US Department of Energy CCUS Program Overview

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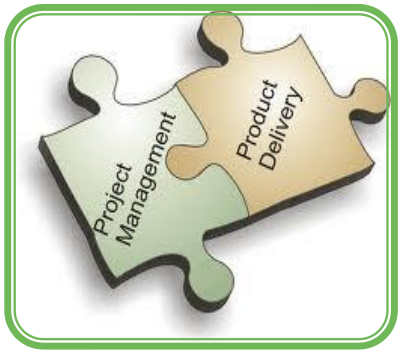
FOSSIL.ENERGY.GOV/ NETL.DOE.GOV

Fossil Energy: Helping Achieve DOE's Mission



Transform Our Energy Systems

- Cost-competitive carbon CCUS
- Advanced modeling and simulation
- Unconventional oil and gas resources

Science & Engineering Enterprise

- Graduate and post-graduate research and internship support

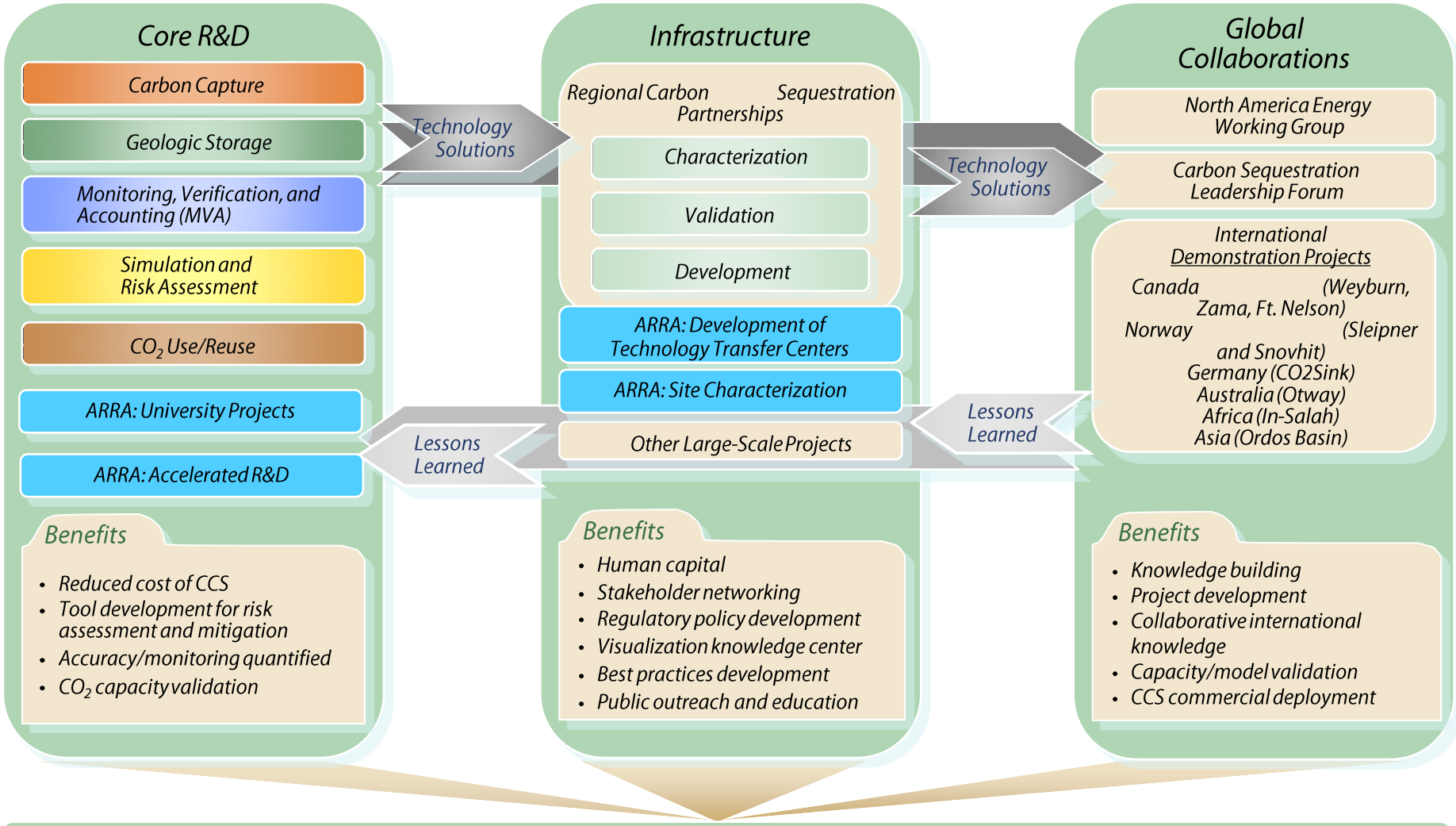
Secure Our Nation

- Technology innovation
- Strategic Petroleum Reserve and Northeast Home Heating Oil Reserve

Management & Operational Excellence

- FE-wide business review assessment for mission success

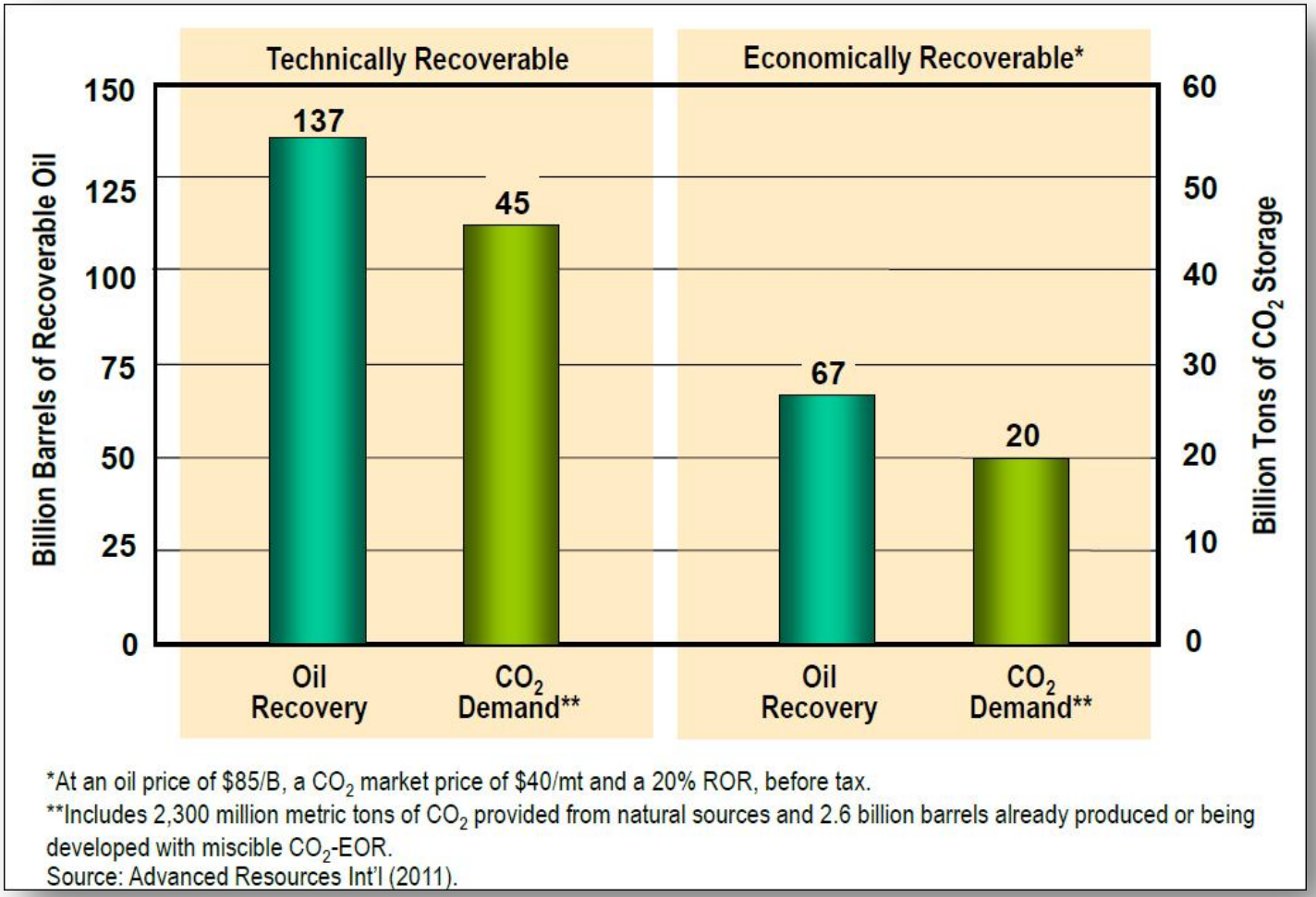
DOE Carbon Capture, Utilization, and Storage (CCUS) Program



Demonstration and Commercialization of CCUS

Enhanced Oil Recovery: Driver for CCUS Deployment

Domestic Oil Supplies and CO_2 Demand (Storage) Volumes from "Next Generation" CO_2-EOR Technology**

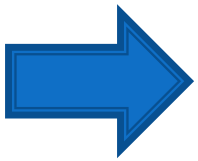


*At an oil price of $85/B, a CO_2 market price of $40/mt and a 20% ROR, before tax.
**Includes 2,300 million metric tons of CO_2 provided from natural sources and 2.6 billion barrels already produced or being developed with miscible CO_2-EOR.
Source: Advanced Resources Int'l (2011).

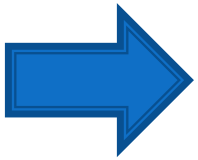
[1] *Source : NETL Report, "Improving Domestic Energy Security and Lowering CO_2 Emissions with "Next Generation" CO_2 EOR," June 2011 .*

CCUS Program Goals

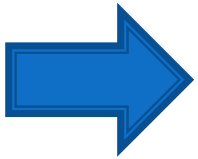
- *< 35% increase in COE with CCUS at 90% capture (post- & oxy-comb.); <10% for pre-combustion (market-based ~$40/tonne CO_2 captured)*
- *> 99% storage permanence of CO_2*
- *+/- 30% storage capacity accuracy*
- *4-5 CCUS demo projects in operation*



Address cost and energy penalty of capture



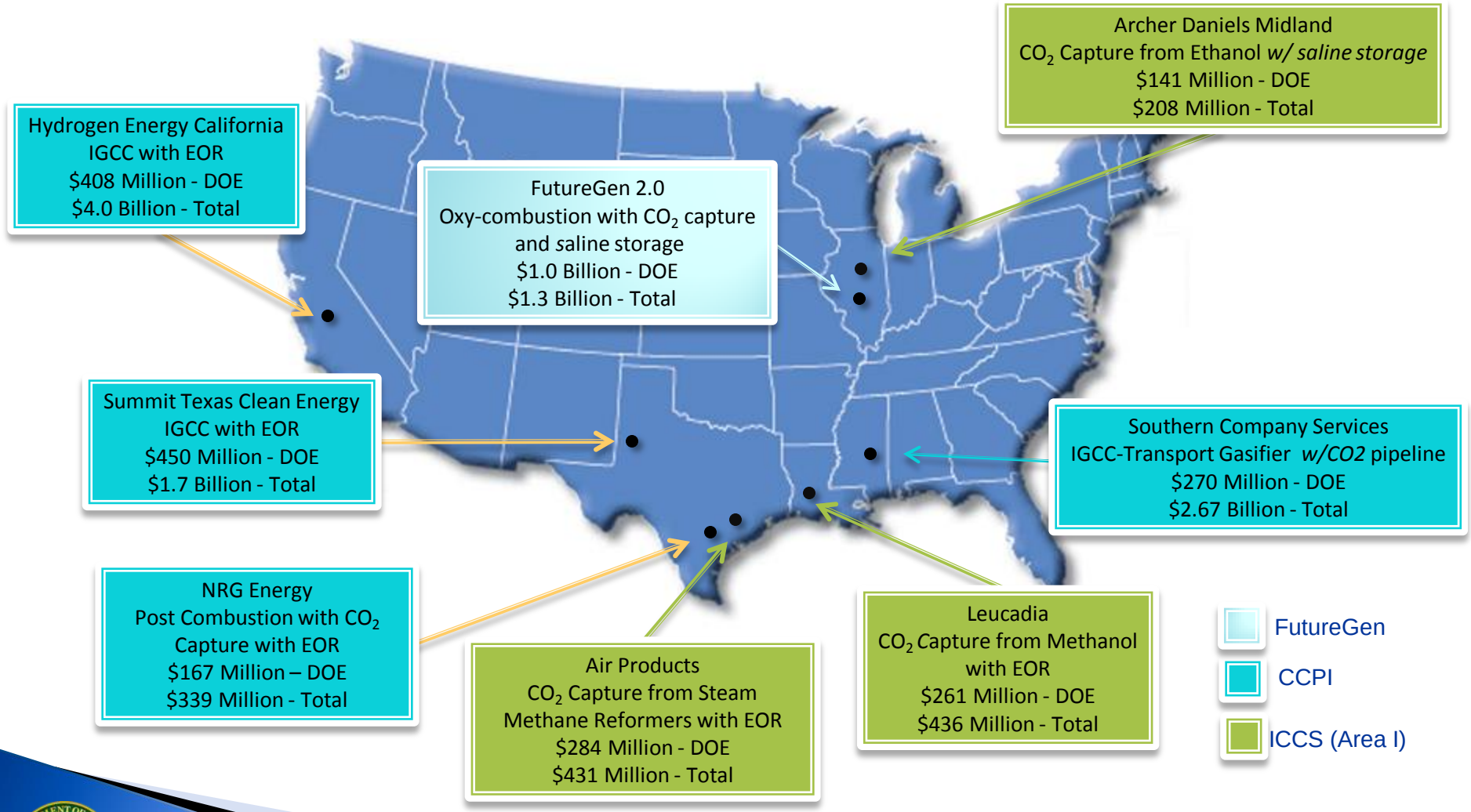
Assess capacity
Ensure safety and permanence



Scale-up and deployment

DOE CCUS Demonstration Projects

Focus – Large-scale commercial demonstration of CCUS integrated with coal power generation and fossil fuel industries.

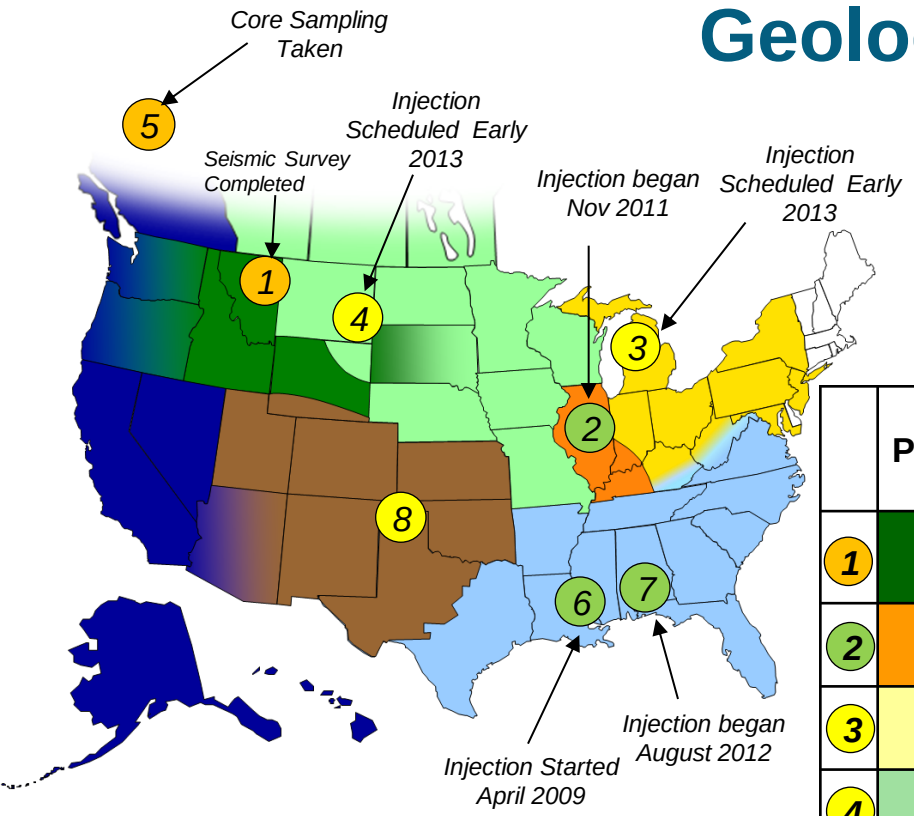


CCUS Demonstration Projects

Program	Project	Recipient	CO_2 Capture Technology	Sequestration	CO_2 Used/Stored (MMTPY)	Estimated Project in-Service Date
CCPI-2	Kemper	SCS	Selexol®	EOR	3.0	2014
CCPI-3	WA Parish	NRG Energy	Fluor Econamine FG Plus^{SM}	EOR	1.4	2015
CCPI-3	TCEP	Summit	Rectisol®	EOR	2.4	2016
CCPI-3	HECA	HECA	TBD	EOR	2.6	2018
ICCS	SMR H_2 Production	APCI	VSA	EOR	1.0	2013
ICCS	Fermentation CO_2	ADM	Dehydration	Saline	1.0	2013
ICCS	Methanol from Petcoke Gasification	Leucadia Energy, LLC	Rectisol®	EOR	4.0	2016
FutureGen	FutureGen 2.0	Ameren, FGA	Oxycombustion w/ CO_2 purification	Saline	1.0	2017

Those in red font currently under construction

Infrastructure: RCSP* Phase III Large-Scale Geologic Tests



- Injection Ongoing
- 2013 Injection Scheduled
- Injection Scheduled 2014-2015

Note: Some locations presented on map may differ from final injection location

- ✓ *Large Volume Tests in Saline and EOR Fields*
- ✓ *Accounting for Stored CO_2*
- ✓ *Three projects currently injecting CO_2*
- ✓ *Three more expected in 2013*
- ✓ *Remaining injections scheduled 2014-2015*

	Partnership	Geologic Province	Type/Target Injection (MT)
1	Big Sky	Nugget Sandstone	Saline/EOR/ 1.0
2	MGSC	Illinois Basin- Mt. Simon Sandstone	Saline/1.0
3	MRCSP	Michigan Basin-Niagaran Reef	EOR/1.0
4	PCOR	Powder River Basin-Muddy Formation	EOR/1.5
5		Horn River Basin-Carbonates	Saline/2.0
6	SECARB	Gulf Coast-Cranfield-Tuscaloosa Formation	Saline/EOR/4.0
7		Gulf Coast- Citronelle Paluxy Formation	Saline/EOR/.45
8	SWP	Regional CCUS Opportunity	EOR/1.0

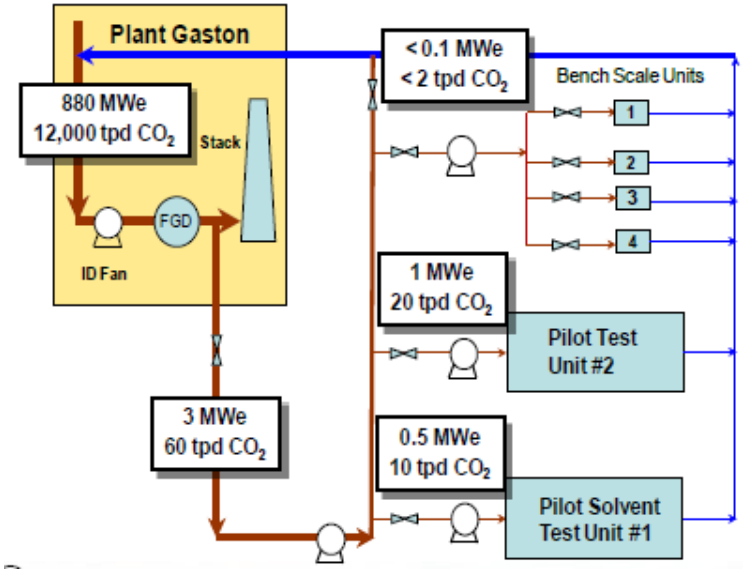
7 RCSPs established by the USDOE in 2003. They form a national network of more than 400 organizations covering 43 states and four Canadian provinces.

National Carbon Capture Center (NCCC) at the Power Systems Development Facility (PSDF)

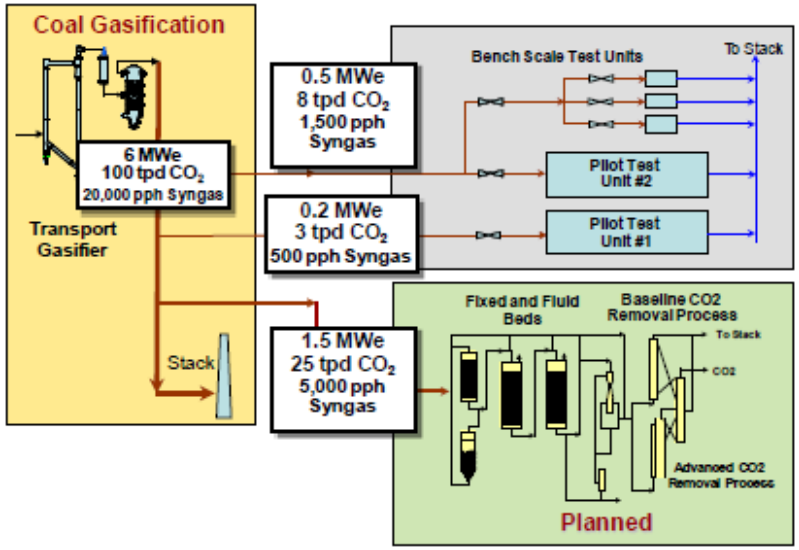
Goals

- Offers flexible testing facility with access to real flue and fuel gas (Post and Pre)
- Serves as technology development facilitator offering facilities for scale-up
- Leveraging ability to test other technologies not in the FE R&D portfolio

Post-Combustion



Pre-Combustion



Core R&D: Capture Program

Post-Combustion Capture

- *Novel solvents, sorbents, membranes, hybrid systems*
- *Novel absorber/regenerator and process designs*
- *Novel materials*
- *Heat integration*

Pre-Combustion Capture

- *Novel solvents, sorbents, membranes*
- *Process intensification*
- *Advanced materials*
- *Process integration*

Oxycombustion and Chemical Looping

- *Oxygen transport membrane*
- *Advanced materials*
- *Advanced designs (pressurized oxy)*
- *Solids handling*
- *Reactor design and heat integration*

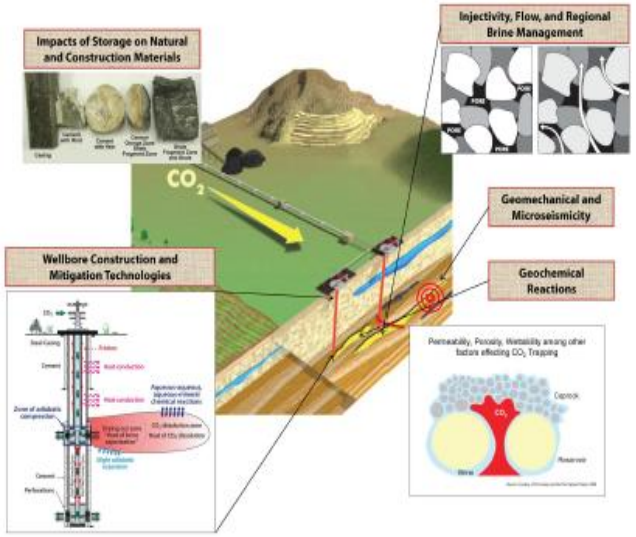
Core R&D: Carbon Storage Program

Monitoring, Verification, and Accounting

- *Atmospheric and Remote Sensing Technologies*
- *Near surface monitoring of soils and vadose zone*
- *Subsurface monitoring in and near injection zone*
- *Intelligent monitoring systems for field management*

Geologic Storage

- *Wellbore construction and materials technologies*
- *Mitigation technologies for wells and natural pathways*
- *Managing fluid flow, reservoir pressure, and brines*
- *Geochemical effects of CO_2 injection*
- *Geomechanical effects on reservoirs and seals*

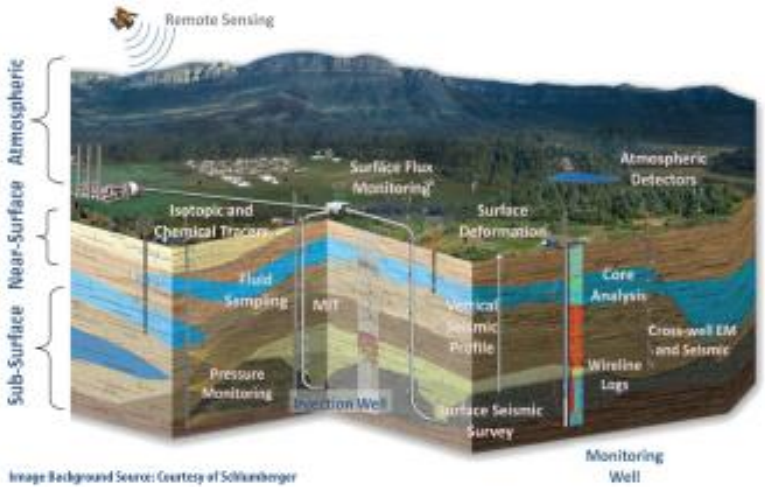


CO_2 Utilization

- *Enhanced Oil Recovery*
- *Conversion to commodities such as chemicals and plastics*
- *Non-geologic storage in cement and minerals*
- *Beneficial use of produced waters*

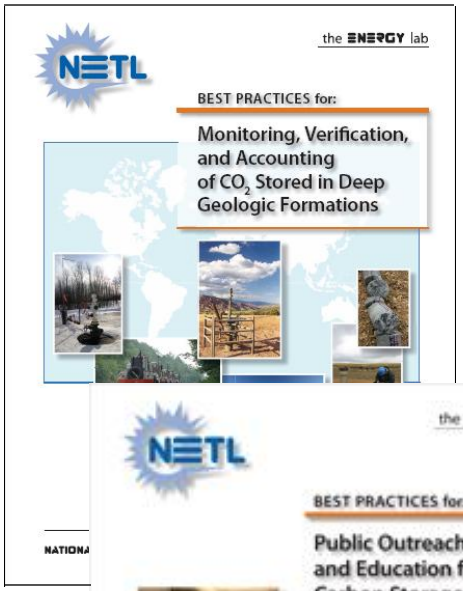
Simulation and Risk Assessment

- *Thermal and hydrologic fate and transport*
- *Geochemical and geomechanical simulations*
- *Predicting biologic impacts on storage formations*
- *Risk assessment and quantification*



CCS Best Practices Manuals

Critical Requirement For Significant Wide Scale Deployment -Capturing Lessons Learned



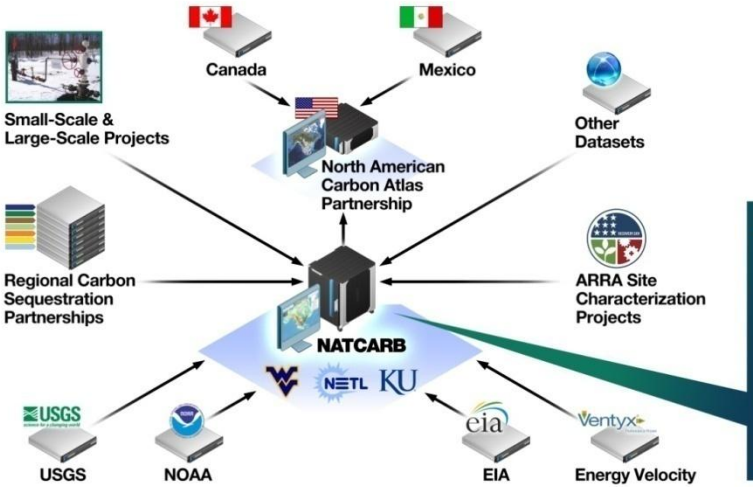
Best Practices Manual	Version 1 (Phase II)	Version 2 (Phase III)	Final Guidelines (Post Injection)
Monitoring, Verification and Accounting	2009/**2012**	2016	2020
Public Outreach and Education	2009	2016	2020
Site Characterization	2010	2016	2020
Geologic Storage Formation Classification	2010	2016	2020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

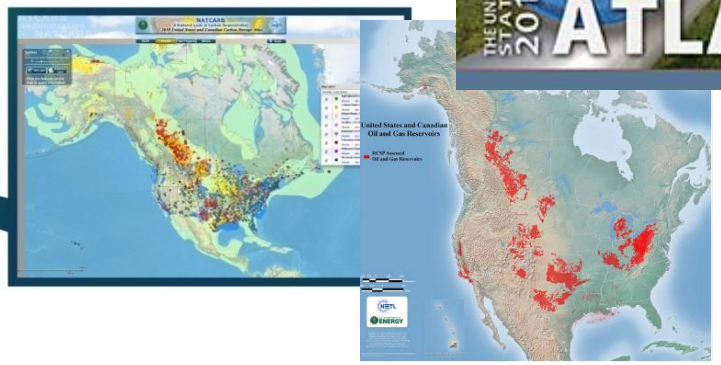
***Regulatory Issues will be addressed within various Manuals*

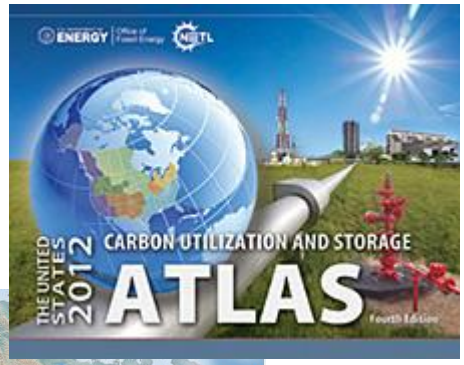
http://www.netl.doe.gov/technologies/carbon_seq/refshelf/refshelf.html

Knowledge Sharing Products

North American Carbon Atlas and NATCARB

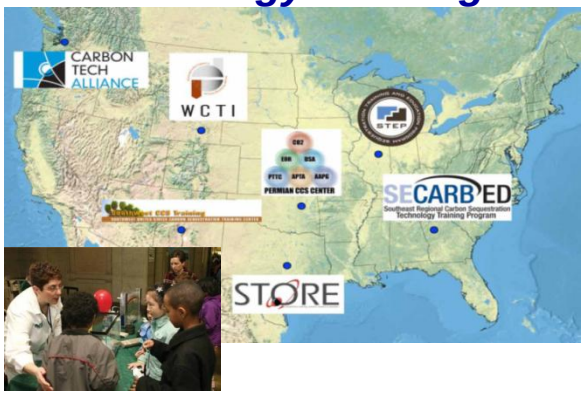






Oil and Gas Fields
226 billion MT CO_2
Storage Resource

ARRA Regional Technology Training



Worldwide CCS Project Database

RCSPs Working Groups

- Geological and Infrastructure
- Monitoring, Verification, Accounting
- Simulation and Risk Assessment
- Capture and Transportation
- GIS and Database
- Water
- Public Outreach and Education

Questions?

Thank You!

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