Status and Policy of CCUS in US

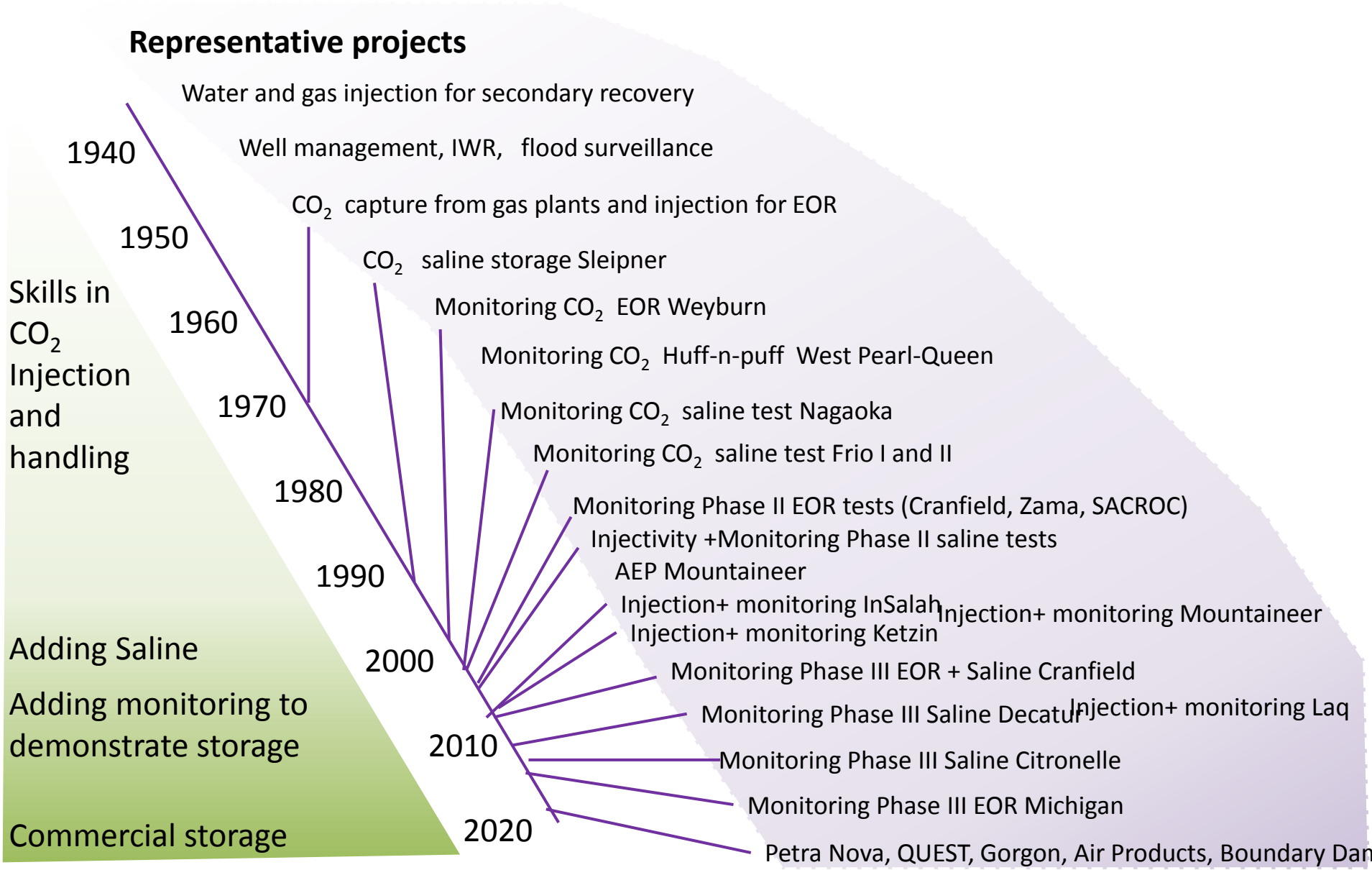
Susan Hovorka
Gulf Coast Carbon Center
Bureau of Economic Geology
Jackson School of Geosciences

CAGS3 CCS workshop in Urumqi, Xinjiang, China

Talk Outline

- Maturity of US CCS program
- Regional Carbon Sequestration Partnerships: 10 year characterization to deployment reaching conclusions
- Major integrated capture and storage projects
  - 4 our of 7 have progressed
- New ventures
  - CarbonSAFE
  - Mission Innovation
- Global collaboration
- Policy status and uncertainties

Safe and Effective Injection > 50 years

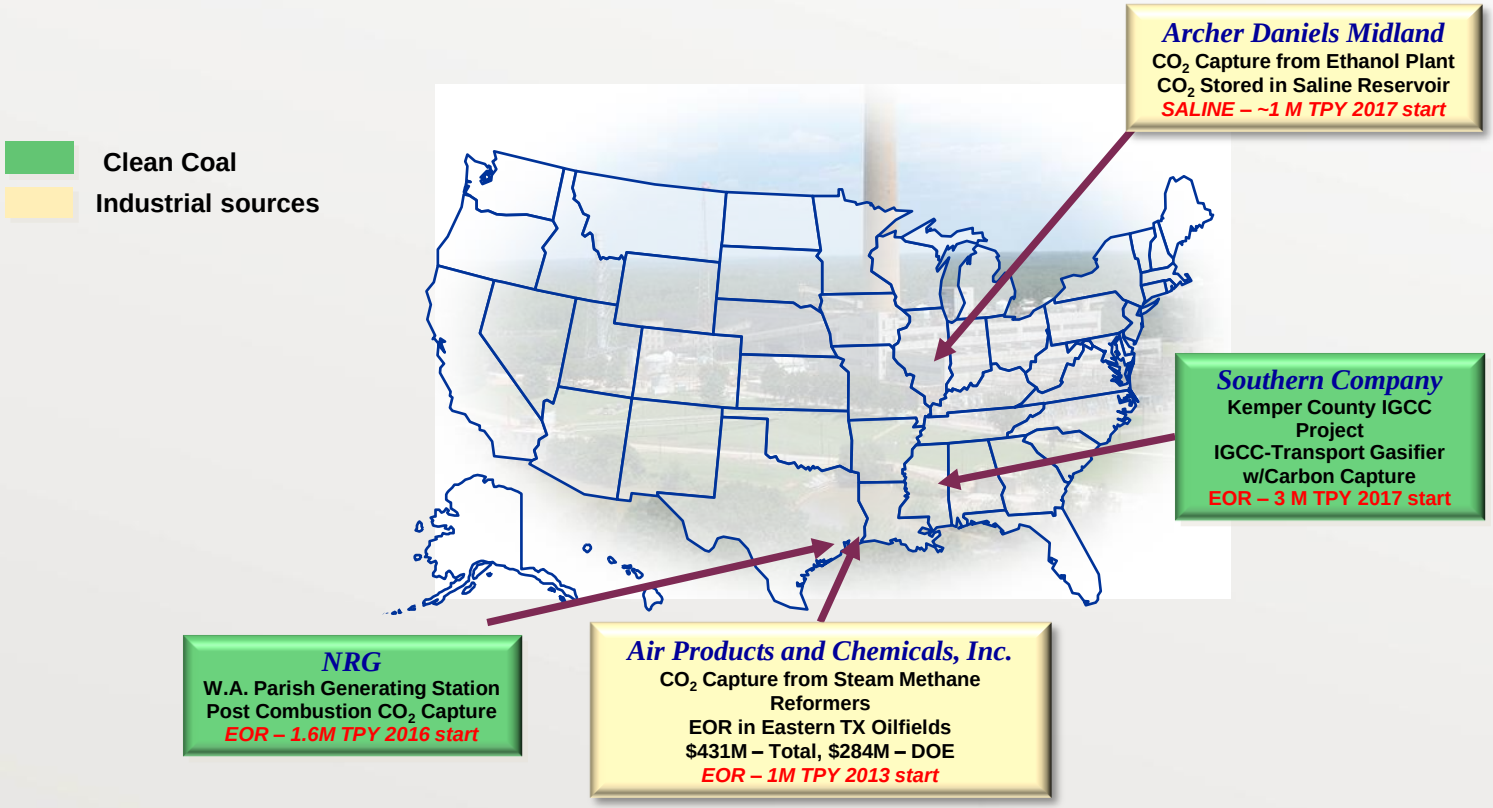


Examples of the many parts of the US CCUS program

- US Department of Energy (Fossil Energy at Headquarters)
  - Bilaterals, Carbon Sequestration leadership Forum (CSLF)
- US National Laboratories
  - National Energy Technology Lab (NETL) clean coal program, leadership oil and gas research
  - Other laboratories technology development and modeling
- Environmental Protection Agency
  - Safe drinking water act – well permitting
  - Clean Air Act– authority regulate greenhouse gasses – reporting rules
- State and municipality rules
  - Incentives and rules to favor clean energy, recently State of California has been leading
- Bureau of Ocean Management – studying offshore storage rules

Global and local progress

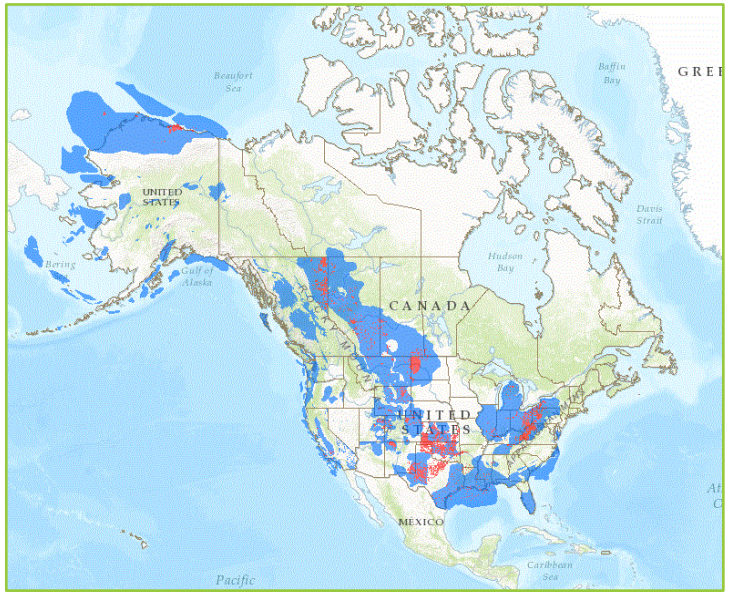
DOE's Major CCUS



Source NETL 2014, updated 2017

Carbon Storage Program
Lessons Learned

- The U.S. has a very large storage resource to exploit
- Storage can be safely integrated with capture and transportation
- A variety of geologies have proven the ability to accept CO_2 at commercial-scale injection rates
- No insurmountable scientific/technical barriers to geologic storage have been identified
- Technology advancements and field experience have increased confidence in predicting CO_2 movement and confirming confining system integrity
  - ➢ More work is required—reduce cost, risk, and increase certainty in technologies



Carbon Storage Program
Addressing Subsurface Challenges and Risk

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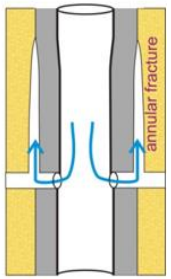
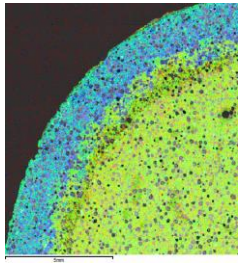
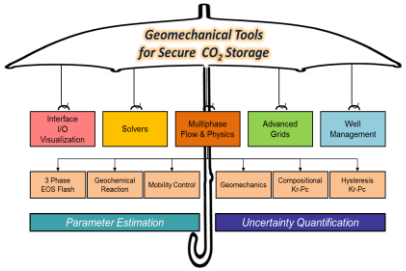
Well Integrity and Mitigation

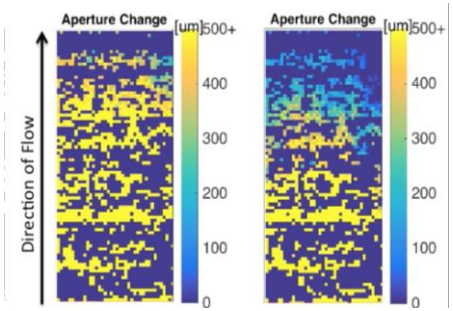




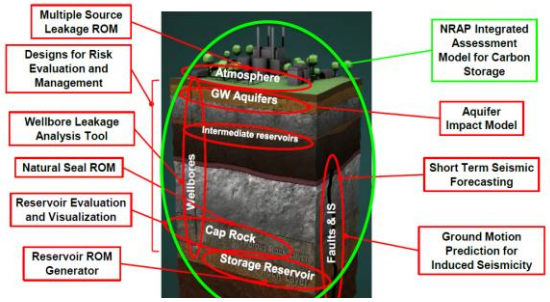
Monitoring Verification and Accounting (MVA)

Storage Complex Efficiency and Security





Risk Assessment



National Risk Assessment Partnerships
Identifying Critical Storage/Risk Relationships

Size of CO_2 plume injection

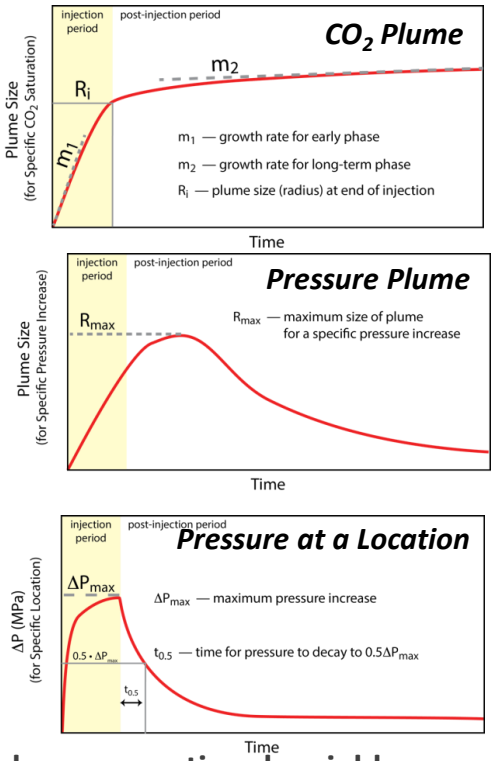
Rapid growth during injection; slower growth post injection

Size of pressure-affected plume

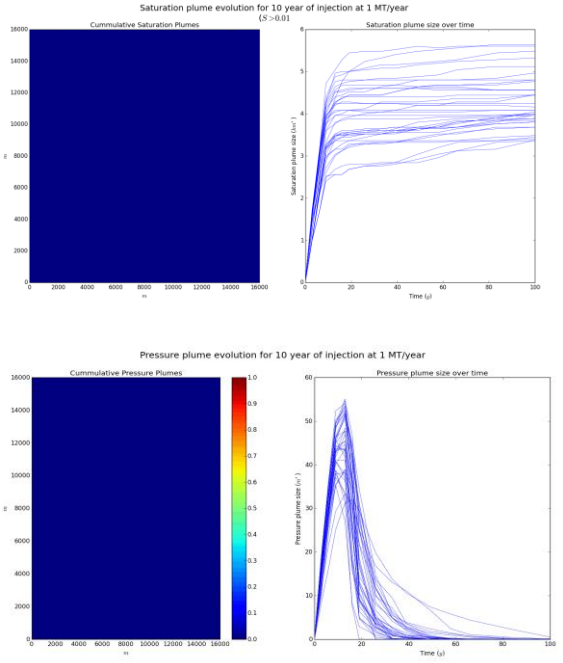
Rapid growth during injection; reaches maximum and decays post

Pressure at a location

Rapid growth during injection; rapid decline post injection



Example Results from NRAP's Reservoir Evaluation and Visualization Tool



Impact of geologic variables is on the same order as operational variables.

Bromhal et al. 2014

Subsurface Technology and Engineering R&D Crosscut (SubTER)

Wellbore Integrity		Reduce the risk of uncontrolled release of formation fluid throughout the lifecycle of a wellbore – protecting groundwater resources
Subsurface Stress & Induced Seismicity		Understanding of subsurface stress state — to predict and control potential induced seismicity
Permeability Manipulation & Fluid Control		Precise control over fracturing and fluid flow – characterize the deep subsurface and further understanding of coupled processes
New Subsurface Signals		New class of capabilities —characterize fractures and associated processes at high spatial resolution and over large operational areas

Carbon Storage Program
Addressing Larger-scale Challenges

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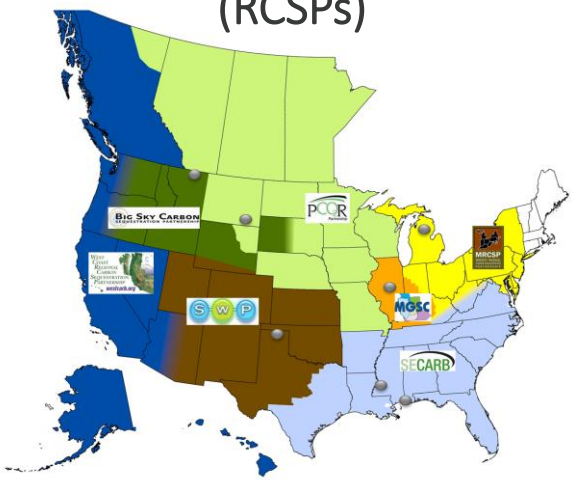
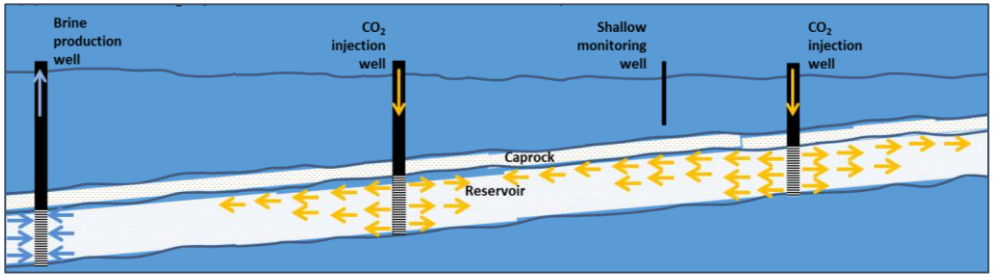
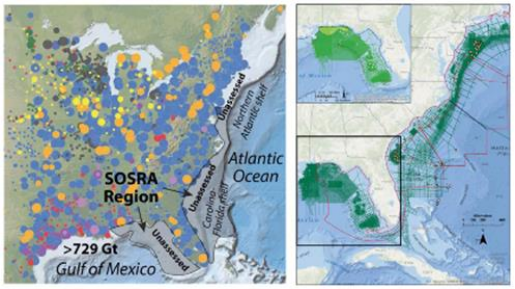
Regional Carbon Sequestration Partnerships (RCSPs)



Brine Extraction Storage Tests (BEST)



Offshore Storage



Carbon SAFE

GCCC Field Tests for Monitoring Verification and Accounting

DOE-NETL and Industry Hosts

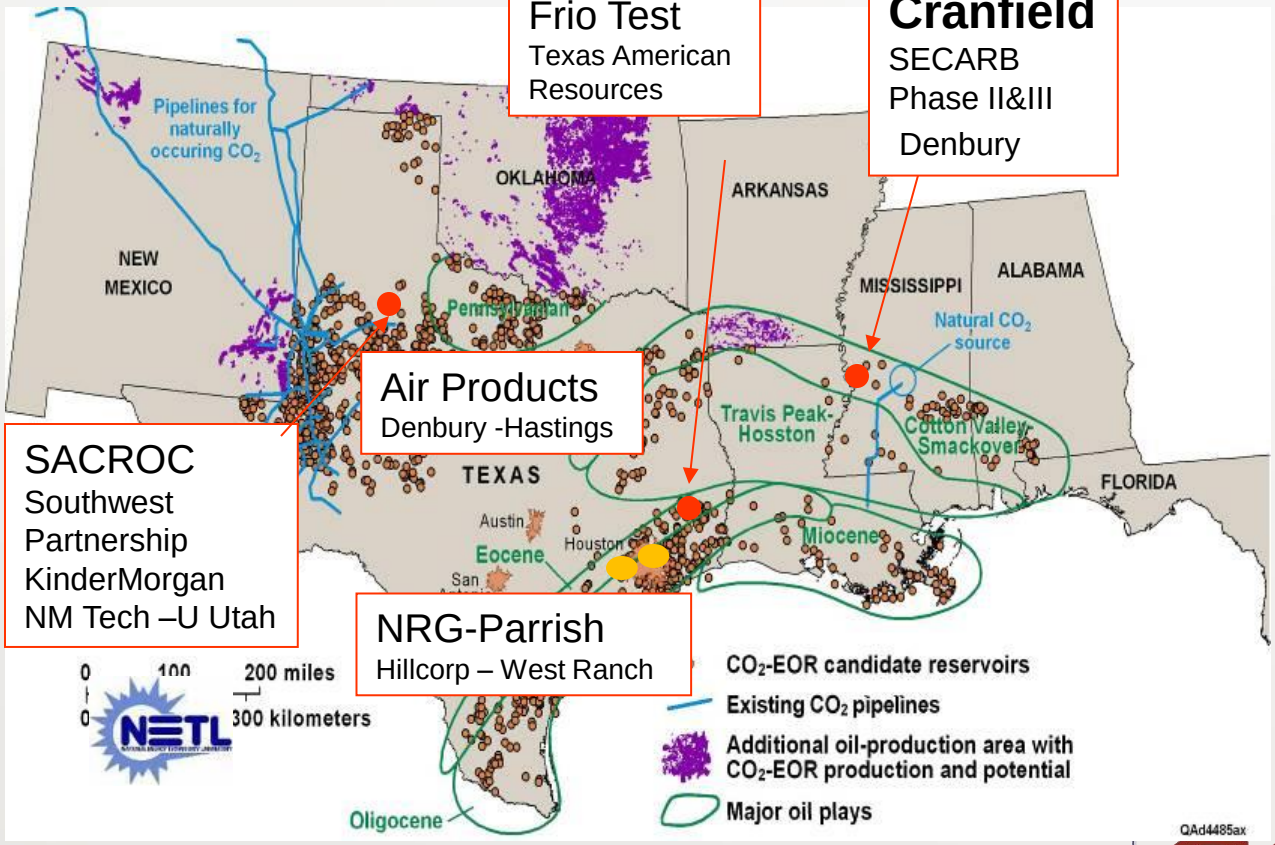
Frio Test
Texas American Resources

Cranfield
SECARB
Phase II&III
Denbury

Air Products
Denbury -Hastings

SACROC
Southwest Partnership
KinderMorgan
NM Tech –U Utah

NRG-Parrish
Hillcorp – West Ranch



SECARB
Southeast Regional Carbon Sequestration Partnership

QAd4485ax

GCCC
GULF COAST CARBON CENTER

RCSP SECARB "early" test at Cranfield- Monitoring design and optimization leanings applied to West Ranch

High confidence in storage permanence through characterization

Oil and gas trapped over geologic time

Material Risk of failing to retain

Uncertainty and risk assessment → Semi-quantitative assessment via Certification Framework

Research Questions

- P&A well performance in retention?
- Limited analogy between injected and natural fluid retention
- Off structure migration?
- Response to pressure elevation?

Selected assessment approach

shallow → deep

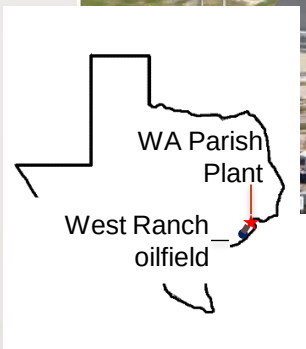
- Well-pad vadose gas
- Ground water chem.
- AZMI pressure
- 4-D Seismic
- 4-D VSP
- IZ pressure
- Microseismic

Protocol Sensitivity & reliability

Components of Petra Nova project

- Existing coal-fueled electrical generating unit at WA Parish power plant
- 240 MW equivalent slipstream of flue gas
- MHI amine capture 90% of carbon dioxide
- 50-50 joint venture by NRG and JX Nippon
- Capture more than 5,000 tons of CO_2 per day,
- 81-mile pipeline to West Ranch oil field
- Use for EOR
- Oil production at the field estimated to increase from 300 barrels to 15,000 barrels per day
- Monitoring by Hilcorp and the University Of Texas Bureau of Economic Geology

NRG Petra Nova CCUS Project



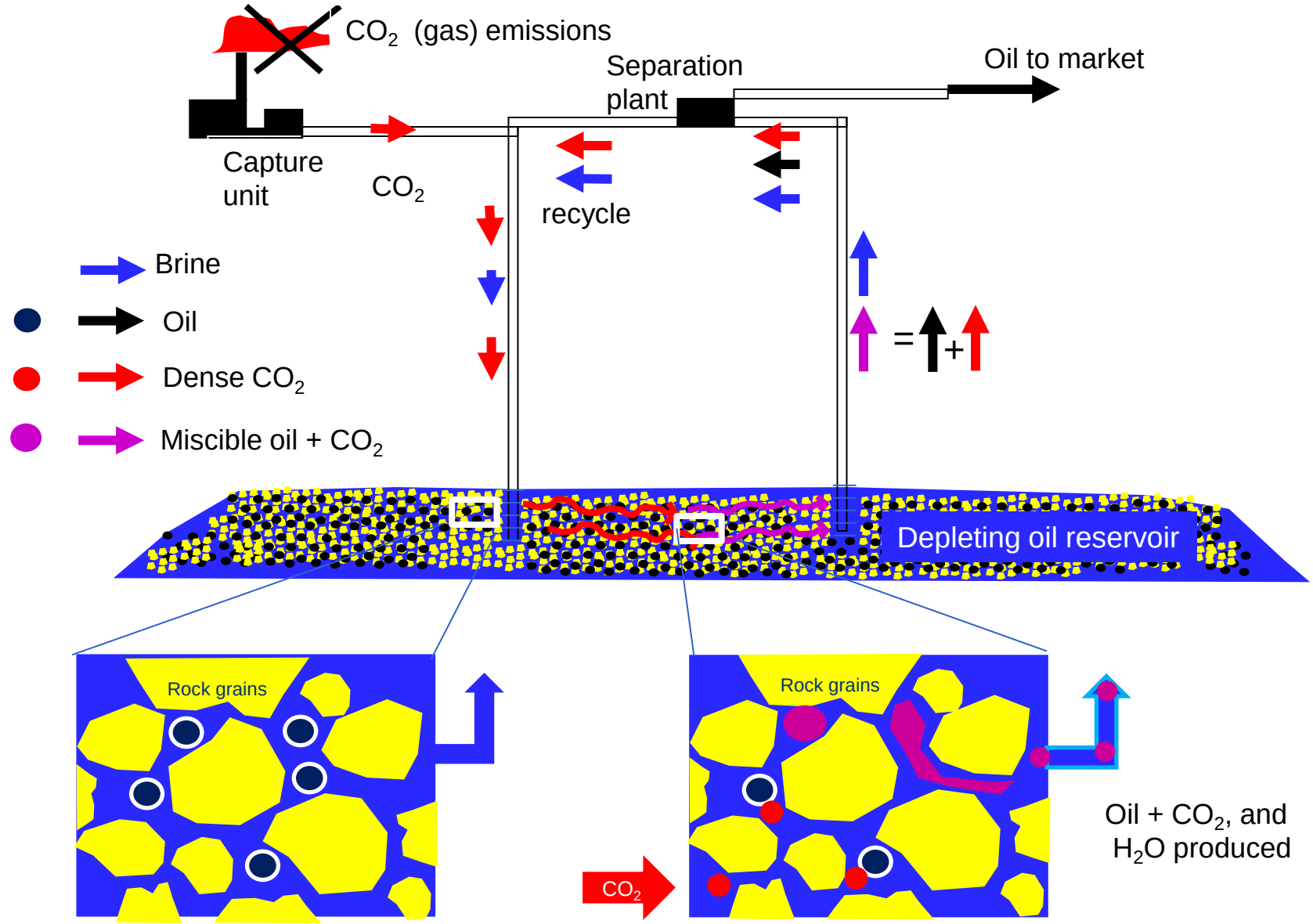
Capture 90 percent of the CO_2 from a 240 MW equivalent slipstream of flue gas for use and sequester up to 1.6 million tons of this greenhouse gas annually.

http://www.nrg.com/documents/business/pla-2014-petranova-waparish-factsheet.pdf

nrg Power to be free℠

JX

Accounting for CO_2 Enhanced Oil Recovery in Storage



www.gulfcoastcarbon.org

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