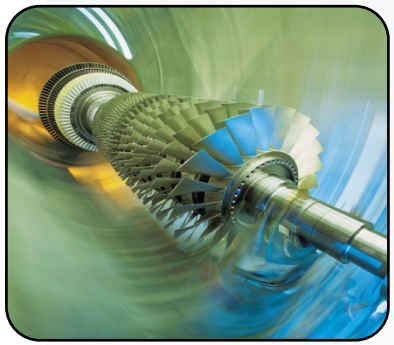

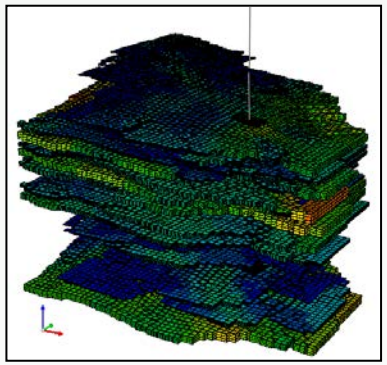

Carbon Capture and Storage Research and Best Practices

Sarah M. Forbes

U.S. Department of Energy, Office of Clean Coal and Carbon Management

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February 12, 2016

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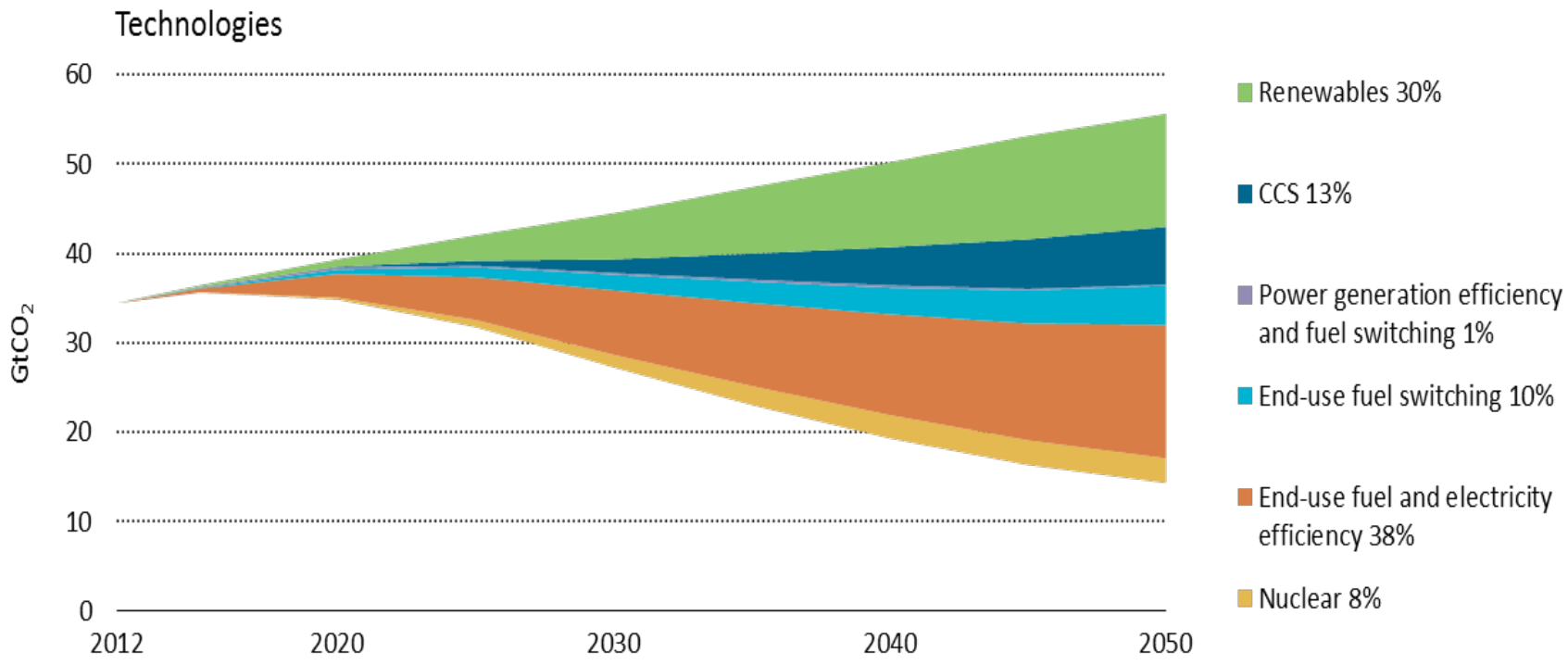
CCS Will Be Required To Meet Our Global Carbon Emission Reduction Goals



Source: International Energy Agency, ETP 2015

We must strengthen our commitment to deployment of CCS

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CCS Deployment: Urgent and Important

Not just about cost

- Costs are higher than plants without CCS
- Costs are lower than many clean energy alternatives

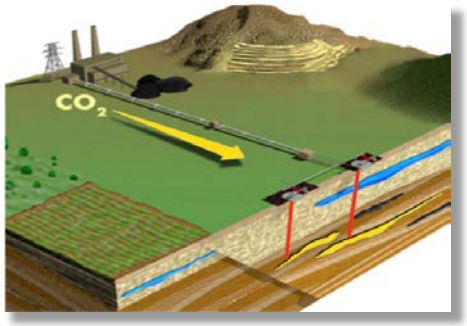
Not just about technology

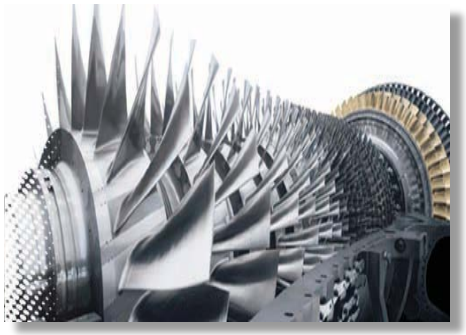
- Many technologies are well demonstrated
- Improvement potential is very large

Policy Issue: Could finance many ways

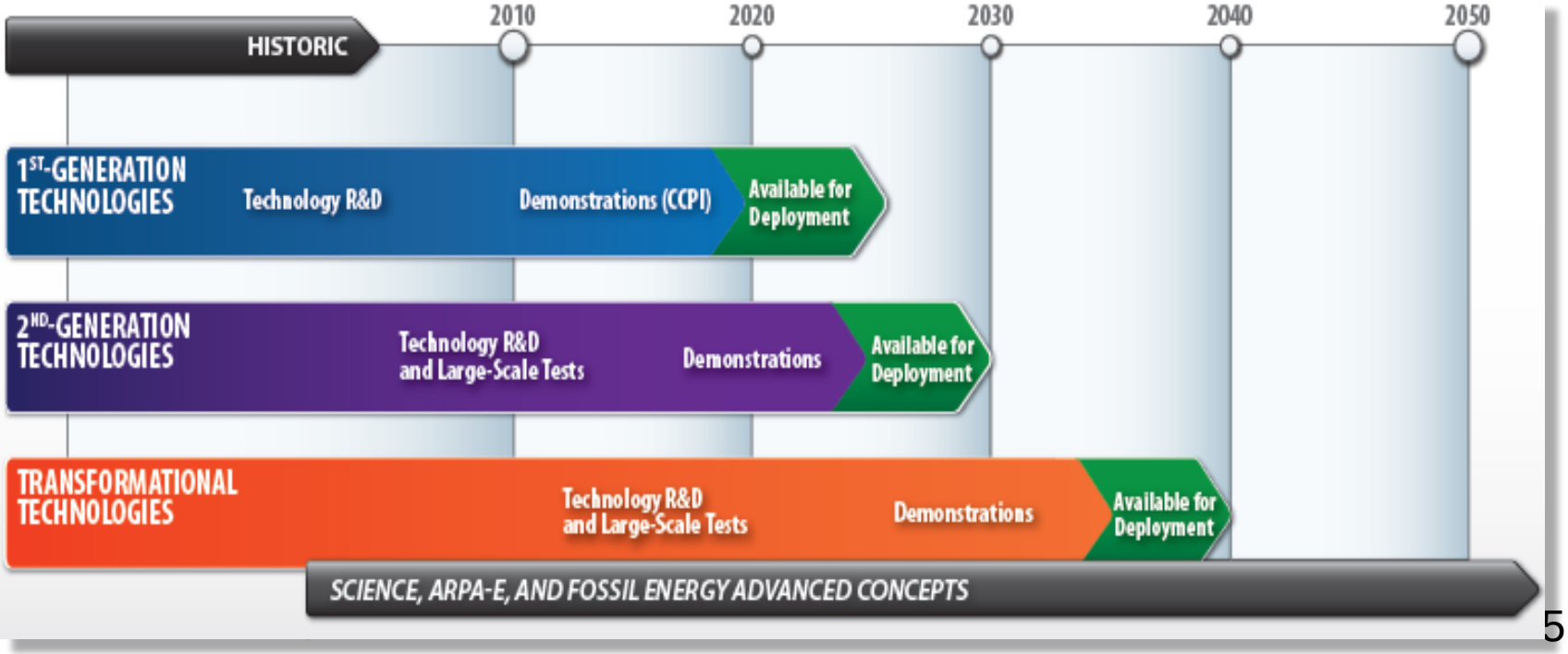
- Rate recovery; feed-in tariffs; direct grants
- Clean energy portfolios; tax-free debt financing; others

A technology pipeline for CCS innovations



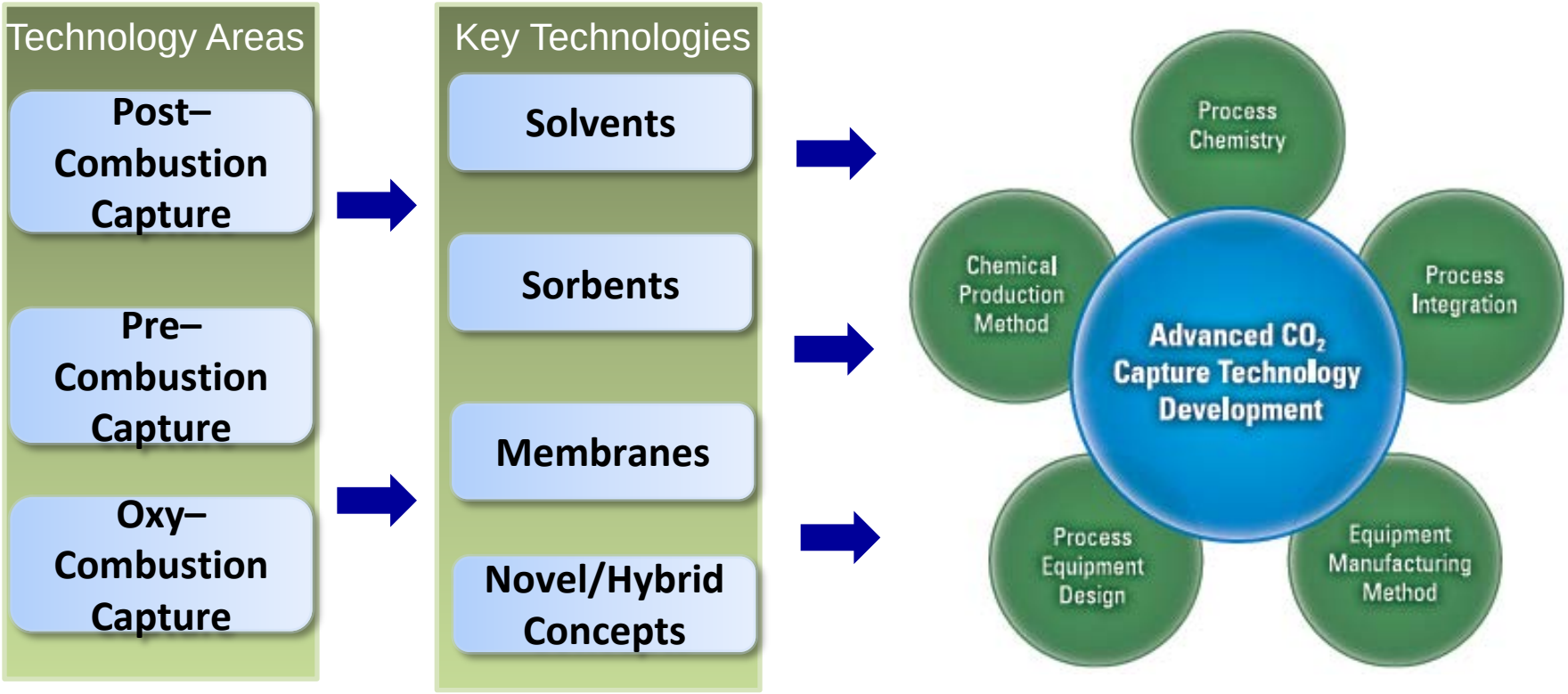


CO_2 Capture	CO_2 Storage	Advanced Energy Systems	Crosscutting Research
Cost-effective capture for new and existing plants	Safe, permanent storage of CO_2 from power and industry	Gasification, advanced turbines, advanced combustion, and fuel cells	Crosscutting technology development



CO_2 Capture

Requires Multiple Technologies and Multiple Scientific and Engineering Disciplines

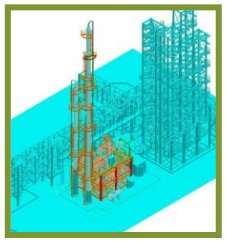


This is the primary pathway to steep cost reductions

DOE Pilots Program: *Reducing the risk for demonstration*

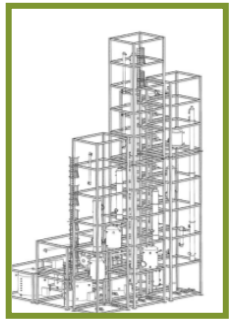
1:100

1 MW Membrane System (MTR)



1 MW Solvent Pilot (Linde)

1 MW Solvent Pilot (Neumann)



1 MW Solvent System (Univ. of KY)

1 MW Solid Sorbent Pilot (ADA-ES)

NCCC: 0.5 MW PSTU, Ion Engineering, GE

1:10

Green Field Plant
10+MWe

10-25 MWe Greenfield Capture Facility

TCM 13MWe Solvent Unit

25 MW Solvent Heat Integration MHI KS1 Solvent

Demos
100+MWe

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Major CCS 1st Gen Demonstration Projects

Project Locations & Cost Share

Clean Coal Power Initiative

ICCS Area 1

Archer Daniels Midland
CO_2 Capture from Ethanol Plant
CO_2 Stored in Saline Reservoir
$208M – Total, $141M – DOE
SALINE – ~0.9M MTPY 2015 start

Summit TX Clean Energy
Commercial Demo of Advanced IGCC w/ Full Carbon Capture
~$1.7B – Total, $450M – DOE
EOR – ~2.2M MTPY 2018 start

Southern Company
Kemper County IGCC Project
Transport Gasifier w/ Carbon Capture
~$4.12B – Total, $270M – -DOE
EOR – ~3.0M MTPY 2015/2016 start

HECA
Commercial Demo of Advanced IGCC w/ Full Carbon Capture
~$4B – Total, $408M – DOE
EOR – ~2.6M MTPY 2019 start

Petra Nova (formerly NRG)
W.A. Parish Generating Station
Post Combustion CO_2 Capture
$775 M – Total
$167M – DOE
EOR – ~1.4M MTPY 2017 start

Air Products and Chemicals, Inc.
CO_2 Capture from Steam Methane Reformers
EOR in Eastern TX Oilfields
$431M – Total, $284M – DOE
EOR – ~0.93M MTPY 2012 start

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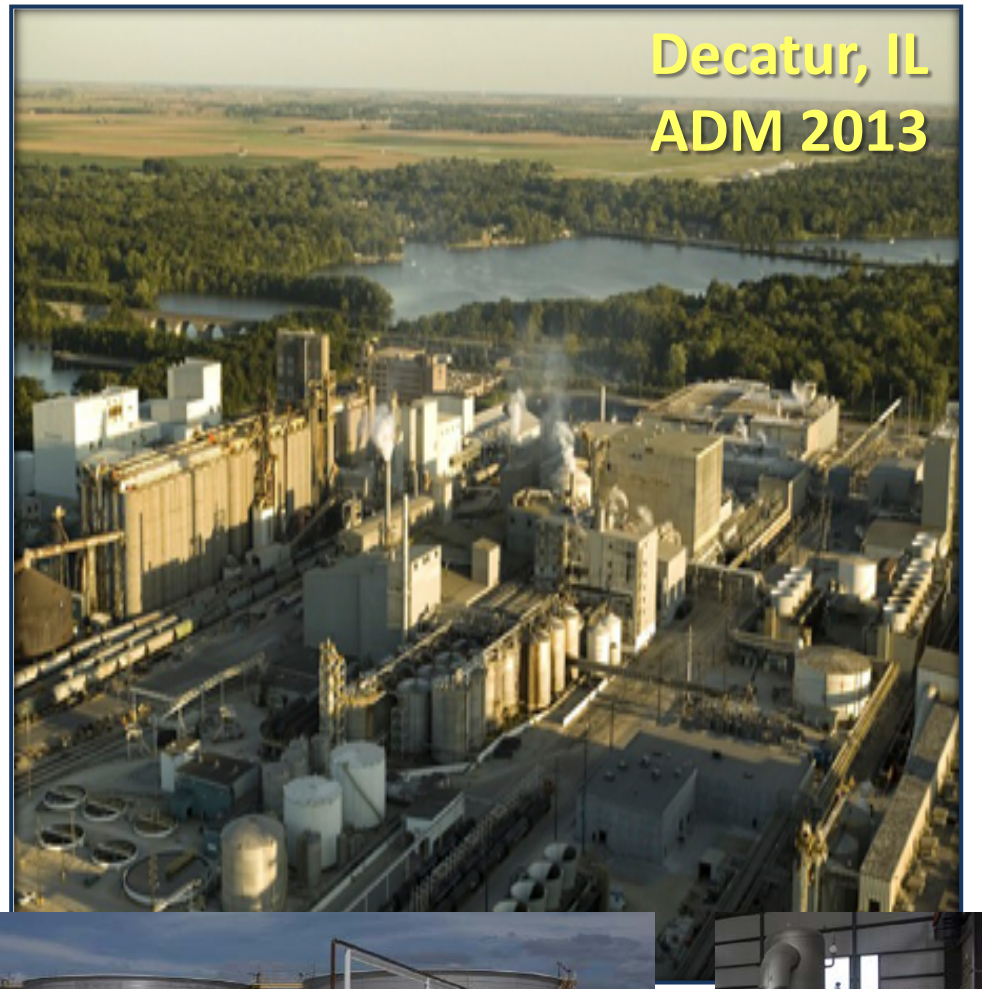
Archer Daniels Midland (ADM) Ethanol Facility

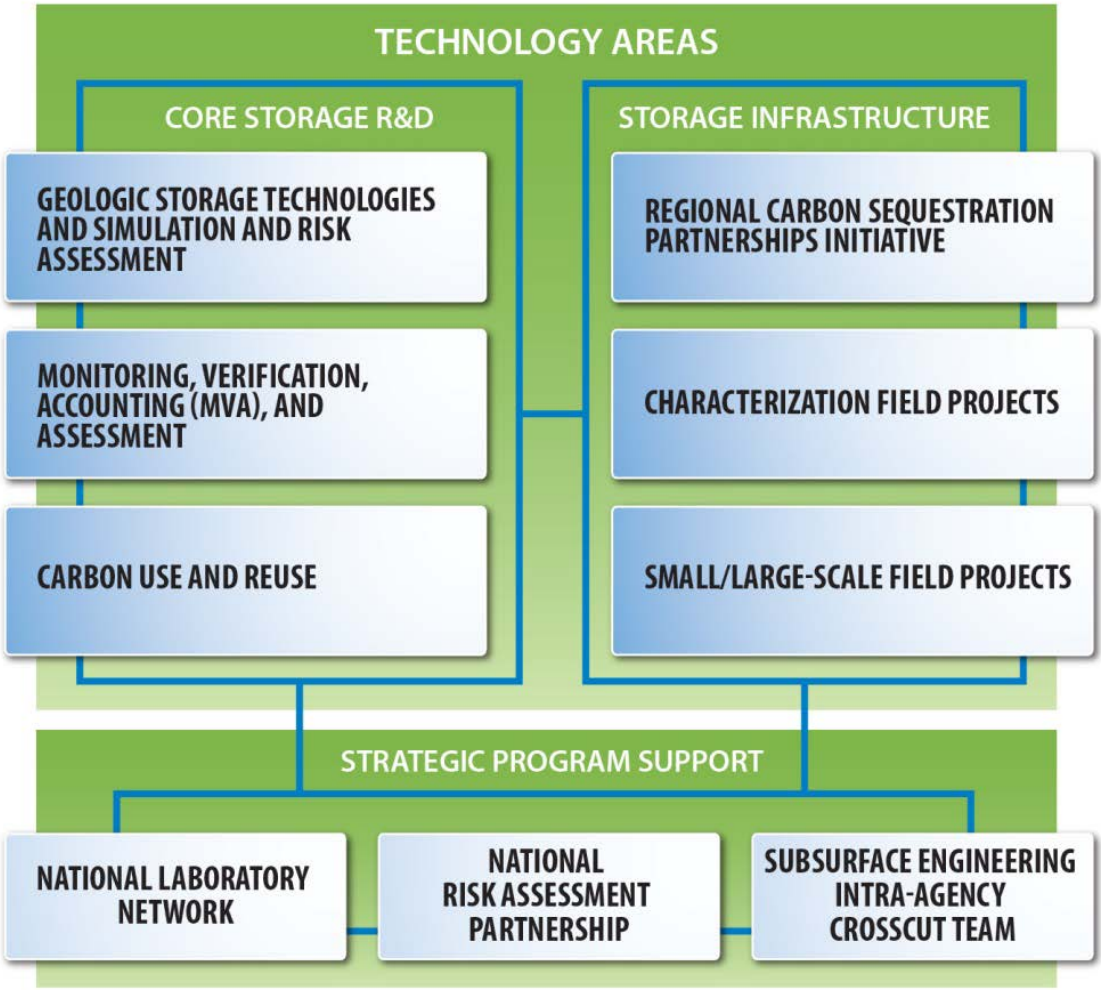
A Dehydration/ compression facility location
B Pipeline route
C Injection well site
D Verification well site
E Geophone well



CO_2 Pipe to Injection Well

Compression Facility

Carbon Storage Program Overview



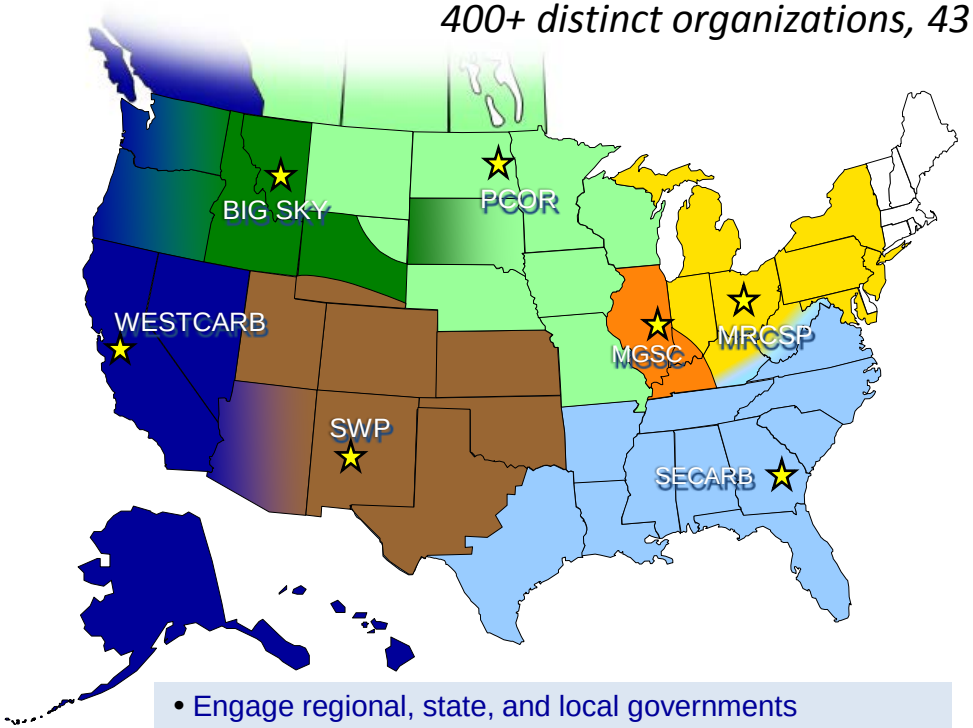
- Predicting and monitoring CO_2 plume and brine pressure front movement, stabilization, and impacts
- Developing and validating risk assessment strategies
- Mitigating risks such as the risk of leakage from old wells and induced seismicity
- Carrying out field tests for different storage types and depositional environments

Regional Carbon Sequestration Partnerships

Developing the Infrastructure for Wide Scale Deployment

Seven Regional Partnerships

400+ distinct organizations, 43 states, 4 Canadian Provinces



- Engage regional, state, and local governments
- Determine regional sequestration benefits
- Baseline region for sources and sinks
- Establish monitoring and verification protocols
- Validate sequestration technology and infrastructure

Characterization Phase (2003-2005)

Search of potential storage locations and CO_2 sources	Found potential for 100s of years of storage

Validation Phase (2005-2011)

20 injection tests in saline formations, depleted oil, unmineable coal seams, and basalt

Development Phase (2008-2018+)

8 large scale injections (over 1 million tons each)	Commercial scale understanding and validation

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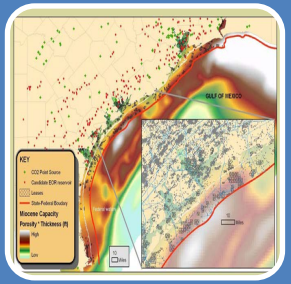
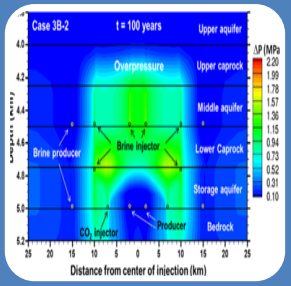
Carbon Storage Program

Addressing Future Technical Challenges



Offshore Storage Resource Assessment

- Prospective Storage Resource for East Coast and/or Gulf of Mexico
- Depleted Oil and Natural Gas Reservoirs and Saline Formations



Fit-for-Purpose Field Project– Brine Extraction Storage Test (BEST)

- Managing formation pressure and movement of differential pressure and CO_2 plume through brine extraction and treatment of extracted brine for re-use

Intelligent Monitoring Systems and Advanced Well Integrity and Mitigation

- Next generation technologies to monitor, control and optimize CO_2 injection
- Advanced tools and methods for assessing wellbore integrity (identifying and quantifying wellbore leakage) and mitigation

Carbon Storage Program

Knowledge Sharing—Best Practices Manuals

Best Practices Manual	Version 1 (Phase II)	Version 2 (Phase III)	Final Version (Post-Injection)
Monitoring, Verification and Accounting	2009/2012	2016	2020
Public Outreach and Education	2009	2016	2020
Site Characterization	2010	2016	2020
Geologic Storage Formation Classification	2010	2016	2020
Simulation and Risk Assessment	2010	2016	2020
Carbon Storage Systems and Well Management Activities	2011	2016	2020
Terrestrial	2010		

http://www.netl.doe.gov/research/coal/carbon-storage/publications

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Best Practice Manuals (BPMs) are Important Program Outputs

- Based on DOE Supported and leveraged monitoring activities
  - RCSP Program
  - Core R&D
  - International Projects
  - Industrial applications
- Regulatory requirements and associated monitoring needs

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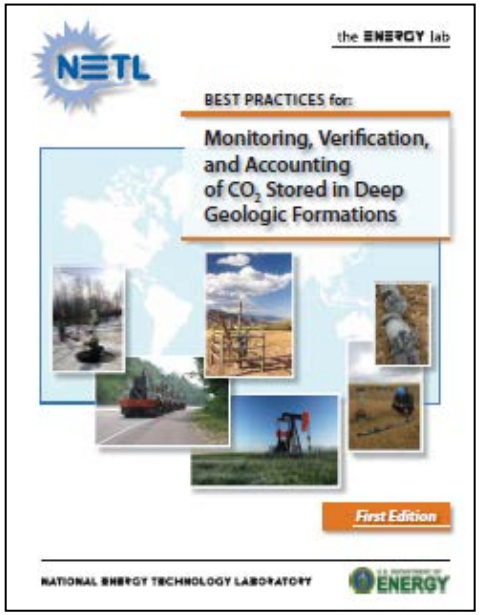
Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations

- Based on DOE Supported and leveraged monitoring activities
  - RCSP Program
  - Core R&D
  - International Projects
  - Industrial applications
- Regulatory requirements and associated monitoring needs
- 35 Technologies divided into:
  - Primary
  - Secondary
  - Additional



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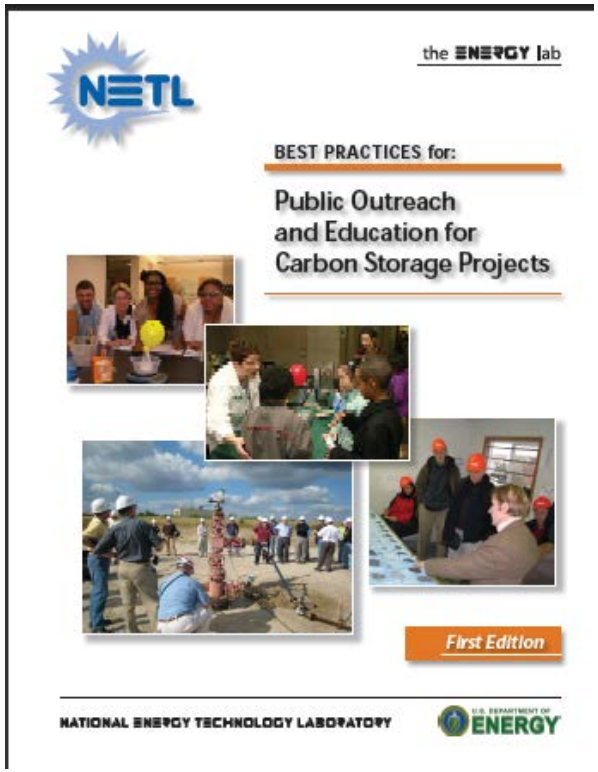
Public Outreach and Education for Carbon Storage Projects:
Focused on project developers providing 10 Best Practices based on practical RCSP experience

- Do your homework
  - Integrate outreach with project management
  - Establish an outreach team
  - Identify stakeholders
  - Conduct and apply social characterization
- Develop plans and materials
  - Develop plan tailored to community
  - Develop key messages
  - Tailor materials to audience
- Implement, Assess and Refine



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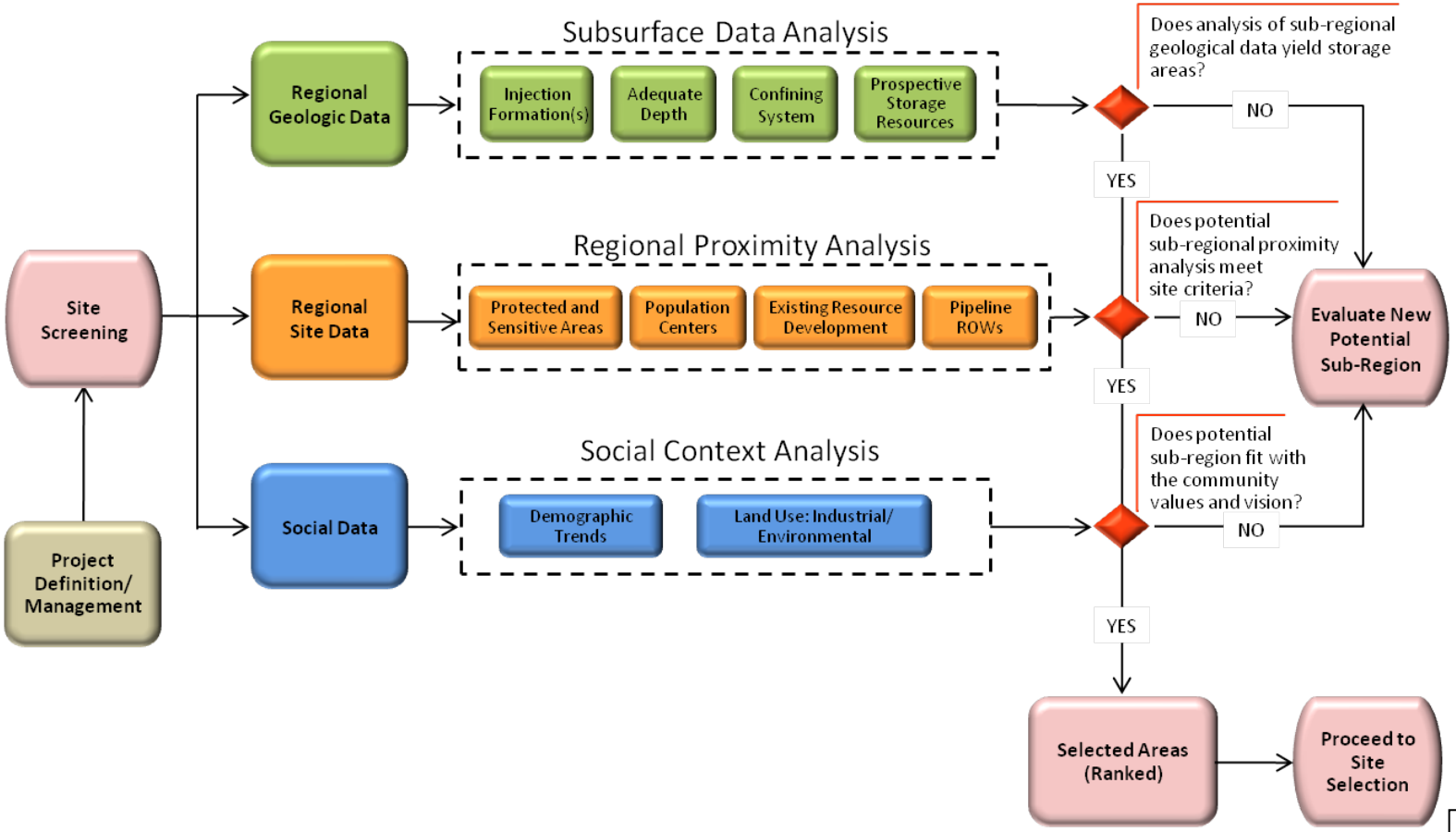
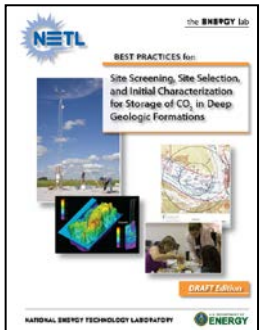
Site Screening, Site Selection, and Initial Characterization





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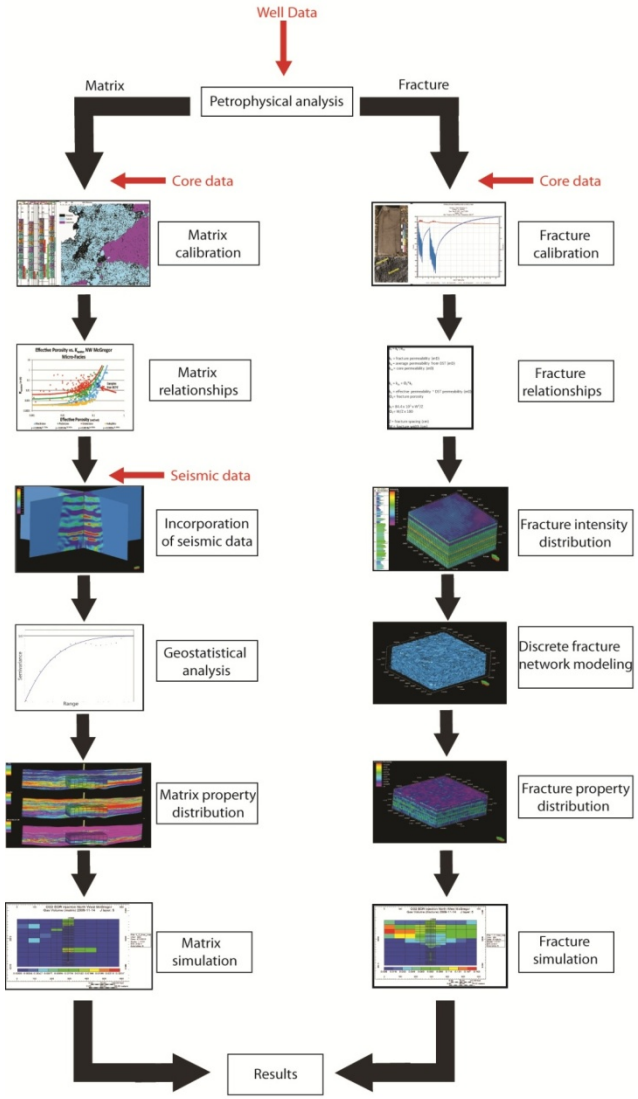
Risk Assessment and Simulation



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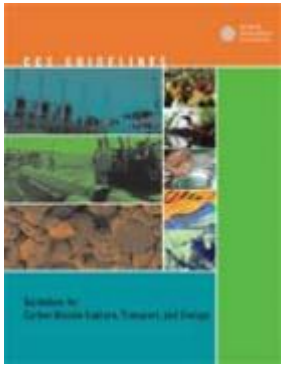
Other Standards and Best Practices in Use

- EPA Guidance documents for Class VI regulations
- World Resources Institute
  - Guidelines for CCS (2008)
  - Guidelines for community engagement in CCS projects (2010)
- DNV Certification Framework (2012, DNV-RP-J203 and DNV-DSS—402)
- Canadian Standards Association Carbon Storage Standards (2012, CSA Z741-12)
- ISO Standards (under development, ISO/TC265)



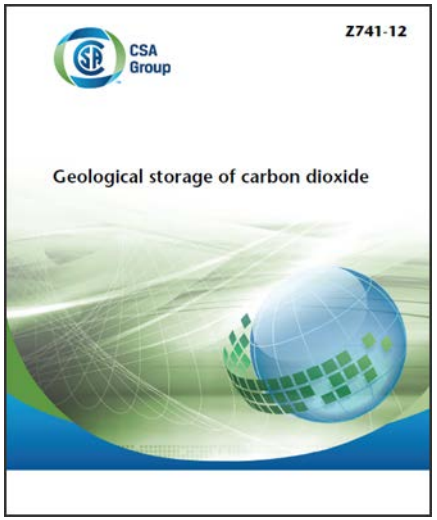
RECOMMENDED PRACTICE

DNV-RP-J203

Geological Storage of Carbon Dioxide

APRIL 2012

This document has been amended since the main revision (April 2012), most recently in July 2013. See "Changes" on page 3.



DNV SERVICE SPECIFICATION

DNV-DSS-402

Qualification Management for Geological Storage of CO_2

JUNE 2012

EPA United States Environmental Protection Agency

Geologic Sequestration of Carbon Dioxide

Underground Injection Control (UIC) Program Class VI Well Site Characterization Guidance

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