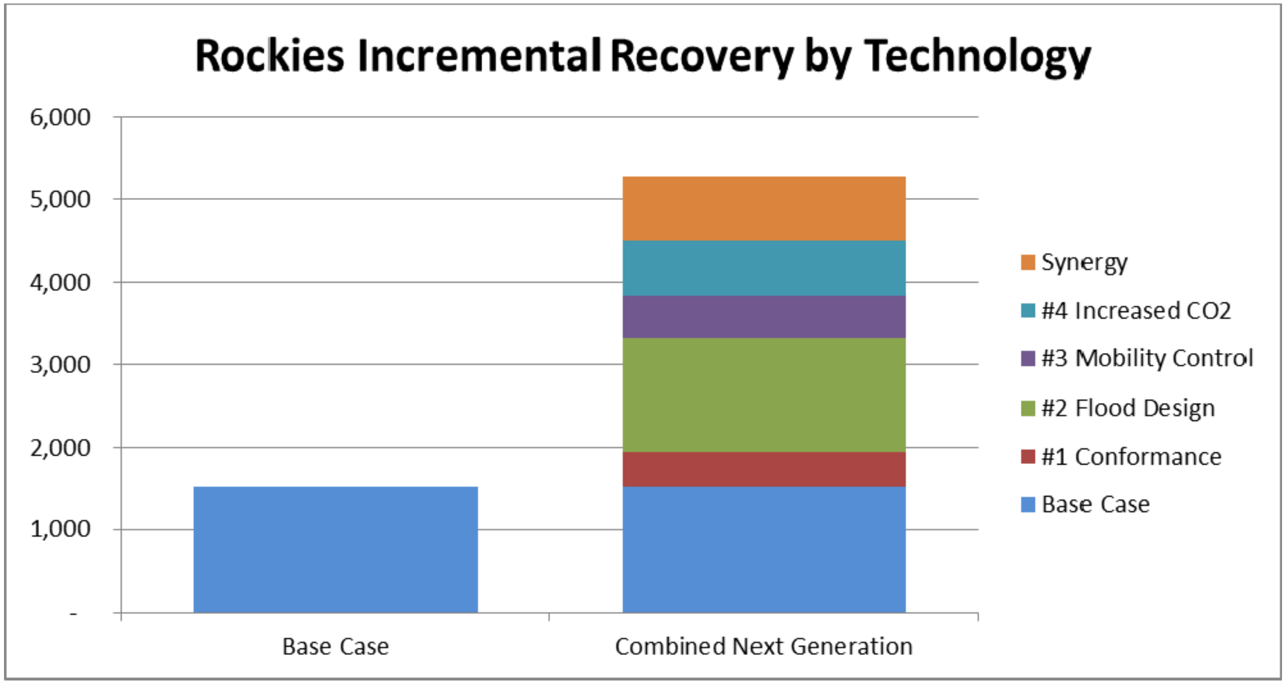
Combined Application of Three and Four Next Generation CO_2-EOR on Rockies Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	1,515	70	13.3%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	4,610	107	24.4%	3,095	+11.1%
Technologies # 1, #2 and #4	4,202	104	24.3%	2,687	+11.0%
Technologies # 1, #3 and #4	2,943	99	18.8%	1,428	+5.4%
Technologies # 2, #3 and #4	4,341	107	23.0%	2,826	+9.6%
Technologies # 1, #2, #3 and #4	5,281	107	28.0%	3,766	+14.6%

Rockies Next Generation Technology Case Results

Rockies Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	2,605	20,958	12.4%	-	1,515	11,349	13.3%	-
Tech 1	3,236	20,958	15.4%	3.0%	1,945	12,372	15.7%	2.4%
Tech 2	3,845	20,958	18.3%	5.9%	2,896	16,676	17.4%	4.0%
Tech 3	2,748	20,958	13.1%	0.7%	2,023	15,077	13.4%	0.1%
Tech 4	3,199	20,958	15.3%	2.8%	2,186	14,201	15.4%	2.0%
Tech 1,2	4,799	20,958	22.9%	10.5%	3,545	16,676	21.3%	7.9%
Tech 1,3	3,425	20,958	16.3%	3.9%	2,515	15,562	16.2%	2.8%
Tech 1,4	3,955	20,958	18.9%	6.4%	2,666	14,704	18.1%	4.8%
Tech 2,3	4,242	20,958	20.2%	7.8%	3,748	18,894	19.8%	6.5%
Tech 2,4	4,452	20,958	21.2%	8.8%	3,504	17,229	20.3%	7.0%
Tech 3,4	3,319	20,958	15.8%	3.4%	2,350	15,120	15.5%	2.2%
Tech 1,2,3	5,288	20,958	25.2%	12.8%	4,610	18,894	24.4%	11.1%
Tech 1,2,4	5,540	20,958	26.4%	14.0%	4,202	17,279	24.3%	11.0%
Tech 1,3,4	4,053	20,958	19.3%	6.9%	2,943	15,676	18.8%	5.4%
Tech 2,3,4	4,970	20,958	23.7%	11.3%	4,341	18,894	23.0%	9.6%
Tech 1,2,3,4	6,162	20,958	29.4%	17.0%	5,281	18,894	28.0%	14.6%

Rockies Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	1,515	1,515
#1 Conformance	-	430
#2 Flood Design	-	1,381
#3 Mobility Control	-	508
#4 Increased CO2	-	671
Synergy	-	776
Total	1,515	5,281

Rockies—Colorado Production Totals

Colorado Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	552	3,766	14.7%	-	25	458	3,025	15.2%	-	17
Tech 1	683	3,766	18.1%	3.5%	25	573	3,025	18.9%	3.8%	17
Tech 2	752	3,766	20.0%	5.3%	25	602	3,138	19.2%	4.0%	18
Tech 3	596	3,766	15.8%	1.2%	25	501	3,202	15.6%	0.5%	19
Tech 4	695	3,766	18.4%	3.8%	25	583	3,202	18.2%	3.0%	19
Tech 1,2	938	3,766	24.9%	10.2%	25	747	3,138	23.8%	8.7%	18
Tech 1,3	742	3,766	19.7%	5.0%	25	619	3,202	19.3%	4.2%	19
Tech 1,4	849	3,766	22.5%	7.9%	25	714	3,202	22.3%	7.1%	19
Tech 2,3	809	3,766	21.5%	6.8%	25	664	3,202	20.7%	5.6%	19
Tech 2,4	875	3,766	23.2%	8.6%	25	719	3,202	22.4%	7.3%	19
Tech 3,4	698	3,766	18.5%	3.9%	25	528	3,202	16.5%	1.3%	19
Tech 1,2,3	1,004	3,766	26.7%	12.0%	25	821	3,202	25.6%	10.5%	19
Tech 1,2,4	1,089	3,766	28.9%	14.2%	25	880	3,202	27.5%	12.3%	19
Tech 1,3,4	850	3,766	22.6%	7.9%	25	716	3,202	22.4%	7.2%	19
Tech 2,3,4	931	3,766	24.7%	10.0%	25	750	3,202	23.4%	8.3%	19
Tech 1,2,3,4	1,158	3,766	30.7%	16.1%	25	940	3,202	29.4%	14.2%	19

Rockies—Utah Production Totals

Utah Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	750	5,016	14.9%	-	17	273	1,614	16.9%	-	8
Tech 1	937	5,016	18.7%	3.7%	17	417	2,137	19.5%	2.6%	9
Tech 2	1,036	5,016	20.7%	5.7%	17	608	2,940	20.7%	3.8%	12
Tech 3	791	5,016	15.8%	0.8%	17	464	3,040	15.2%	-1.7%	13
Tech 4	903	5,016	18.0%	3.1%	17	449	2,517	17.9%	0.9%	10
Tech 1,2	1,295	5,016	25.8%	10.9%	17	759	2,940	25.8%	8.9%	12
Tech 1,3	988	5,016	19.7%	4.8%	17	574	3,040	18.9%	2.0%	13
Tech 1,4	1,129	5,016	22.5%	7.6%	17	611	2,940	20.8%	3.9%	12
Tech 2,3	1,181	5,016	23.5%	8.6%	17	1,093	4,642	23.5%	6.6%	15
Tech 2,4	1,203	5,016	24.0%	9.0%	17	726	3,040	23.9%	6.9%	13
Tech 3,4	954	5,016	19.0%	4.1%	17	549	3,040	18.1%	1.1%	13
Tech 1,2,3	1,476	5,016	29.4%	14.5%	17	1,344	4,642	28.9%	12.0%	15
Tech 1,2,4	1,504	5,016	30.0%	15.0%	17	887	3,090	28.7%	11.8%	14
Tech 1,3,4	1,172	5,016	23.4%	8.4%	17	685	3,040	22.5%	5.6%	13
Tech 2,3,4	1,384	5,016	27.6%	12.6%	17	1,268	4,642	27.3%	10.4%	15
Tech 1,2,3,4	1,706	5,016	34.0%	19.1%	17	1,566	4,642	33.7%	16.8%	15

Rockies—Wyoming Production Totals

Wyoming Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	1,302	12,175	10.7%	-	91	783	6,710	11.7%	-	45
Tech 1	1,616	12,175	13.3%	2.6%	91	955	7,210	13.2%	1.6%	47
Tech 2	2,057	12,175	16.9%	6.2%	91	1,686	10,598	15.9%	4.2%	67
Tech 3	1,361	12,175	11.2%	0.5%	91	1,059	8,834	12.0%	0.3%	61
Tech 4	1,601	12,175	13.2%	2.5%	91	1,154	8,482	13.6%	1.9%	58
Tech 1,2	2,566	12,175	21.1%	10.4%	91	2,039	10,598	19.2%	7.6%	67
Tech 1,3	1,694	12,175	13.9%	3.2%	91	1,322	9,320	14.2%	2.5%	65
Tech 1,4	1,977	12,175	16.2%	5.5%	91	1,341	8,561	15.7%	4.0%	60
Tech 2,3	2,252	12,175	18.5%	7.8%	91	1,992	11,050	18.0%	6.3%	73
Tech 2,4	2,374	12,175	19.5%	8.8%	91	2,060	10,987	18.7%	7.1%	71
Tech 3,4	1,667	12,175	13.7%	3.0%	91	1,273	8,878	14.3%	2.7%	62
Tech 1,2,3	2,808	12,175	23.1%	12.4%	91	2,445	11,050	22.1%	10.5%	73
Tech 1,2,4	2,948	12,175	24.2%	13.5%	91	2,435	10,987	22.2%	10.5%	71
Tech 1,3,4	2,030	12,175	16.7%	6.0%	91	1,542	9,433	16.3%	4.7%	67
Tech 2,3,4	2,656	12,175	21.8%	11.1%	91	2,324	11,050	21.0%	9.4%	73
Tech 1,2,3,4	3,298	12,175	27.1%	16.4%	91	2,775	11,050	25.1%	13.4%	73

Southeast Gulf Coast

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 204 Southeast Gulf Coast oil reservoirs technically favorable for miscible CO_2-EOR:

- The 204 reservoirs have 23.5 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 9.0 billion barrels (B bbls), with remaining P/S reserves of 0.2 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 38.3%, a sizable 14.5 billion barrel target remains for CO_2-EOR.

Several mature CO_2-EOR operations are located in the Southeast Gulf Coast region.

Southeast Gulf Coast Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 204 Southeast Gulf Coast oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection, and a tapered WAG.

- The oil recovery and economic models showed that 43 of the 204 Southeast Gulf Coast oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 43 oil reservoirs is 0.9 billion, with the following performance measures:
  - Oil Recovery Efficiency: 13.5% OOIP
  - Purchased CO2/Oil Ratio: 7.4 Mcf/B
- An additional total of 2.1 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Southeast Gulf Coast Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 204 Southeast Gulf Coast oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #2 (Advanced CO_2 Flood Design) provides 1.5 billion barrels of additional, economically viable oil recovery (EVOR). Contacting unswept portions of the reservoir improves oil recovery efficiency (+3.6%) and also enables an additional 59 reservoirs to become economic.

Dual Application

Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 3.1 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+5.9%) and also enables an additional 117 Southeast Gulf Coast reservoirs to become economic.

Application of Next Generation CO_2-EOR on Southeast Gulf Coast Oil Reservoirs

Triple Application

Technology #1 (Improved Reservoir Conformance), Technology #2 (Advanced CO_2 Flood Design), and Technology #3 (Enhanced Mobility Control) provide 4.0 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+9.9%) and also enables an additional 124 Southeast Gulf Coast reservoirs to become economic.

Combined Technologies

The combination of all four "Next Generation" Technologies provides 4.7 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+13.0%), and enables an additional 132 Southeast Gulf Coast reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Southeast Gulf Coast Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	865	43	13.5%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	1,078	50	15.7%	213	+2.1%
Tech #2. Advanced CO_2 Flood Design	2,372	102	17.1%	1,507	+3.6%
Tech #3. Enhanced Mobility Control	2,103	98	14.0%	1,238	+0.5%
Tech #4. Increased Volumes of Efficiently Used CO_2	1,917	75	16.0%	1,052	+2.5%

Dual Application of Next Generation CO_2-EOR on Southeast Gulf Coast Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	865	43	13.5%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	2,973	106	20.8%	2,108	7.3%
Technologies #1 and #3	2,707	112	16.3%	1,842	2.8%
Technologies #1 and #4	2,699	93	18.6%	1,834	5.1%
Technologies #2 and #3	3,926	160	19.4%	3,061	5.9%
Technologies #2 and #4	3,720	137	20.1%	2,855	6.6%
Technologies #3 and #4	2,599	114	15.9%	1,734	2.4%

*For reservoirs economically feasible for CO2-EOR.

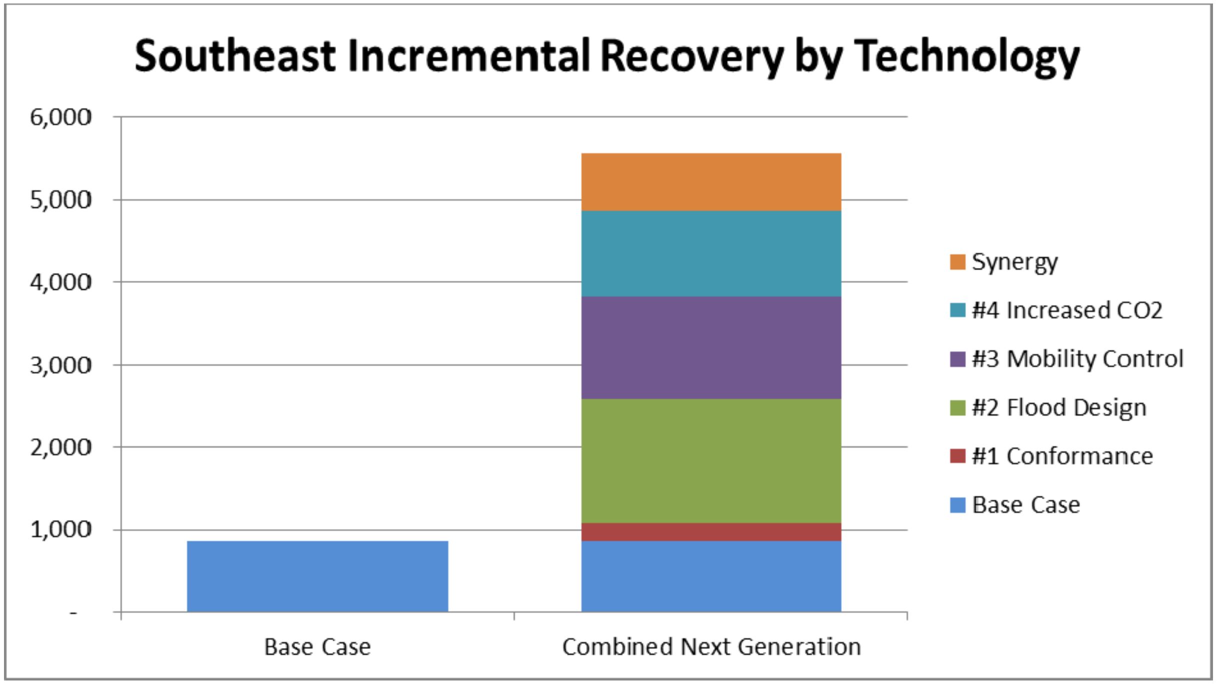
Combined Application of Three and Four Next Generation CO_2-EOR on Southeast Gulf Coast Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	865	43	13.5%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	4,835	167	23.4%	3,970	9.9%
Technologies # 1, #2 and #4	4,558	143	24.2%	3,693	10.7%
Technologies # 1, #3 and #4	3,321	127	18.6%	2,456	5.1%
Technologies # 2, #3 and #4	4,526	171	21.8%	3,661	8.3%
Technologies # 1, #2, #3 and #4	5,555	175	26.5%	4,690	13.0%

Southeast Gulf Coast Next Generation Technology Case Results

Southeast Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	2,988	23,543	12.7%	-	865	6,398	13.5%	-
Tech 1	3,670	23,543	15.6%	2.9%	1,078	6,884	15.7%	2.1%
Tech 2	4,193	23,543	17.8%	5.1%	2,372	13,884	17.1%	3.6%
Tech 3	3,257	23,543	13.8%	1.1%	2,103	15,035	14.0%	0.5%
Tech 4	3,823	23,543	16.2%	3.5%	1,917	11,973	16.0%	2.5%
Tech 1,2	5,195	23,543	22.1%	9.4%	2,973	14,274	20.8%	7.3%
Tech 1,3	4,049	23,543	17.2%	4.5%	2,707	16,592	16.3%	2.8%
Tech 1,4	4,599	23,543	19.5%	6.8%	2,699	14,510	18.6%	5.1%
Tech 2,3	4,641	23,543	19.7%	7.0%	3,926	20,208	19.4%	5.9%
Tech 2,4	4,967	23,543	21.1%	8.4%	3,720	18,524	20.1%	6.6%
Tech 3,4	4,006	23,543	17.0%	4.3%	2,599	16,332	15.9%	2.4%
Tech 1,2,3	5,780	23,543	24.6%	11.9%	4,835	20,654	23.4%	9.9%
Tech 1,2,4	6,113	23,543	26.0%	13.3%	4,558	18,836	24.2%	10.7%
Tech 1,3,4	4,856	23,543	20.6%	7.9%	3,321	17,808	18.6%	5.1%
Tech 2,3,4	5,535	23,543	23.5%	10.8%	4,526	20,732	21.8%	8.3%
Tech 1,2,3,4	6,833	23,543	29.0%	16.3%	5,555	20,978	26.5%	13.0%

Southeast Gulf Coast Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	865	865
#1 Conformance	-	213
#2 Flood Design	-	1,507
#3 Mobility Control	-	1,238
#4 Increased CO2	-	1,052
Synergy	-	680
Total	865	5,555

Southeast Gulf Coast—Alabama Production Totals

Alabama Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	332	1,878	17.7%	-	12	87	574	15.2%	-	2
Tech 1	414	1,878	22.0%	4.4%	12	91	574	15.8%	0.6%	2
Tech 2	409	1,878	21.8%	4.1%	12	151	767	19.6%	4.5%	4
Tech 3	349	1,878	18.6%	0.9%	12	129	795	16.2%	1.0%	5
Tech 4	403	1,878	21.5%	3.8%	12	123	695	17.6%	2.5%	4
Tech 1,2	510	1,878	27.2%	9.5%	12	156	767	20.3%	5.1%	4
Tech 1,3	436	1,878	23.2%	5.5%	12	138	795	17.4%	2.2%	5
Tech 1,4	503	1,878	26.8%	9.1%	12	180	795	22.6%	7.4%	5
Tech 2,3	450	1,878	24.0%	6.3%	12	198	847	23.4%	8.2%	6
Tech 2,4	484	1,878	25.7%	8.1%	12	177	795	22.3%	7.1%	5
Tech 3,4	432	1,878	23.0%	5.3%	12	148	795	18.6%	3.5%	5
Tech 1,2,3	562	1,878	29.9%	12.2%	12	210	847	24.8%	9.7%	6
Tech 1,2,4	603	1,878	32.1%	14.5%	12	240	795	30.1%	15.0%	5
Tech 1,3,4	539	1,878	28.7%	11.0%	12	195	795	24.6%	9.4%	5
Tech 2,3,4	540	1,878	28.8%	11.1%	12	231	847	27.2%	12.1%	6
Tech 1,2,3,4	674	1,878	35.9%	18.2%	12	288	847	34.0%	18.8%	6

Southeast Gulf Coast—Louisiana Production Totals

Louisiana Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	2,145	17,796	12.1%	-	162	566	4,183	13.5%	-	28
Tech 1	2,635	17,796	14.8%	2.8%	162	735	4,632	15.9%	2.3%	34
Tech 2	3,044	17,796	17.1%	5.1%	162	1,669	9,942	16.8%	3.3%	77
Tech 3	2,340	17,796	13.1%	1.1%	162	1,538	11,073	13.9%	0.4%	72
Tech 4	2,757	17,796	15.5%	3.4%	162	1,339	8,325	16.1%	2.6%	53
Tech 1,2	3,762	17,796	21.1%	9.1%	162	2,150	10,331	20.8%	7.3%	81
Tech 1,3	2,907	17,796	16.3%	4.3%	162	2,083	12,608	16.5%	3.0%	85
Tech 1,4	3,316	17,796	18.6%	6.6%	162	2,014	10,692	18.8%	5.3%	69
Tech 2,3	3,386	17,796	19.0%	7.0%	162	3,020	15,818	19.1%	5.6%	127
Tech 2,4	3,621	17,796	20.3%	8.3%	162	2,864	14,434	19.8%	6.3%	109
Tech 3,4	2,889	17,796	16.2%	4.2%	162	1,888	12,069	15.6%	2.1%	83
Tech 1,2,3	4,214	17,796	23.7%	11.6%	162	3,795	16,264	23.3%	9.8%	134
Tech 1,2,4	4,454	17,796	25.0%	13.0%	162	3,553	14,746	24.1%	10.6%	115
Tech 1,3,4	3,493	17,796	19.6%	7.6%	162	2,482	13,425	18.5%	5.0%	95
Tech 2,3,4	4,045	17,796	22.7%	10.7%	162	3,496	16,342	21.4%	7.9%	138
Tech 1,2,3,4	4,994	17,796	28.1%	16.0%	162	4,313	16,515	26.1%	12.6%	141

Southeast Gulf Coast—Mississippi Production Totals

Mississippi Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	301	2,377	12.7%	-	24	212	1,641	12.9%	-	13
Tech 1	368	2,377	15.5%	2.8%	24	253	1,678	15.1%	2.1%	14
Tech 2	441	2,377	18.5%	5.9%	24	369	2,102	17.5%	4.6%	19
Tech 3	324	2,377	13.6%	1.0%	24	286	2,120	13.5%	0.6%	19
Tech 4	382	2,377	16.1%	3.4%	24	312	2,000	15.6%	2.7%	17
Tech 1,2	551	2,377	23.2%	10.5%	24	441	2,102	21.0%	8.1%	19
Tech 1,3	403	2,377	17.0%	4.3%	24	326	2,143	15.2%	2.3%	20
Tech 1,4	446	2,377	18.8%	6.1%	24	357	2,070	17.2%	4.3%	18
Tech 2,3	475	2,377	20.0%	7.3%	24	475	2,377	20.0%	7.0%	24
Tech 2,4	509	2,377	21.4%	8.7%	24	467	2,222	21.0%	8.1%	21
Tech 3,4	387	2,377	16.3%	3.6%	24	369	2,347	15.7%	2.8%	23
Tech 1,2,3	594	2,377	25.0%	12.3%	24	543	2,377	22.8%	9.9%	24
Tech 1,2,4	634	2,377	26.7%	14.0%	24	540	2,222	24.3%	11.4%	21
Tech 1,3,4	469	2,377	19.7%	7.1%	24	410	2,347	17.5%	4.5%	23
Tech 2,3,4	557	2,377	23.5%	10.8%	24	540	2,377	22.7%	9.8%	24
Tech 1,2,3,4	695	2,377	29.2%	16.6%	24	630	2,377	26.5%	13.6%	24

Southeast Gulf Coast—Florida Production Totals

Florida Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	210	1,492	14.1%	-	6	-	-	0.0%	-	-
Tech 1	253	1,492	17.0%	2.9%	6	-	-	0.0%	0.0%	-
Tech 2	299	1,492	20.1%	6.0%	6	183	1,073	17.1%	17.1%	2
Tech 3	244	1,492	16.4%	2.3%	6	150	1,047	14.4%	14.4%	2
Tech 4	281	1,492	18.8%	4.8%	6	143	954	15.0%	15.0%	1
Tech 1,2	371	1,492	24.9%	10.8%	6	226	1,073	21.0%	21.0%	2
Tech 1,3	303	1,492	20.3%	6.3%	6	159	1,047	15.2%	15.2%	2
Tech 1,4	334	1,492	22.4%	8.3%	6	149	954	15.6%	15.6%	1
Tech 2,3	330	1,492	22.1%	8.1%	6	234	1,166	20.0%	20.0%	3
Tech 2,4	353	1,492	23.7%	9.6%	6	211	1,073	19.7%	19.7%	2
Tech 3,4	299	1,492	20.0%	6.0%	6	194	1,121	17.3%	17.3%	3
Tech 1,2,3	410	1,492	27.5%	13.4%	6	288	1,166	24.7%	24.7%	3
Tech 1,2,4	422	1,492	28.3%	14.2%	6	225	1,073	21.0%	21.0%	2
Tech 1,3,4	355	1,492	23.8%	9.8%	6	234	1,240	18.9%	18.9%	4
Tech 2,3,4	392	1,492	26.3%	12.2%	6	260	1,166	22.3%	22.3%	3
Tech 1,2,3,4	470	1,492	31.5%	17.4%	6	324	1,240	26.1%	26.1%	4

Williston Basin

This section examines the impact of using SOA versus Next Generation CO_2-EOR technologies on 82 Williston Basin oil reservoirs technically favorable for miscible CO_2-EOR:

- The 82 reservoirs have 8.3 billion barrels of OOIP.
- Cumulative primary/secondary (P/S) oil recovery is 2.1 billion barrels (B bbls), with remaining P/S reserves of 0.3 billion barrels (end of 2010).
- With P/S oil recovery efficiency of 28.9%, a moderate 5.9 billion barrel target remains for CO_2-EOR.

Several mature CO_2-EOR operations are located in the Williston Basin.

Williston Basin Base Case: State of Art (SOA) CO_2-EOR

We modeled the performance of each of the 82 Williston Basin oil reservoirs favorable for miscible CO_2-EOR using PROPHET2 with "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection, and a tapered WAG.

- The oil recovery and economic models showed that 20 of the 82 Southeast Gulf Coast oil reservoirs are economically viable under SOA technology.
- The economically viable oil recovery (EVOR) from the 20 oil reservoirs is 0.4 billion, with the following performance measures:
  - Oil Recovery Efficiency: 14.9% OOIP
  - Purchased CO_2/Oil Ratio: 6.0 Mcf/B
- An additional 1.1 billion barrels is technically recoverable using Base Case (SOA) technology but requiring higher oil prices or lower costs.

Application of Next Generation CO_2-EOR on Williston Basin Oil Reservoirs

The application of "next generation" CO_2-EOR technologies to the 82 Williston Basin oil reservoirs shows that each of the technologies provides a positive impact, and that the use of a combination of technologies further improves recoveries by greater than the sum of the recovery by individual technologies.

Single Application

Technology #4 (Increased Volumes of Efficiently Used CO2) provides 0.4 billion barrels of additional, economically viable oil recovery (EVOR). Contacting unswept portions of the reservoir improves oil recovery efficiency (+6.8%) and also enables an additional 13 reservoirs to become economic.

Dual Application

Technology #1 (Improved Reservoir Conformance), and Technology #4 (Increased Volumes of Efficiently Used CO2) provide 0.6 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+10.5%) and also enables an additional 13 Williston Basin reservoirs to become economic.

Application of Next Generation CO_2-EOR on Williston Basin Oil Reservoirs

Triple Application

Technology #2 (Advanced CO_2 Flood Design), Technology #3 (Enhanced Mobility Control), and Technology #4 (Increased Volumes of Efficiently Used CO_2) provide 0.7 billion barrels of additional, economically viable oil recovery (EVOR). This technology combination improves oil recovery efficiency (+13.5%) and also enables an additional 19 Williston Basin reservoirs to become economic.

Combined Technologies

The combination of all four “Next Generation” Technologies provides 0.9 billion barrels of additional, economically viable oil recovery (EVOR), improves oil recovery efficiency (+17.7%), and enables an additional 19 Williston Basin reservoirs to become economic.

Single Application of Next Generation CO_2-EOR on Williston Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(% OOIP)
I. Base Case (State of Art)	409	20	14.9%	-	-
II. "Next Generation" Technologies					
Tech #1. Improved Reservoir Conformance	464	21	16.6%	55	+1.6%
Tech #2. Advanced CO_2 Flood Design	635	26	20.9%	226	+6.0%
Tech #3. Enhanced Mobility Control	711	34	18.4%	302	+3.4%
Tech #4. Increased Volumes of Efficiently Used CO_2	836	33	21.7%	427	+6.8%

Dual Application of Next Generation CO_2-EOR on Williston Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case*	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	409	20	14.9%	-	-
II. "Next Generation" Technologies					
Technologies #1 and #2	720	26	23.7%	311	+8.7%
Technologies #1 and #3	822	34	21.2%	413	+6.3%
Technologies #1 and #4	980	33	25.5%	571	+10.5%
Technologies #2 and #3	956	38	23.9%	547	+8.9%
Technologies #2 and #4	874	34	25.6%	465	+10.7%
Technologies #3 and #4	895	37	22.6%	486	+7.7%

*For reservoirs economically feasible for CO_2-EOR.

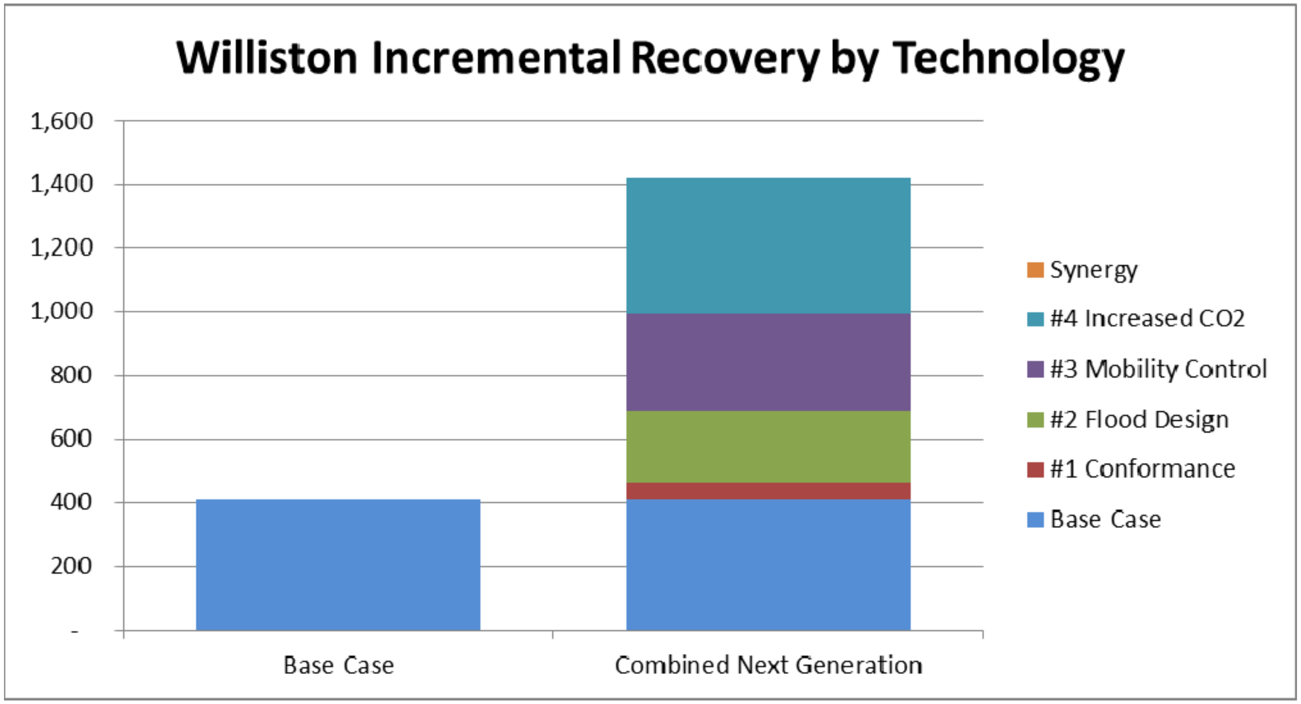
Combined Application of Three and Four Next Generation CO_2-EOR on Williston Basin Oil Reservoirs

	Economic Oil Recovery		Recovery Efficiency	Impact: Change Over Base Case	
	(MM bbls)	(# of Reservoirs)	(%OOIP)	(MM bbls)	(%OOIP)
I. Base Case (State of Art)	409	20	14.9%	-	-
II. "Next Generation" Technologies					
Technologies # 1, #2 and #3	1,109	38	27.7%	700	+12.8%
Technologies # 1, #2 and #4	1,140	36	30.7%	731	+15.8%
Technologies # 1, #3 and #4	1,052	37	26.6%	643	+11.6%
Technologies # 2, #3 and #4	1,150	39	28.5%	741	+13.5%
Technologies # 1, #2, #3 and #4	1,318	39	32.6%	909	+17.7%

Williston Basin Next Generation Technology Case Results

Williston Next Generation Technology Case Results								
	Technical				Economic @ $85/Bbl; $40/mt			
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %
Base Case	1,486	8,304	17.9%	-	409	2,738	14.9%	-
Tech 1	1,792	8,304	21.6%	3.7%	464	2,800	16.6%	1.6%
Tech 2	1,921	8,304	23.1%	5.2%	635	3,040	20.9%	6.0%
Tech 3	1,623	8,304	19.5%	1.6%	711	3,872	18.4%	3.4%
Tech 4	1,881	8,304	22.7%	4.8%	836	3,847	21.7%	6.8%
Tech 1,2	2,363	8,304	28.5%	10.6%	720	3,040	23.7%	8.7%
Tech 1,3	1,997	8,304	24.0%	6.2%	822	3,872	21.2%	6.3%
Tech 1,4	2,296	8,304	27.6%	9.8%	980	3,847	25.5%	10.5%
Tech 2,3	2,071	8,304	24.9%	7.0%	956	4,004	23.9%	8.9%
Tech 2,4	2,279	8,304	27.4%	9.5%	874	3,411	25.6%	10.7%
Tech 3,4	1,970	8,304	23.7%	5.8%	895	3,960	22.6%	7.7%
Tech 1,2,3	2,562	8,304	30.9%	13.0%	1,109	4,004	27.7%	12.8%
Tech 1,2,4	2,812	8,304	33.9%	16.0%	1,140	3,713	30.7%	15.8%
Tech 1,3,4	2,370	8,304	28.5%	10.6%	1,052	3,960	26.6%	11.6%
Tech 2,3,4	2,461	8,304	29.6%	11.7%	1,150	4,040	28.5%	13.5%
Tech 1,2,3,4	3,026	8,304	36.4%	18.5%	1,318	4,040	32.6%	17.7%

Williston Basin Next Generation Technology Case Results



Technology	Base Case	Combined Next Generation
Base Case	409	409
#1 Conformance	-	55
#2 Flood Design	-	226
#3 Mobility Control	-	302
#4 Increased CO2	-	427
Synergy	-	-
Total	409	*1,318

*The combination of four Next Generation technologies includes an overlapping benefit of 101 million barrels compared to the sum of the individual technologies.

Williston Basin—Montana Production Totals

Montana Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	753	4,578	16.4%	-	38	215	1,694	12.7%	-	12
Tech 1	918	4,578	20.1%	3.6%	38	240	1,694	14.1%	1.5%	12
Tech 2	991	4,578	21.6%	5.2%	38	370	1,778	20.8%	8.1%	15
Tech 3	812	4,578	17.7%	1.3%	38	348	2,141	16.2%	3.6%	18
Tech 4	957	4,578	20.9%	4.5%	38	413	2,116	19.5%	6.8%	17
Tech 1,2	1,227	4,578	26.8%	10.4%	38	447	1,778	25.1%	12.4%	15
Tech 1,3	1,011	4,578	22.1%	5.6%	38	400	2,141	18.7%	6.0%	18
Tech 1,4	1,185	4,578	25.9%	9.4%	38	496	2,116	23.4%	10.8%	17
Tech 2,3	1,087	4,578	23.8%	7.3%	38	506	2,175	23.3%	10.6%	20
Tech 2,4	1,182	4,578	25.8%	9.4%	38	459	1,862	24.6%	12.0%	17
Tech 3,4	991	4,578	21.6%	5.2%	38	439	2,208	19.9%	7.2%	20
Tech 1,2,3	1,356	4,578	29.6%	13.2%	38	597	2,175	27.4%	14.8%	20
Tech 1,2,4	1,470	4,578	32.1%	15.7%	38	667	2,165	30.8%	18.1%	19
Tech 1,3,4	1,202	4,578	26.3%	9.8%	38	521	2,208	23.6%	10.9%	20
Tech 2,3,4	1,291	4,578	28.2%	11.8%	38	607	2,211	27.4%	14.8%	21
Tech 1,2,3,4	1,605	4,578	35.1%	18.6%	38	711	2,211	32.2%	19.5%	21

Williston Basin—North Dakota Production Totals

North Dakota Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	723	3,633	19.9%	-	43	194	1,044	18.6%	-	8
Tech 1	864	3,633	23.8%	3.9%	43	224	1,106	20.3%	1.7%	9
Tech 2	909	3,633	25.0%	5.1%	43	265	1,262	21.0%	2.4%	11
Tech 3	791	3,633	21.8%	1.9%	43	364	1,731	21.0%	2.4%	16
Tech 4	901	3,633	24.8%	4.9%	43	423	1,731	24.4%	5.9%	16
Tech 1,2	1,109	3,633	30.5%	10.6%	43	323	1,262	25.6%	7.0%	11
Tech 1,3	961	3,633	26.5%	6.6%	43	422	1,731	24.4%	5.8%	16
Tech 1,4	1,088	3,633	30.0%	10.1%	43	484	1,731	27.9%	9.4%	16
Tech 2,3	962	3,633	26.5%	6.6%	43	450	1,829	24.6%	6.0%	18
Tech 2,4	1,073	3,633	29.5%	9.6%	43	415	1,549	26.8%	8.2%	17
Tech 3,4	956	3,633	26.3%	6.4%	43	456	1,752	26.0%	7.5%	17
Tech 1,2,3	1,179	3,633	32.5%	12.6%	43	512	1,829	28.0%	9.4%	18
Tech 1,2,4	1,318	3,633	36.3%	16.4%	43	473	1,549	30.6%	12.0%	17
Tech 1,3,4	1,145	3,633	31.5%	11.6%	43	531	1,752	30.3%	11.8%	17
Tech 2,3,4	1,145	3,633	31.5%	11.6%	43	543	1,829	29.7%	11.1%	18
Tech 1,2,3,4	1,395	3,633	38.4%	18.5%	43	607	1,829	33.2%	14.6%	18

Williston Basin—South Dakota Production Totals

South Dakota Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	10	93	0.0%	-	1	-	-	0.0%	-	-
Tech 1	10	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 2	21	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 3	20	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 4	22	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 1,2	27	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 1,3	25	93	27.1%	27.1%	1	-	-	0.0%	0.0%	-
Tech 1,4	22	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 2,3	22	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 2,4	24	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 3,4	23	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 1,2,3	28	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 1,2,4	24	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 1,3,4	23	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 2,3,4	25	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-
Tech 1,2,3,4	25	93	0.0%	0.0%	1	-	-	0.0%	0.0%	-

Appendix B
Near Miscible Results by State

Near-Miscible CO_2-EOR—Results by State

Arkansas Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	29	506	5.7%	-	4	21	207	10.4%	-	2
Upside	42	506	8.3%	2.6%	4	36	382	9.3%	-1.1%	3

California Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	485	7,897	6.1%	-	14	25	314	7.9%	-	3
Upside	680	7,897	8.6%	2.5%	14	275	3,015	9.1%	1.2%	6

Illinois Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	14	203	6.7%	-	4	6	58	10.8%	-	1
Upside	17	203	8.6%	1.8%	4	8	58	13.3%	2.5%	1

Near-Miscible CO_2-EOR - - Results by State

Kansas Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	38	242	15.9%	-	1	38	242	15.9%	-	1
Upside	41	242	16.9%	1.0%	1	41	242	16.9%	1.0%	1

Kentucky Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	5	245	2.1%	-	2	-	-	0.0%	-	-
Upside	10	245	4.1%	2.0%	2	-	-	0.0%	0.0%	-

Louisiana Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	10	190	5.4%	-	1	-	-	0.0%	-	-
Upside	24	190	12.6%	7.2%	1	24	190	12.6%	12.6%	1

Near-Miscible CO_2-EOR—Results by State

Mississippi Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	4	149	2.5%	-	2	-	-	0.0%	-	-
Upside	7	149	4.6%	2.1%	2	-	-	0.0%	0.0%	-

Montana Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	14	317	4.3%	-	2	4	54	7.4%	-	1
Upside	23	317	7.1%	2.9%	2	5	54	8.4%	1.0%	1

North Dakota Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	7	96	7.7%	-	1	7	96	7.7%	-	1
Upside	9	96	9.9%	2.2%	1	9	96	9.9%	2.2%	1

Near-Miscible CO_2-EOR—Results by State

Ohio Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	16	123	13.2%	-	2	16	123	13.2%	-	2
Upside	20	123	16.3%	3.0%	2	20	123	16.3%	3.0%	2

Oklahoma Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	662	3,940	16.8%	-	5	662	3,940	16.8%	-	5
Upside	843	3,940	21.4%	4.6%	5	843	3,940	21.4%	4.6%	5

Pennsylvania Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	30	310	9.7%	-	4	27	215	12.7%	-	2
Upside	39	310	12.6%	2.8%	4	34	215	16.0%	3.3%	2

Near-Miscible CO_2-EOR—Results by State

Texas Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	1,136	13,456	8.4%	-	22	957	7,210	13.3%	-	8
Upside	1,521	13,456	11.3%	2.9%	22	1,187	7,504	15.8%	2.5%	10

West Virginia Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	8	136	6.2%	-	3	7	70	9.7%	-	2
Upside	11	136	8.3%	2.0%	3	9	70	12.2%	2.6%	2

Wyoming Next Generation Technology Case Results										
	Technical					Economic @ $85/Bbl; $40/mt				
Technology Case	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields	Oil (MMBbl)	OOIP (MMBbl)	Recovery %	Incremental %	# Fields
Base Case	72	1,681	4.3%	-	10	26	385	6.7%	-	3
Upside	115	1,681	6.8%	2.6%	10	69	667	10.3%	3.6%	5

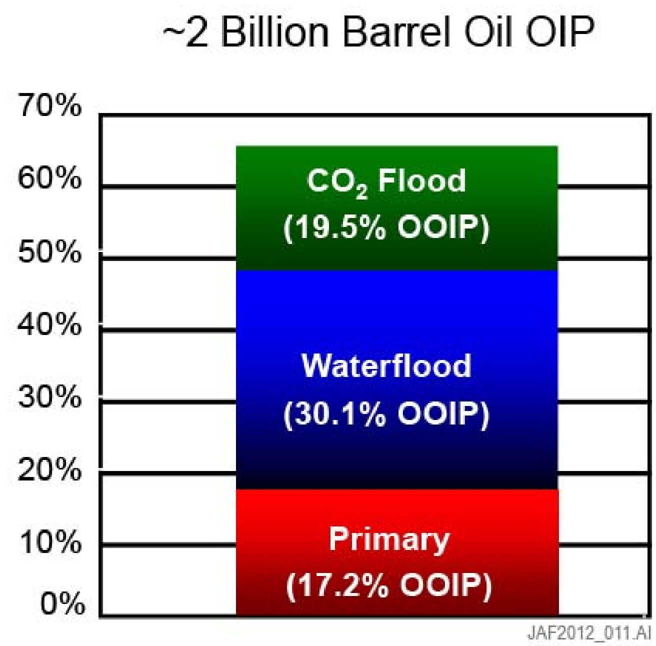
Appendix C:
Case Study Applying the Five Technology Areas of Next Generation CO2 EOR to a Reservoir in the Permian Basin

Permian Basin CO_2-EOR Case Study

"What Does a Successful CO_2-EOR Project Look Like?"

- CO_2 injection into the Denver Unit of the giant Wasson (San Andres) oil field began in 1985.
- Before the start of CO_2-EOR, oil production had declined from 90,000 B/D to 40,000 B/D and was on pace to decline to below 1,000 B/D in the next 20 years.
- After the CO_2 flood, oil production rebounded to 50,000 B/D.
- Today, twenty four years later, the Denver Unit still produces 30,000 B/D.

Denver Unit, Wasson Field*
Oil Recovery



Source: Advanced Resources International, Inc., 2013

"Example" San Andres Reservoir

To illustrate the impact on oil recovery and CO_2 storage of using SOA versus "Next Generation" CO_2-EOR technologies, we selected an "example" San Andres oil reservoir in the Permian Basin.

The "example" oil reservoir has oil viscosity of 1.43 cp, a Dykstra-Parsons heterogeneity co-efficient of 0.81, and an oil saturation in the swept zone of 30% with a Bo of 1.05%.

The "example" oil reservoir has 2,372 million barrels of original oil in-place (OOIP). The reservoir is near-depleted, with 98% of its 932 million barrels of ultimate primary/secondary recovery already produced. The oil recovery efficiency for this light oil (33^{o} API) reservoir is 39% of OOIP.

With 1,440 million barrels of remaining oil in-place and a minimum miscibility pressure of 1,450 psi, compared to a maximum allowable reservoir pressure of 3,100 psi, this "example" San Andres oil reservoir is an attractive candidate for miscible CO_2-EOR.

“Example” San Andres Reservoir

Reservoir Properties	
Depth	5,200 ft
Net Pay	141 ft
Porosity	12%
Initial Oil Saturation	0.85
Initial FVF	1.31
Initial Pressure	1,850 psi
Temperature	105^o F
Oil Gravity	33^o API
Oil Viscosity	1.43 cp

Oil Resource and Recovery Data	
Original Oil In-Place	2,372 MMBbls
Ultimate P/S Rec.	932 MMBls
Ultimate Recovery Eff.	39%
Swept Zone Sor	0.30
Current FVF	1.05
P/S Sweep Efficiency	70%
“Unswept” Zone Sor	0.45
Min. Miscibility Pressure	1,450 psi
Dykstra-Parsons	0.81

Base Case: State of Art (SOA) CO_2-EOR

As the starting point, we modeled one 40 acre pattern in the "example" San Andres oil reservoir with PROPHET2 under "State of Art" (SOA) CO_2-EOR technology using 1 HCPV of CO_2 injection and a tapered WAG.

The technical oil recovery from this "example" oil reservoir is 611,000 barrels, produced from one, forty acre inverted 5-spot pattern.

- Overall technical oil recovery efficiency in the SOA case is 14.4% of OOIP, representative of a geologically favorable San Andres oil reservoir developed with current CO_2-EOR practices.
- The net (purchased) CO_2 to oil ratio is 8.0 Mcf of CO_2 per barrel (2.4 barrels of oil per metric ton) of technically recovered oil (Mcf/BO), with a gross CO_2 to oil ratio of 17.4 Mcf/BO.

Example Permian Basin (San Andres) Oil Reservoir: One 40-Acre "Type Pattern"

The CO_2 flood (recovering 611,000 barrels from a 40 acre "type pattern") is economically viable, at $85 per barrel oil price, a purchased CO_2 cost of $40/mt ($2.13 per Mcf), and a minimum financial threshold of 20% ROR (before tax).

	Total	Per Barrel
Capex ($MM)	$2.9	$4.77
CO_2 Cost ($MM)	$12.1	$19.82
O&M Cost ($MM)	$3.7	$6.04
Total	$18.7	$30.63

The project does not include a NGL capture facility (e.g., Ryan-Holmes) and re-injects the produced CO_2 after recovering the liquid hydrocarbons and dehydrating the CO_2.

4B. Analytical Results #1— "Next Generation"

"Example" San Andres Oil Reservoir

Example Permian Basin (San Andres) Oil Reservoir: One 40-Acre "Type Pattern"

The application of "next generation" CO_2-EOR technologies to the example Permian Basin (San Andres) oil reservoir shows that "Advanced CO_2 Flood Design (Tech #2)" has the biggest impact (in terms of increase in oil recovery efficiency, RE).

Next, in terms of importance: Improved Reservoir Conformance (Tech #1); Increased Volumes of Efficiently Used CO_2 (Tech #4); and Enhanced Mobility Control (Tech #3).

The impact, in terms of change over "Base Case" oil recovery efficiency (RE) for each of the four technologies, applied singly, is shown below:

- Advanced CO_2 Flood Design — +4.8% OOIP
- Improved Reservoir Conformance — +3.5% OOIP
- Increased Volumes of Efficiently Used CO_2 — +2.1% OOIP
- Enhanced Mobility Control — +0.2% OOIP

Example Permian Basin (San Andres) Oil Reservoir: One 40-Acre "Type Pattern"

	Technical Oil Recovery (M bbls)	Recovery Efficiency (%OOIP)	Impact: Change Over Base Case (% OOIP)
I. Base Case (State of Art)	611	14.4%	-
II. "Next Generation" Technologies			
Tech #1. Improved Reservoir Conformance	764	17.9%	+3.5%
Tech #2. Advanced CO_2 Flood Design	818	19.2%	+4.8%
Tech #3. Enhanced Mobility Control	620	14.6%	+0.2%
Tech #4. Increased Volumes of Efficiently Used CO_2	701	16.5%	+2.1%

NETL

Example Permian Basin (San Andres) Oil Reservoir: One 40-Acre "Type Pattern"

The dual application of "next generation" CO_2-EOR technologies further improves oil recovery efficiency.

The combination of Technology #1 (Reservoir Conformance) and Technology #2 (Advanced CO_2 Flood Design) provides the biggest impact (9.6% increase in RE).

Importantly, we see a synergistic beneficial impact from dual application of technologies. For example, the combined application of Tech #1 and Tech #2 provides a larger improvement of 9.6% in RE than the summed single application of these two technologies (8.3%).

The dual application of Technology #2 (Advanced CO_2 Flood Design) and Technology #4 (Increased Volumes of Efficiently Used CO_2) provides the second largest impact - - 7.1% increase in RE.

Example Permian Basin (San Andres) Oil Reservoir:
One 40-Acre "Type Pattern"

	Technical Oil Recovery (M bbls)	Recovery Efficiency (%OOIP)	Impact: Change Over Base Case (% OOIP)
I. Base Case (State of Art)	611	14.4%	-
II. "Next Generation" Technologies			
Technologies #1 and #2	1,023	24.0%	+9.6%
Technologies #1 and #3	775	18.2%	+3.8%
Technologies #1 and #4	905	21.3%	+6.9%
Technologies #2 and #3	860	20.2%	+5.8%
Technologies #2 and #4	914	21.5%	+7.1%
Technologies #3 and #4	724	17.0%	+2.6%

Example Permian Basin (San Andres) Oil Reservoir:
One 40-Acre "Type Pattern"

The combined application of three of the "next generation" CO_2-EOR technologies shows continued improvements in oil recovery efficiency as well as synergistic benefits from their combined use:

- The largest impact, in terms of improvement in RE of 13.3% OOIP, is from combined application of Technologies #1 (Improved Reservoir Conformance), #2 (Advanced CO_2 Flood Design), and #4 (Increased Volumes of Efficiently Used CO_2).
- The synergistic benefit of jointly using the three best technologies is demonstrated by the increase in RE (over the Base Case) of 13.3% compared to the summed single application of these three technologies of an increase in RE of 10.4%.

Use of all four technologies in combination provides an increase in RE (over the Base Case) of 15.8%, compared to the increase in RE from summed single application of the four individual technologies (10.6%).

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Example Permian Basin (San Andres) Oil Reservoir: One 40-Acre "Type Pattern"

	Technical Oil Recovery (Mbbl)	Recovery Efficiency (%OOIP)	Impact: Change Over Base Case (% OOIP)
I. Base Case (State of Art)	611	14.4%	-
II. "Next Generation" Technologies			
Technologies # 1, #2 and #3	1,075	25.2%	+10.8%
Technologies # 1, #2 and #4	1,180	27.7%	+13.3%
Technologies # 1, #3 and #4	953	22.4%	+8.0%
Technologies # 2, #3 and #4	999	23.5%	+9.1%
Technologies # 1, #2, #3 and #4	1,286	30.2%	+15.8%

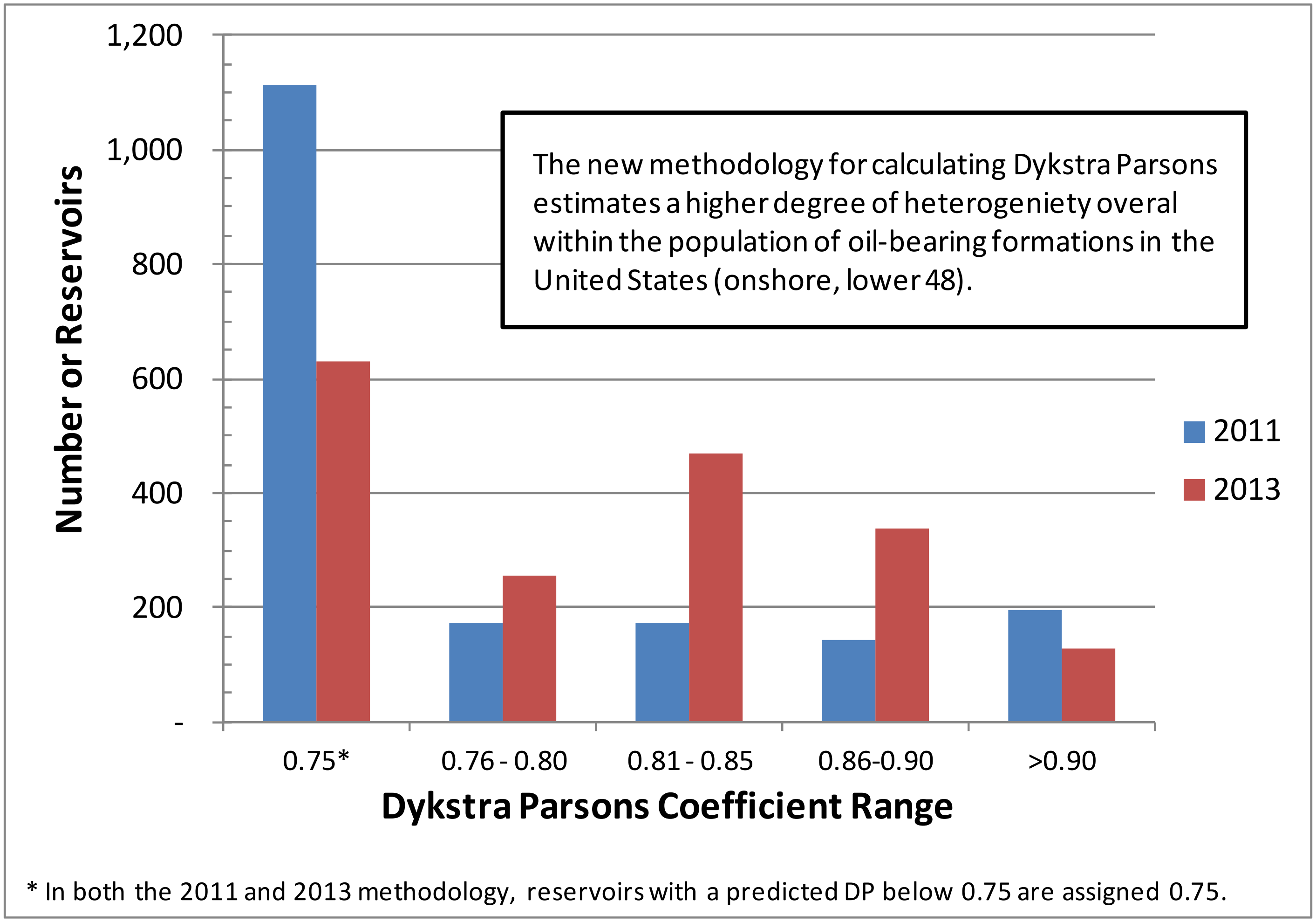
Appendix D:
Supplemental Information

Modifications Since the Last Resource Assessment

The 2011 CO_2-EOR Resource Assessment determined a recoverable resource of 24 billion barrels of oil using State of the Art Technology from the lower 48 States. This study updated that target amount to 20 billion barrels due to several study modifications:

- Dykstra-Parsons values in the Data Base are calculated based on recovery efficiency. Previously, historical Dykstra-Parsons values from reservoir studies were used in the oil recovery model. Calculated values give a more rigorous estimation of reservoir heterogeneity, which affects recovery efficiency.
- The PROPHET2 oil recovery model has been modified since the last Resource Assessment to calculate CO_2 "losses" in the reservoir. Previously, a base loss percentage was assumed for all reservoirs. This modification accurately determines volumes of purchased and recycled CO_2.
- Several cost elements were updated for this study including well CAPEX and CO_2 recycling costs.
- The oil recovery model assumes that the residual oil left in the pore space fully swept by CO_2 injection (S_{orm}) is 10%. The previous State of the Art case assumed the S_{orm} value to be 8%. This value was changed to account for the lesser amount of CO_2 injection modeled in this study.

Revised Dykstra Parsons Methodology



CO_2-EOR Model Features

The CO_2-EOR model incorporates the following functions:

- The oil recovery model assumes that the residual oil left in the pore space fully swept by CO_2 injection (S_{orm}) is 10%.
- The model uses a tapered WAG, starting with an initial large slug of CO_2 before introducing water for mobility control.
- The model accounts for injected CO_2 dissolved in the reservoirs water or oil and losses of CO2 outside of the pattern (10%), precluding this injected CO_2 from being available as recycled CO_2 for meeting total CO_2 injection needs.
- The analysis assumes that the thinner, edge areas of the oil field, accounting for 20% of reservoir area and 10% of the OOIP, will not be feasible for application of CO_2-EOR.
- An economic truncation algorithm (comparing annual revenues with annual costs) halts project operation and CO_2 injection once annual cash flow becomes negative after 15 years.

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Cost and Economics Models

Cost Model. A detailed, up-to-date CO_2-EOR Cost Model is used by the study, which includes capital costs for: (1) drilling new wells or reworking existing wells; (2) providing surface equipment for new wells; (3) installing the CO_2 recycle plant; (4) constructing a CO_2 spur-line from the main CO_2 trunkline to the oil field; and (5) other costs.

The cost model accounts for normal well operation and maintenance (O&M), for lifting costs of the produced fluids, and for costs of capturing, separating and reinjecting the produced CO_2.

The cost model also incorporates the extra costs of implementing the various next generation CO_2-EOR technologies, as further discussed on the following pages.

Economic Model. The economic model is an industry standard cash flow model that is run on both a pattern and a field-wide basis. The economic model accounts for royalties, severance and ad valorem taxes, as well as any oil gravity and market location discounts (or premiums) from the "marker" oil price.

Next Generation Technology Costs

To model each Next Generation Technology case, additional capital and O&M expenditures have been incorporated into the economics to account for costs of implementing each technology.

These include costs for reservoir characterization, reservoir and well monitoring, well maintenance, injectivity maintenance and mobility control.

Next Generation Technology Costs

Reservoir Characterization: Several of the Next Generation technologies require new logs and coring to more rigorously characterize the reservoir. Additional characterization costs are:

- Coring sample: $200,000/sq mi
- Coring analysis: $100,000/sq mi
- Total coring costs: $300,000/sq mi
- Reservoir logging: $150,000/sq mi

Reservoir Monitoring: Several Next Generation technologies also require reservoir monitoring, surveillance and control during operation of the CO_2 flood to track CO_2 pathways and optimize flood performance.

- Seismic survey: $130,000/sq mi/yr (performed years 1-5, 8, 11, 14 of the flood)
- Spinner survey: $10,000/well/yr (performed each year of thief zone flood time)
- Fiber optics: $400,000/sq mi/yr (year 1 of flood)

Next Generation Technology Costs

Flow Path Diversion: For reservoir conformance (Technology #1), placement of the flow diversion materials will require use of a workover rigs and diversion materials:

- Workover rig and materials: $67,000/injector

Improved Injectivity: Two of the Next General technologies require the creation of higher CO_2 and water injectivity (processing rate).

- Small tip-screenout frac: $60,000/injector

Mobility Control: Enhanced mobility control will require the addition of polymers to the injection water. The amount of polymers is based on raising the viscosity of water to 2.0 centipoise.

- Polymers: $0.21/bbl injected water

Next Generation Technology Costs

	Reservoir Characterization		Improved Injectivity	Monitoring, Diagnostics and Control			Flow Path Diversion	Mobility Control
	Logs	Coring	Single Frac	Seismic Survey	Spinner Survey	Fiber Optics	Workover Rig	Polymer
Technology #1. Improved Reservoir Conformance	✓	✓			✓	✓	✓	
Technology #2. Advanced CO_2 Flood Design	✓	✓		✓				
Technology #3. Enhanced Mobility Control			✓					✓
Technology #4. Increased Volumes of Efficiently Used CO_2			✓	✓	✓			

Next Generation Technology Costs

Technology #1	Coring	$19,000.00	
Improved Reservoir	Logs	$9,000.00	
Conformance	Spinner Survey	$98,000.00	($11,000/yr x 9 years)
	Fiber Optics	$25,000.00	
	Rig/Materials	$67,000.00	
		$218,000.00	
Technology #2	Additional Injector	$946,000.00	
Advanced CO2 Flood	Coring	$19,000.00	
Design	Logs	$9,000.00	
	Seismic Survey	$65,000.00	($8,100/yr x 8 years)
		$1,039,000.00	
Technology #3	Single Frac	$60,000.00	
Enhanced Mobility Control	Polymer	$773,000.00	(3.7 MMBbl water @ $0.21/bbl)
		$833,000.00	
Technology #4	Incremental		
	Purchased CO2	$4,491,000.00	(2,108 MMcf @ $2.12/Mcf)
Increased Volumes of	Incremental		
Efficiently Used CO2	Recycled CO2	$959,000.00	(3,197 MMcf @ $0.30/Mcf)
	Single Frac	$60,000.00	
	Seismic Survey	$65,000.00	($8,100/yr x 8 years)
	Spinner Survey	$98,000.00	($11,000/yr x 9 years)
		$5,673,000.00	(Additional CO2)

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The information is for technology costs for a representative 40 acre pattern.

The CO_2 flood injects approximately 3.7 MMbbl water, purchases 5,175 MMcf CO_2, and recycles 5,434 MMcf CO_2 over a 25 year flood.

The implementation of Tech #1, Improved Reservoir Conformance (to block the "thief zone"), occurs in year 9.

The placement of the additional CO_2 injector (Tech #2) occurs in year 1.

The use of polymers occurs in each year of water injection.

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