DOE Perspective on CCUS and EOR

Workshop on California Opportunities for CCUS and EOR:
Challenges & Policy Requirements

June 27, 2012

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Meeting the President's Energy Goals

"This country needs an all-out, all-of-the-above strategy that develops every available source of American energy. A strategy that's cleaner, cheaper, and full of new jobs."

President Barack Obama
State of the Union Address
January 24, 2012

Photo courtesy of the White House, Pete Souza

Responding to New Realities - CCUS

No carbon legislation

Oil @ $100/bbl

Low cost natural gas from shale

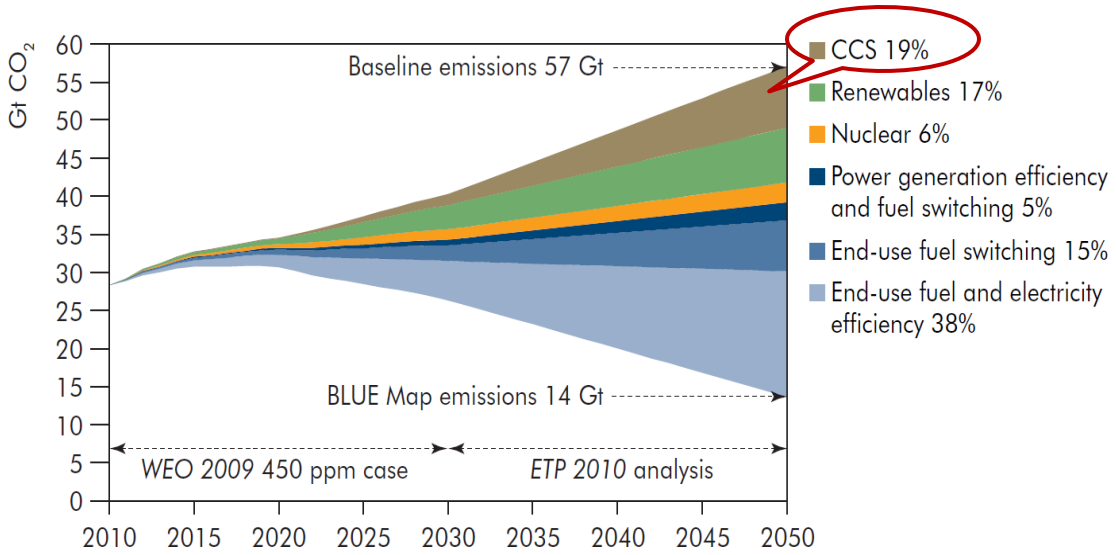
CO_2 capture costs must be driven to business case economics

CCUS is a business-driven path to promote CO_2 capture and storage

Strong incentive to pursue carbon capture and storage

CCUS Meets National and International Climate Goals

- President Obama: By 2050, 83% reduction in GHG emissions from 2005 levels
- IEA:"application of CCS… represents potentially the most important new technology option for reducing direct emissions in industry."



Source: IEA. Energy Technology Perspectives 2010

No CCS? – Game over on Climate Change

Supported by the Environmental Community

*…at present, no other technology comes close to matching the potential of CCS in the fight against global warming…**If we don't implement** carbon capture and storage," says John Thompson of the Clean Air Task Force, an environmental advocacy group, "**it's probably game over on climate change**."*

Excerpted from "What's Killing Carbon Capture?"
by Ken Wells and Ben Elgin in Bloomberg Businessweek
July 21, 2011

CLEAN AIR TASK FORCE

United Nations

NRDC
THE EARTH'S BEST DEFENSE

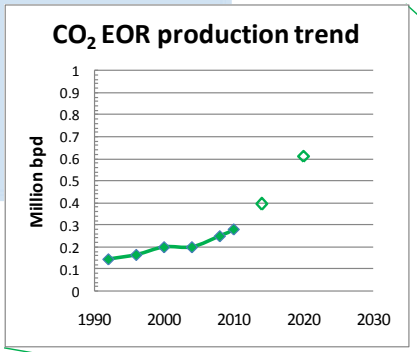
CCUS – EOR

The "Un-Mined Gold" Story for Energy and Jobs

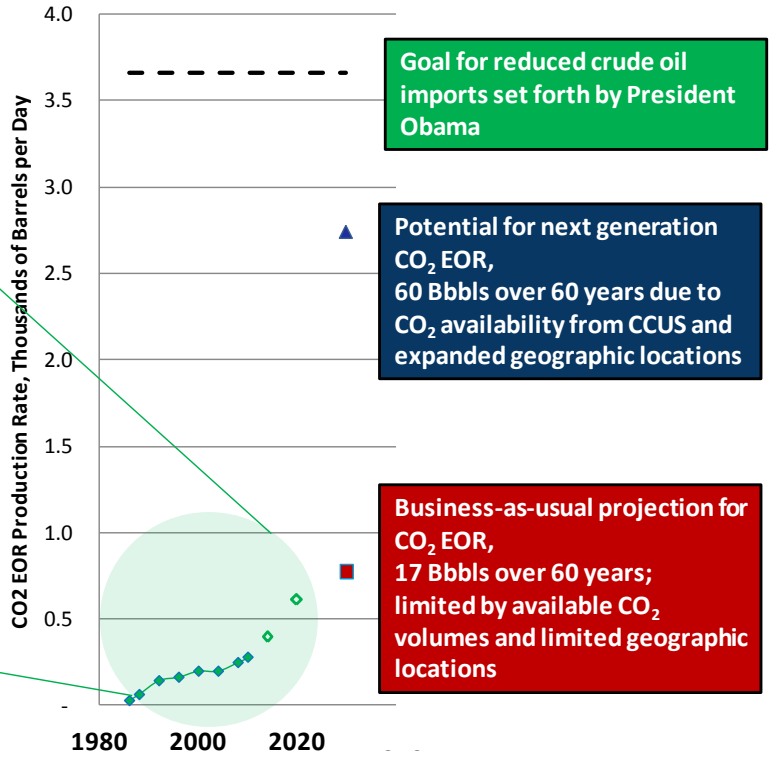
Benefits of CO_2-EOR

- **Improves Balance of Trade**
  $3.5 trillion over 60 years
- **Promotes Energy Security**
  Reduces imports by 2 MMbpd[1]
- **Increases Domestic Activity**
  $60 Billion/year (wages, royalties, taxes, profits)[1]
- **Creates Jobs**
  622,000 new jobs[1]

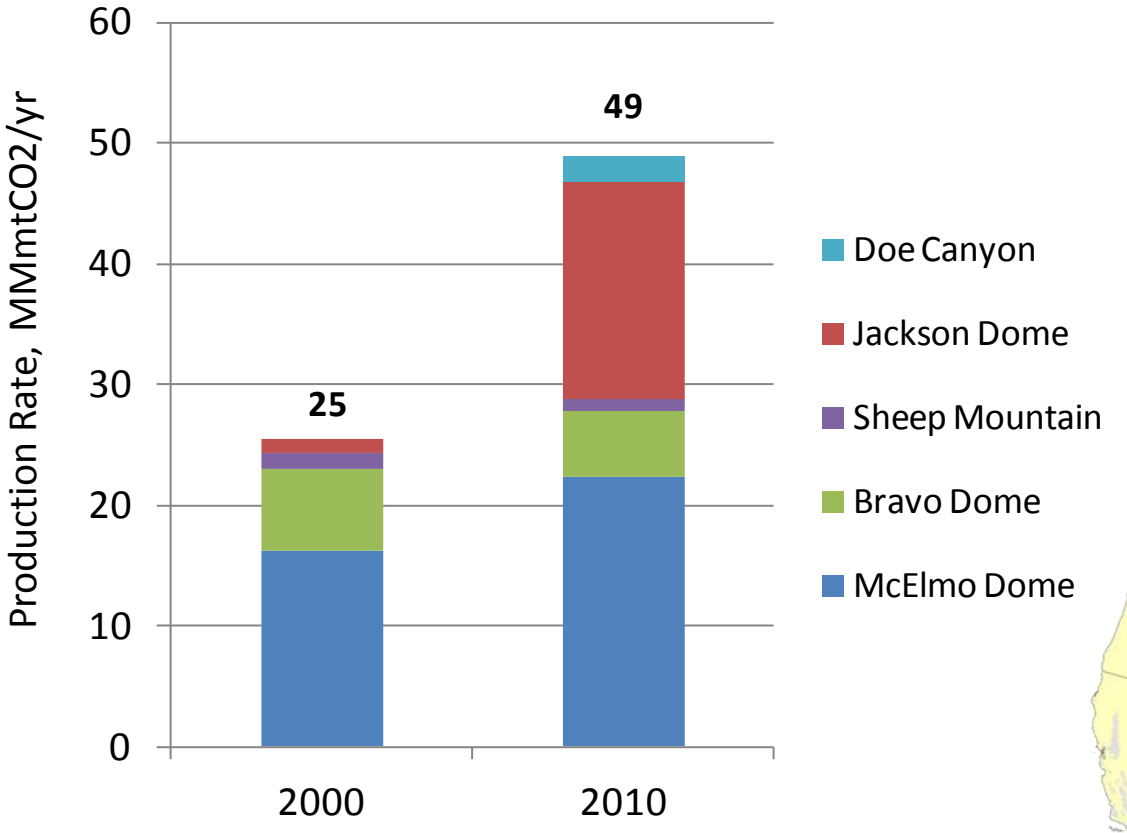
[1] Source : NETL Report, "Improving Domestic Energy Security and Lowering CO_2 Emissions with "Next Generation" CO_2 EOR," June 2011

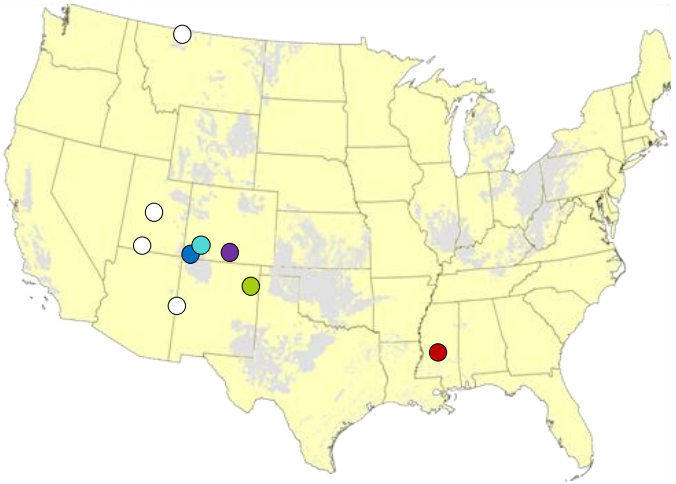


Domestic Oil Supplies and CO_2 Demand (Storage) Volumes enabled by CCUS Technology



CO_2 Production from Natural Sources

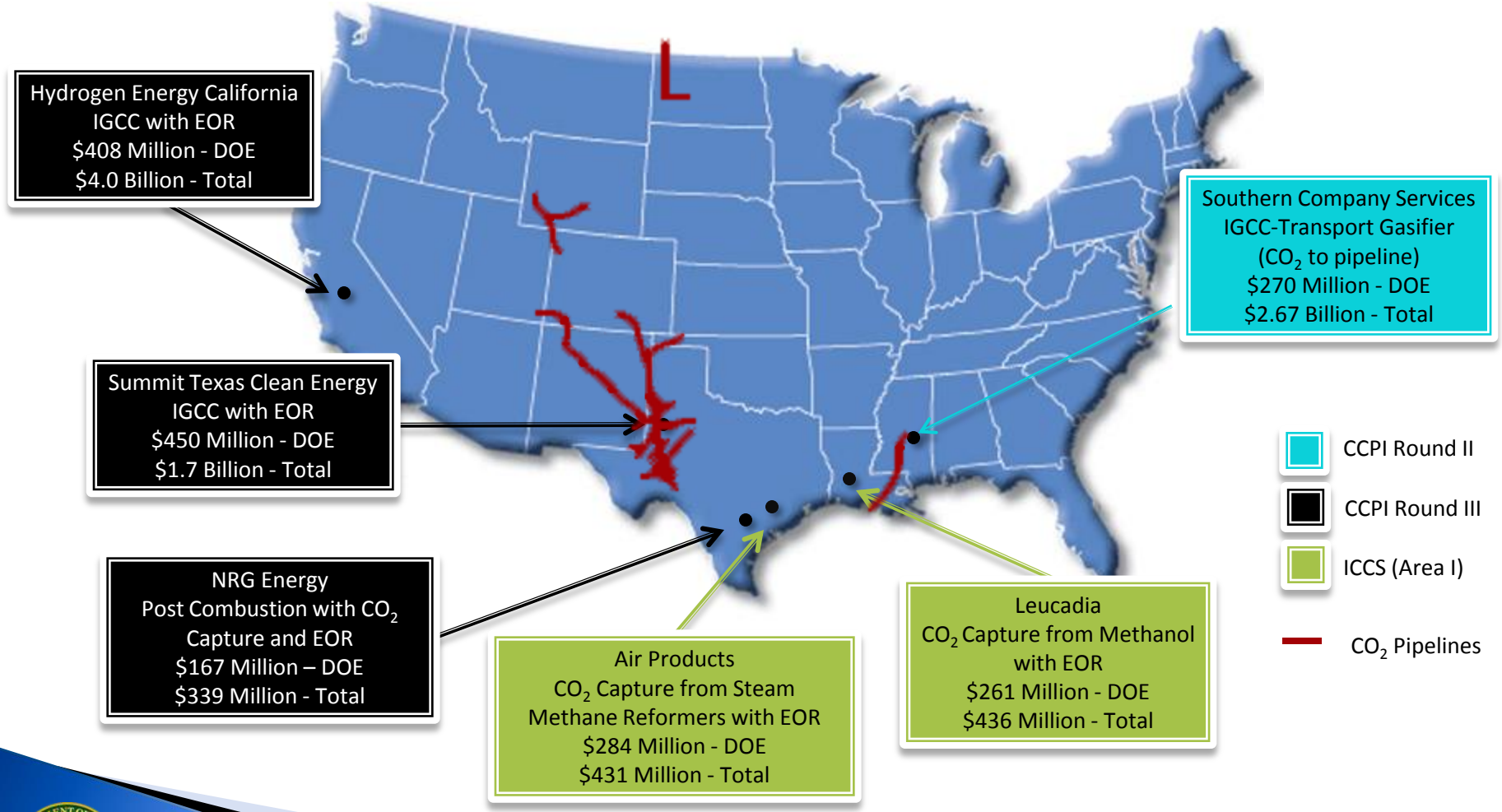




Source: DiPietro, Balash, and Wallace. 2012

Major CO_2-EOR U.S. Demonstrations

Leveraging Existing Infrastructure and Creating New Markets



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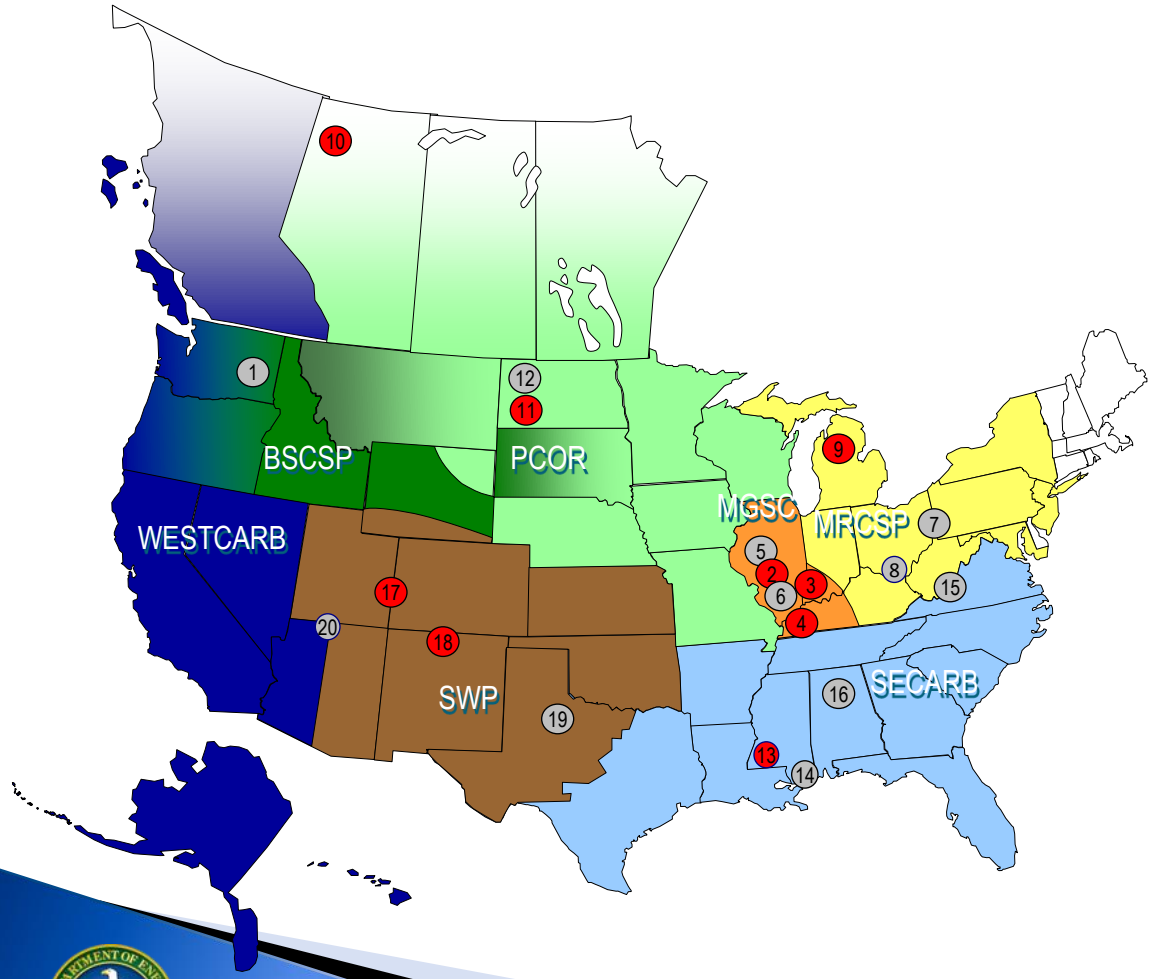
Existing Investment in CCUS

Regional Carbon Sequestration Partnerships – Validation Tests



RCSP	Formation Type
Big Sky	Saline 1
MGSC	Oil-bearing 2 3 4 Saline 5 Coal seam 6
MRCSP	Saline 7 8 Oil-bearing 9
PCOR	Oil-bearing 10 11 Coal seam 12
SECARB	Oil-bearing 13 Saline 14 Coal seam 15 16
SWP	Oil-bearing 17 18 Coal seam 19
WESTCARB	Saline 20

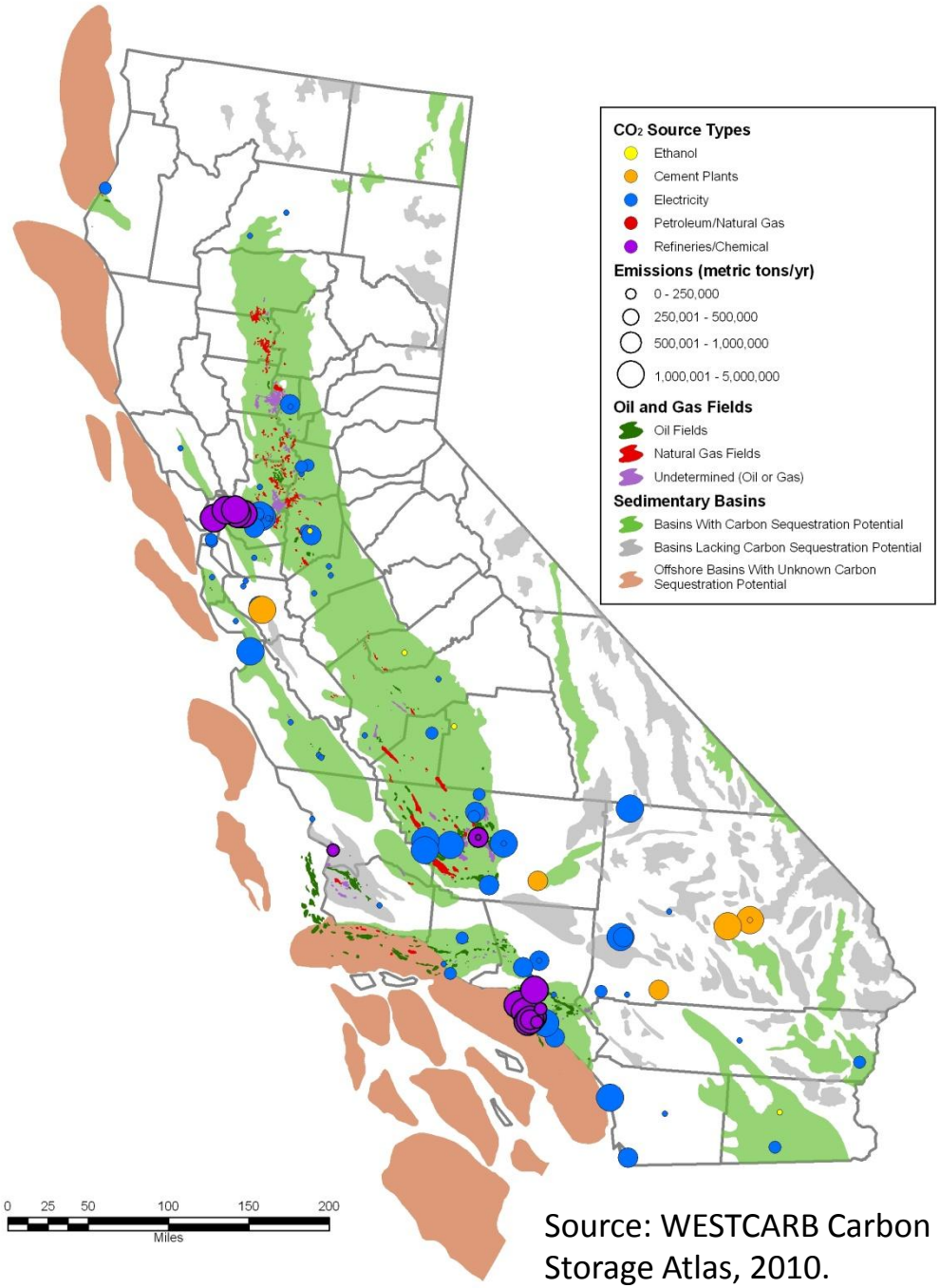
Comparison of State of the Art and Next Generation CO2-EOR Technology: Onshore California

		State of Art	"Next Generation"
Oil Recovery (Billion Barrels)			
	▪ Technical	3.1	7.9
	▪ Economic	1.2	6.7
CO_2 Demand (Million Metric Tons)			
	▪ Technical	1,340	2,320
	▪ Economic	480	1,760

- CA annual CO2 emissions: 84 million metric tons

National Energy Technology Laboratory, Improving Domestic Energy Security and Lowering CO2 Emissions with "Next Generation" CO2-Enhanced Oil Recovery (CO2-EOR), June 20, 2011.

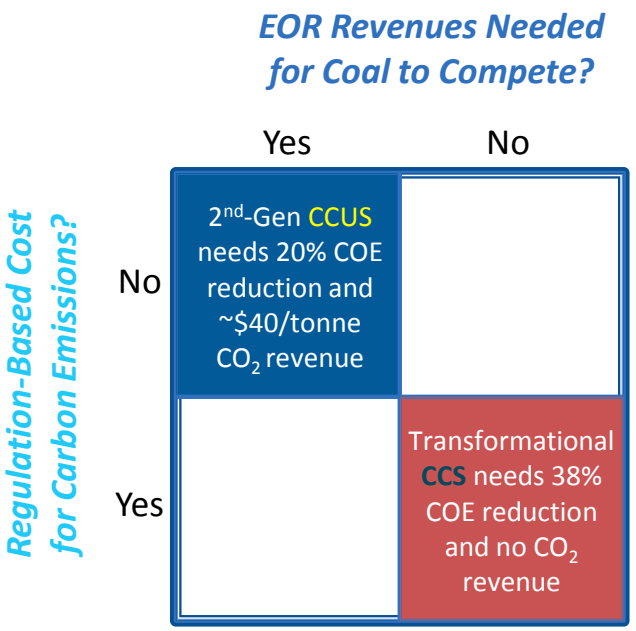
CO2 Sources and Potential Storage Opportunities in California



Source: WESTCARB Carbon Storage Atlas, 2010.

Conditions for Establishing a "Business Case" for CCUS

Matrix of Market and Policy Scenarios



COE reductions are required to compete with other baseload options in the future electricity market (e.g., NGCC and nuclear). Percent reductions are relative to today's IGCC with CCS.

- Fossil Energy's CCS Program can effectively proceed, bridging the mid-term, by Using CO_2 commercially (CCUS)
- The commercial opportunity for anthropogenic CO_2, used for EOR, is expanding rapidly, offering significant, parallel capacity for attaining the President's Energy Security Goal
- CO_2 EOR revenues in the range of $32-46/tonne will enable 2nd-Gen coal with CCUS to have COE parity with NGCC *without* CCUS.
- For all scenarios, 2nd-Gen coal with CCUS has a lower COE than NGCC *with* CCUS at any given CO_2 EOR price.

High Level Program Goals

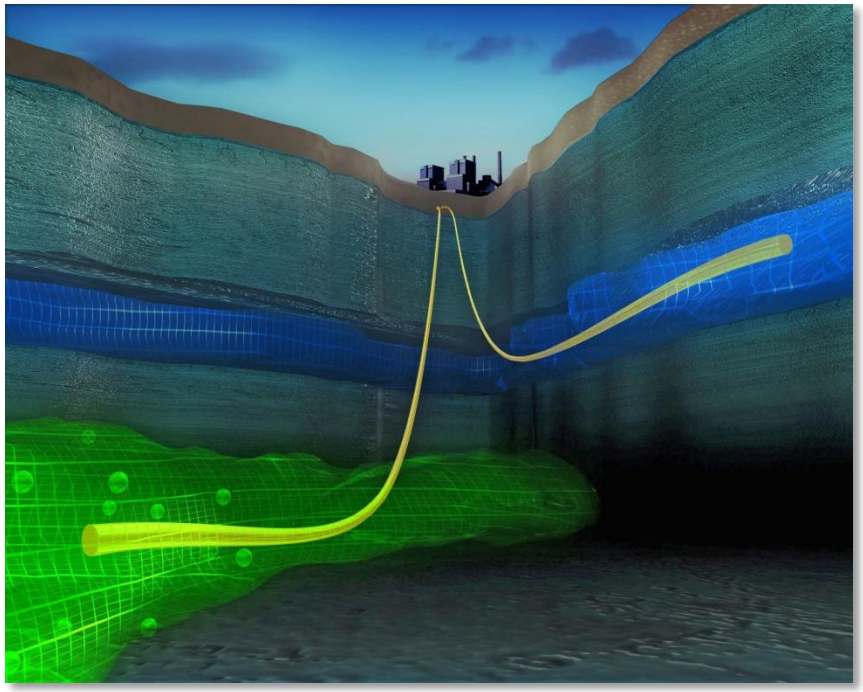
2nd Gen and Transformational Technology

Distilled to the highest level, the FE program for CCS has the following goals:

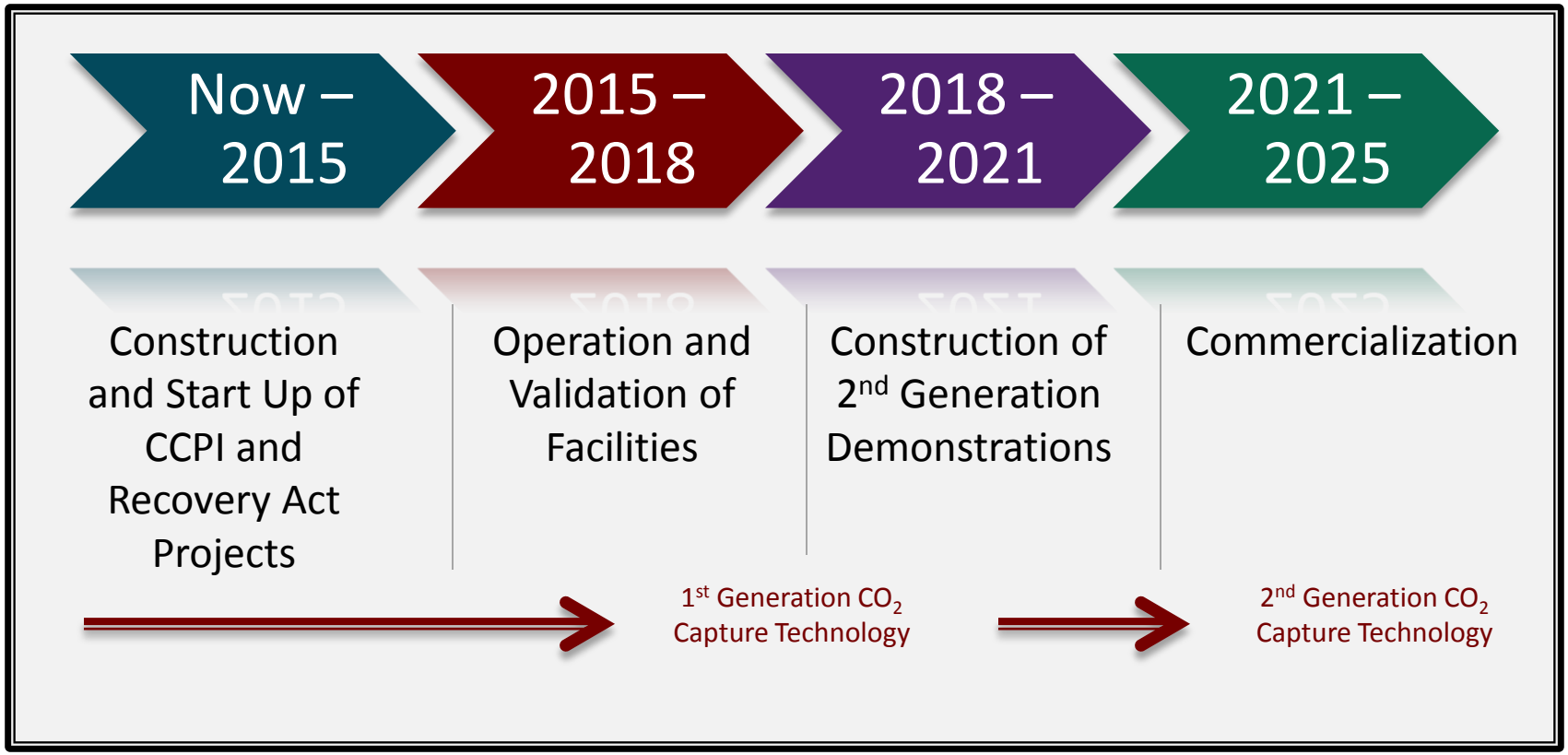
- ***2nd Generation CCUS* technology:** <$40/tonne removed CO_2 capture cost to satisfy strong EOR market opportunities, meet broad acceptance, and enable the United States to benefit from a significant increase in domestic oil production.
- ***99% monitoring and mass balance closure***: tracking CO_2 to ensure leakage from large geologic storage sites does not offset future annual emissions if/when billions of tons of CO_2 is stored.
- ***Best Practice Manuals:*** address key aspects of putting CCUS projects into commercial service on topics such as site selection and reservoir characterization, simulation and risk assessment, well bore completion and closure, monitoring verification and accounting, regulatory compliance, and public outreach and education.
- ***Transformational CCS* technology**: <$10/tonne removed CO_2 capture cost for commercial deployment to:
  - open greater domestic EOR opportunities,
  - expand beneficial utilization opportunities such as conversion of CO_2 to higher value chemicals, and
  - deliver advanced higher performance coal-fueled energy systems that reduce the cost of generating electricity by 38% relative to today's IGCC with CCS, and compete with NGCC systems under EIA's AEO 2011 Low Gas, Reference, and Macro-economic natural gas pricing scenarios (i.e., when the natural gas price is $6.70/MMBtu or higher).

Moving Forward – Next Steps

- Supplement existing oil and gas next generation EOR projects
- Continue next generation EOR R&D and new geologic discovery
- Initiate CO_2 EOR class-based demonstration
- Investigate CO_2 conversion to other value-added products
- Accelerate path to 2nd generation CO_2 capture technology
- CCUS commercialization post-2020



Moving Forward – Next Steps



Linking Business and Policy to Do the Best for America

The Environment
AND
The Economy

The Power of AND – <u>not</u> Or