

Status of Carbon Sequestration Research and Implementation

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Acknowledgement

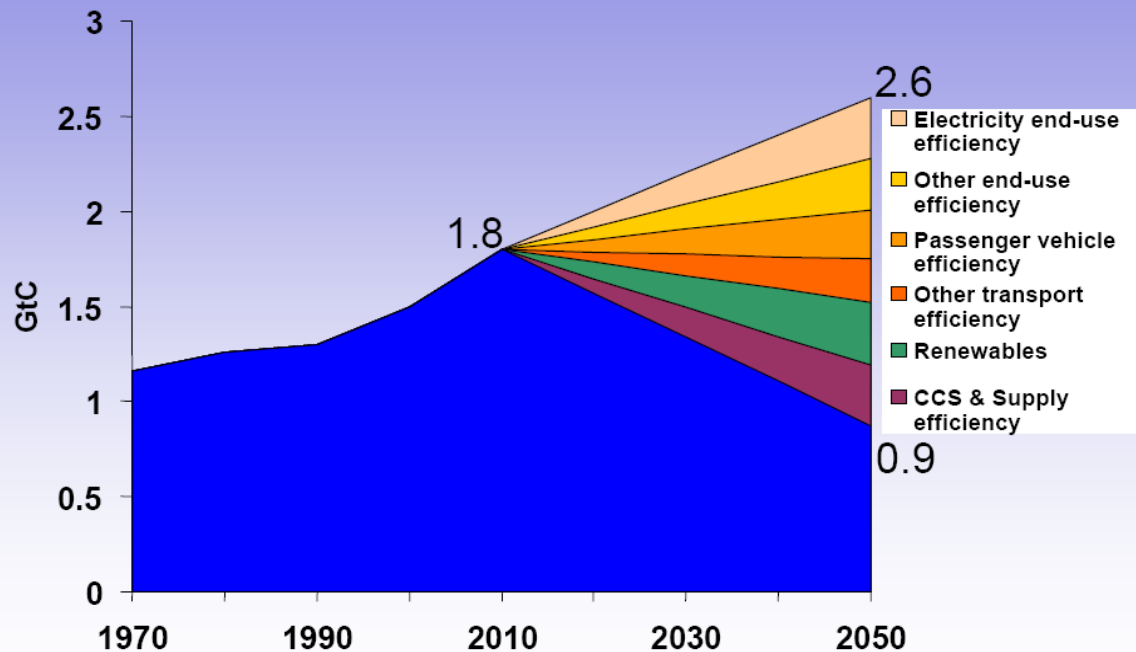
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Outline

- Status of SECARB-VCCER Research in Virginia and Central Appalachia
- The Clean Coal Power Initiative Virginia (CCPIVA)
- CCPIVA-Economic Development Opportunities
- Need for CO₂ Liability Legislation in the Commonwealth

US WEDGES STRATEGY



ARI CarBen3 Spreadsheet...deep reductions needed before 2050

“...CO2 capture and sequestration is the critical enabling technology that would reduce CO2 emissions significantly while also allowing coal to meet the world’s pressing energy needs” (MIT, 2007)

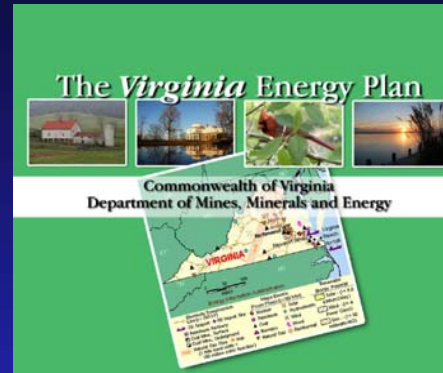
“Even under the most optimistic scenarios for energy efficiency gains and the greater use of low- or no-carbon fuels, sequestration will likely be essential if the world is to stabilize atmospheric concentrations of greenhouse gases at acceptable levels” (DOE Website)

Community Support for CCS

- **Environmental Community – NRDC and EDF**
 - ◆ *“Carbon Capture and Storage (CCS): Let’s Just Do It!”*
- **The Electric Generation Industry - Major Utilities/EPRI**
 - ◆ *“...Deploy capture and storage technologies at most new coal-based generating plants by 2020”*
- **National Governors Association**
 - ◆ *“...Incentivize CCS Technologies”*
- **IOGCC**
 - ◆ *“...the most immediate and viable strategies available for mitigating the release of CO₂ ”*
- **EPA**
 - ◆ *“...by harnessing the power of geologic sequestration technology, we are entering a new age of clean energy”*
- **Virginia Legislation**
 - ◆ *Incentives for Power stations that are “carbon capture compatible”*

The Virginia Energy Plan (2007)

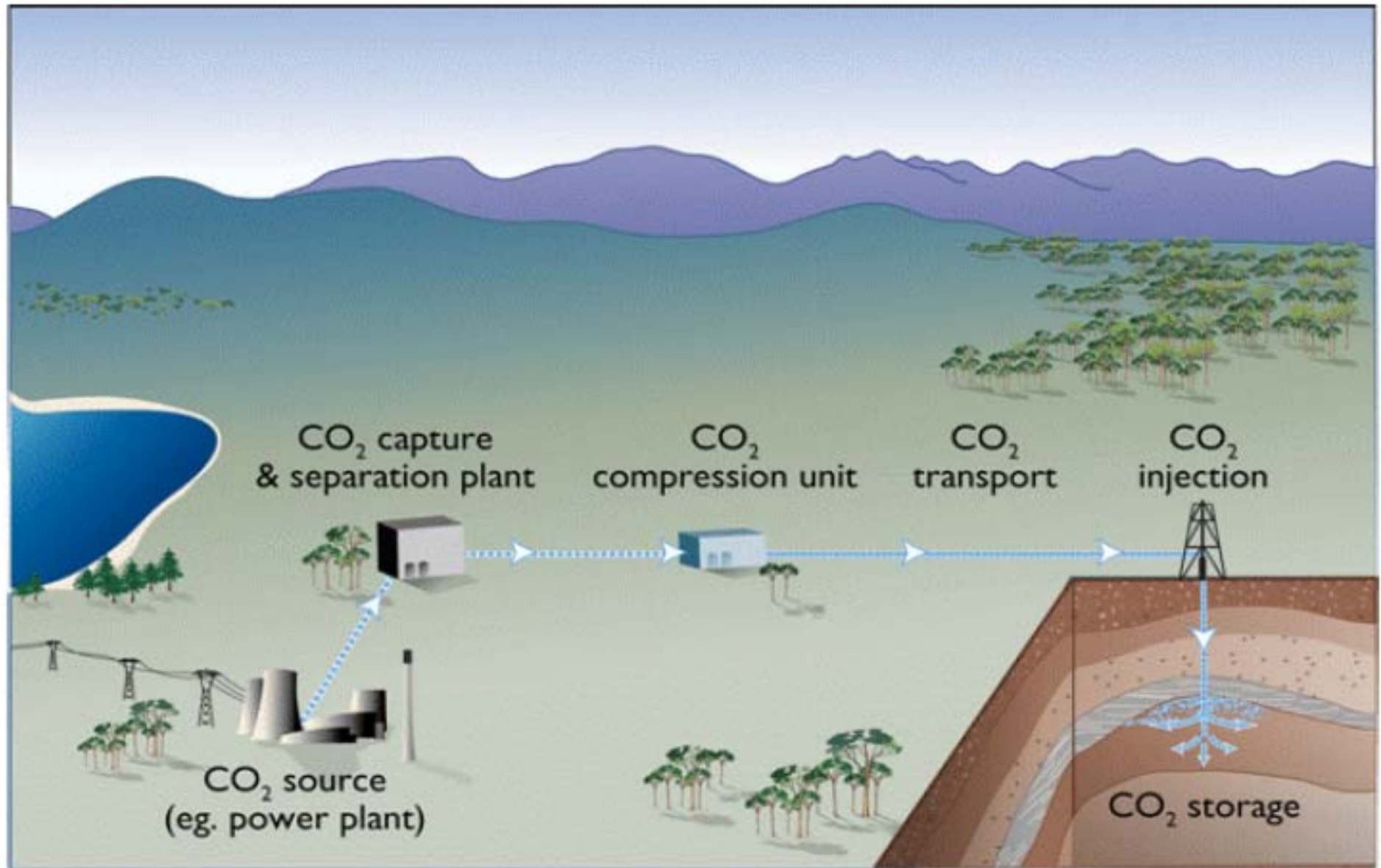
Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes.

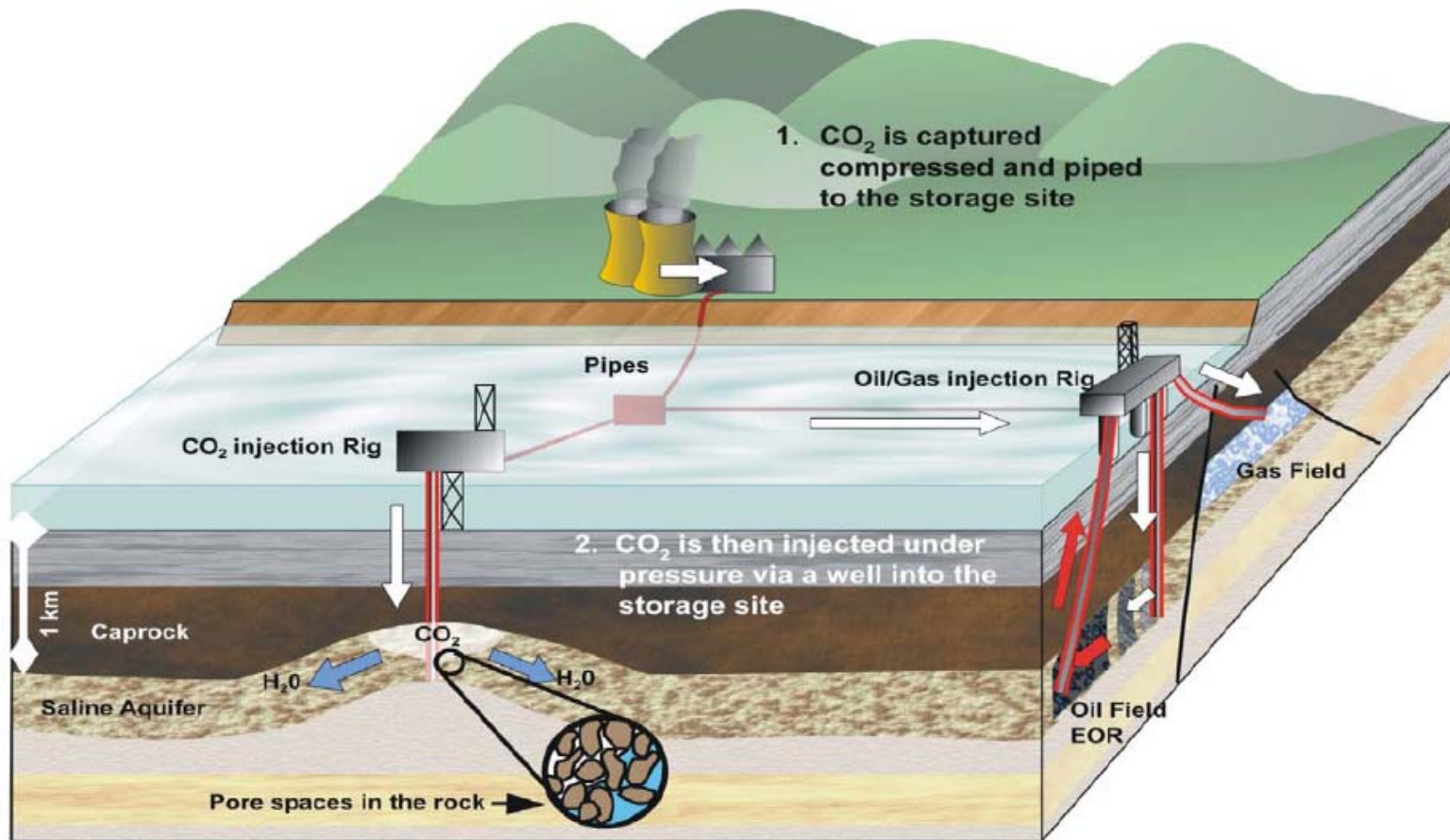


Virginia has the opportunity to sequester carbon in unminable coal seams. A recent report from the Virginia Center for Coal and Energy Research (VCCER) provides detailed information on this opportunity.²¹ Preliminary conclusions indicate that coal in the Central Appalachian Basin has significant sequestration potential, particularly in Buchanan, Dickenson, and Wise Counties. An estimated 7.33 trillion

Virginia Tech, a partner in the Southeast Regional Carbon Sequestration Partnership (SECARB), has researched and developed data on Virginia's potential and is testing carbon capture and storage technology in Virginia's coal seams. The project has the potential to implement a ten-year pilot to capture a million tons of carbon dioxide per year in Virginia. It also could increase the production of coalbed methane from the coal seams, increasing the efficiency of these operations (see Chapter 6).

Carbon Capture and Storage (CCS)





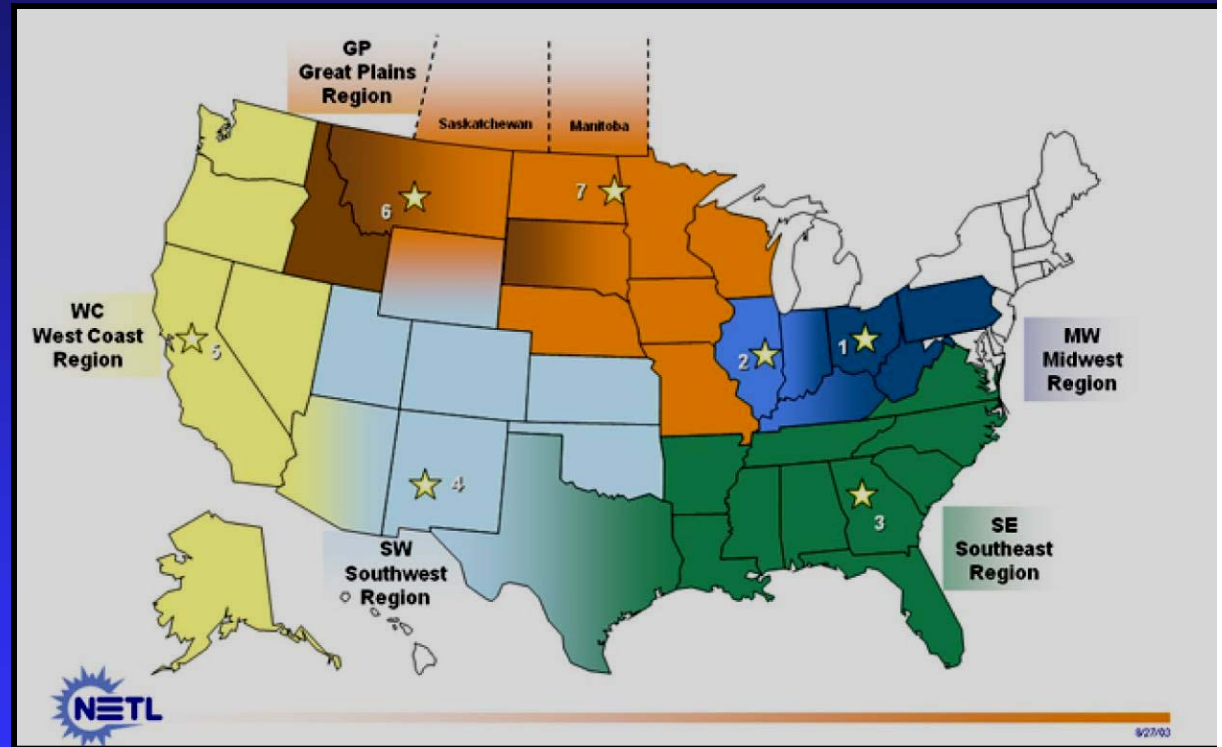
■ Geologic Sequestration

- ◆ Oil/Natural Gas Reservoirs-Enhanced Recovery
- ◆ Saline Aquifers
- ◆ Unminable Coal Seams-Enhanced Recovery

**Status of SECARB-VCCER
Research in Virginia and
Central Appalachia**

DOE- Regional Carbon Sequestration Partnerships

- 7 Regional Partnerships
- Partnerships include +240 organizations in 40 states, three Indian Nations and two Canadian Provinces



Virginia Tech Participates in SECARB, a Partnership Managed by the Southern States Energy Board

Regional Carbon Sequestration Partnerships Program Stages

- **Phase I: Characterization (2003-2005)**
- **Phase II: Validation (2005-2009/2010)**
- **Phase III: Deployment (2008-2017)**

SECARB-VCCER/VT Coal Team

- *Phase II-Task 2, Validation (On-going, 2005-2010):* Perform reservoir modeling and validate technologies conducting two small-scale injections in VA and AL. Injection tests involve 1,000 tons of CO₂ and a comprehensive MVA investigation on-site.
- *Phase II-Task 10, Validation Extension (On-going, 2008-2010):* Characterization and modeling to identify secondary reservoirs, e.g., saline aquifers, depleted oil and gas fields, and Devonian Shale reservoirs, that could support/supplement large-volume injection. Preliminary design for a large-volume test, including the potential for a stacked storage project.

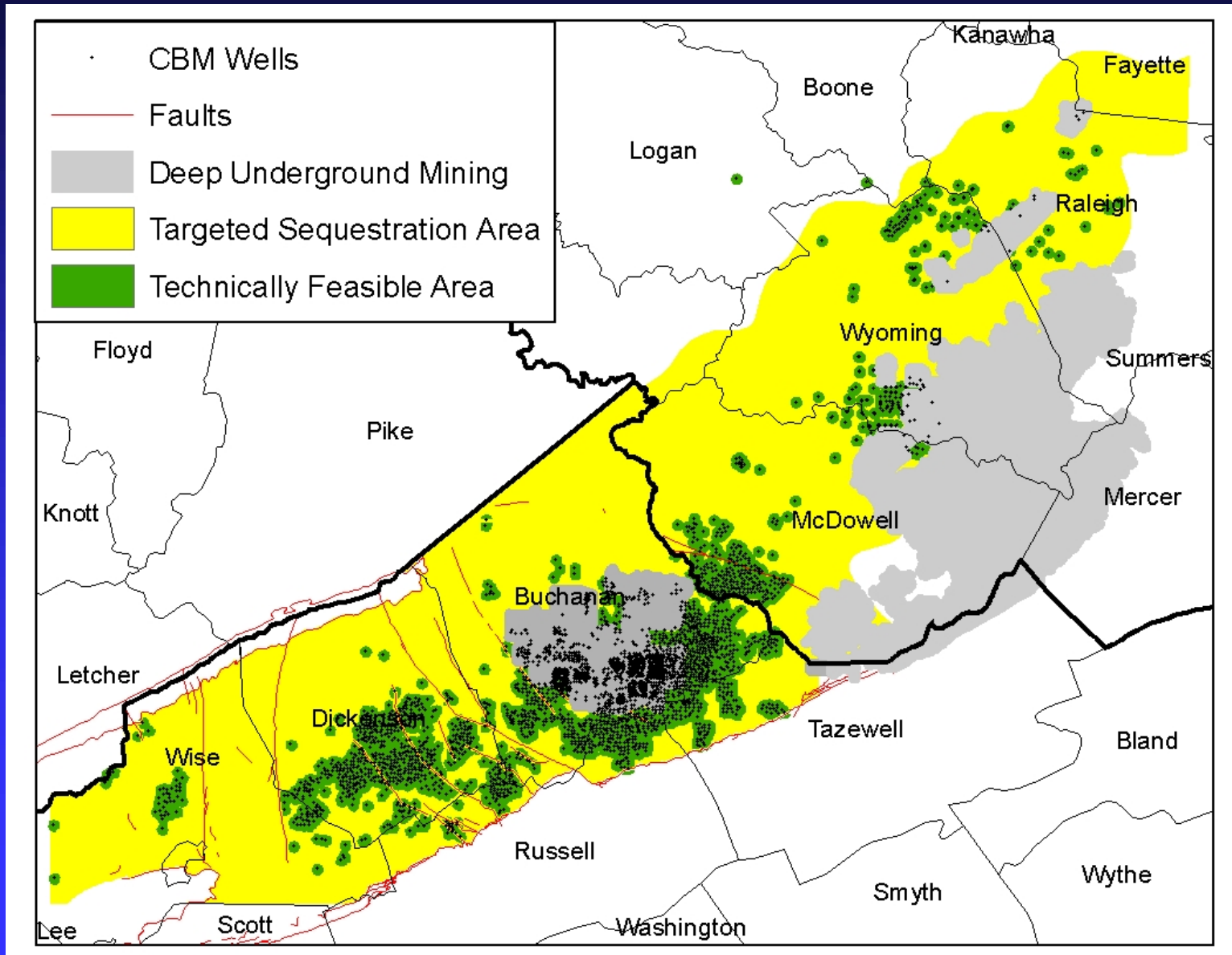
SECARB Coal Group Research Team

- Southern States Energy Board
- VCCER/Virginia Tech
- Marshall Miller and Associates
- Geological Survey of Alabama
- University of Alabama
- Southern Company
- Kentucky Geological Survey
- Advanced Resources International
- Eastern Coal Council
- Consol Energy
- West Virginia University

SECARB Coal Group - Phase II Partners (Cost Share, Data, Wells)

- Alawest
- Alpha Natural Resources
- AMVEST
- Appalachian Production Serv.
- Buckhorn Coal
- CCP2 Project
- CDX Gas
- Clean Energy Tech. Inst (MSU)
- CNX Gas
- CONSOL Energy
- Cumberland Resources
- Dart Oil & Gas
- Denbury Resources
- Dominion
- EPRI
- Equitable Production
- GeoMet
- International Coal Group
- McJunkin Appalachian
- Norfolk Southern
- Natural Resource Partners
- Oak Ridge National Laboratory
- Penn Virginia
- Pine Mountain Oil & Gas
- Piney Land
- Pocahontas Land
- Praxair
- RMB Earth Science Consultants
- Univ. British Columbia

Evaluated Sequestration Area

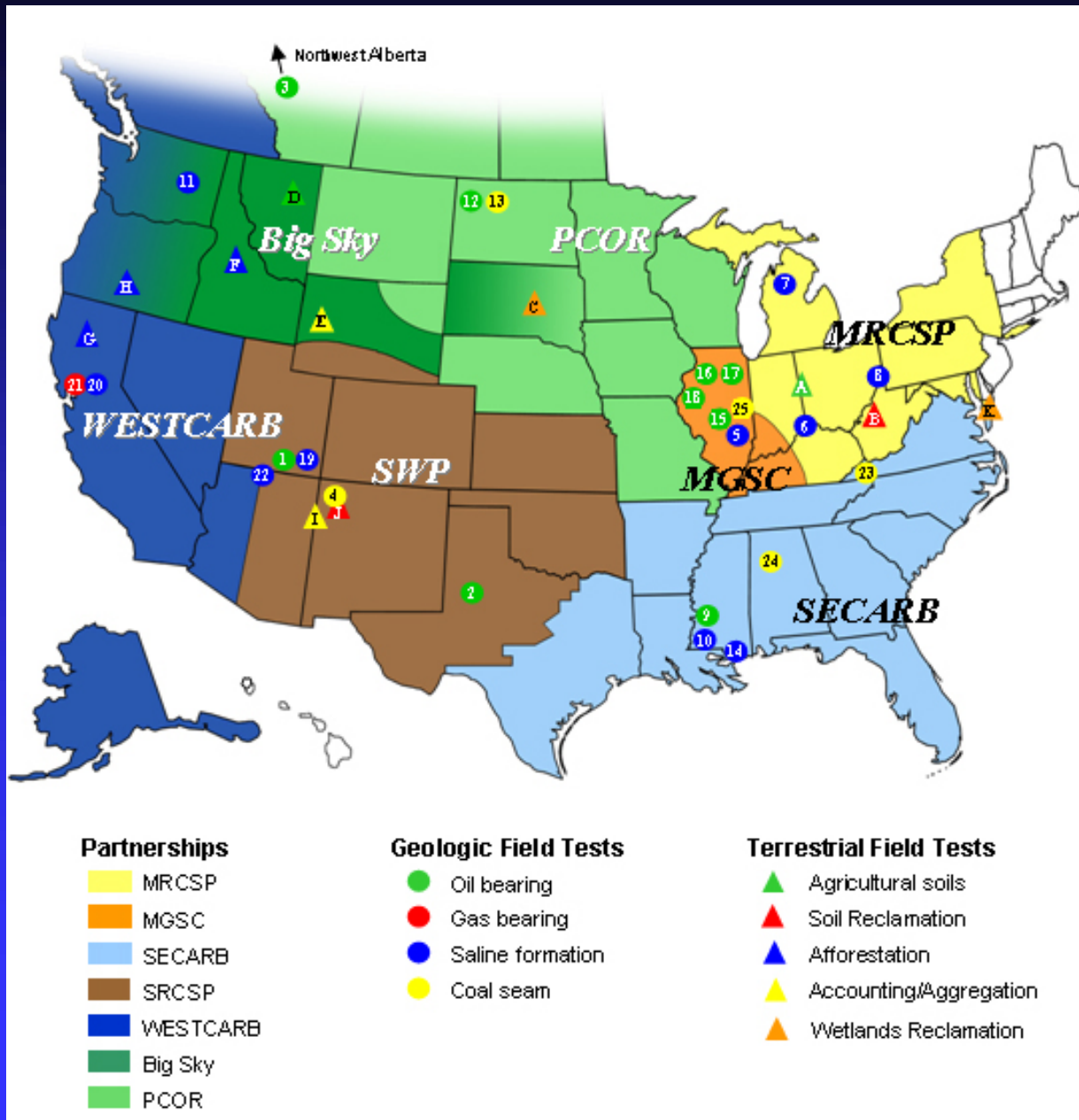


Sequestration and Enhanced CBM Potential

Central Appalachian Basin	
CO ₂ Storage capacity in all non-mining areas	1,345 MMt (23.1 Tcf)
CO ₂ Storage capacity in developed CBM areas only	399 MMt (6.86 Tcf)
ECBM potential in all non-mining areas	2.49 Tcf
ECBM potential in developed CBM areas only	0.79 Tcf

Virginia CBM production in 2008 was about 100 Bcf (0.1 Tcf) of CH₄

Phase II: Validation (2005-2009/10)

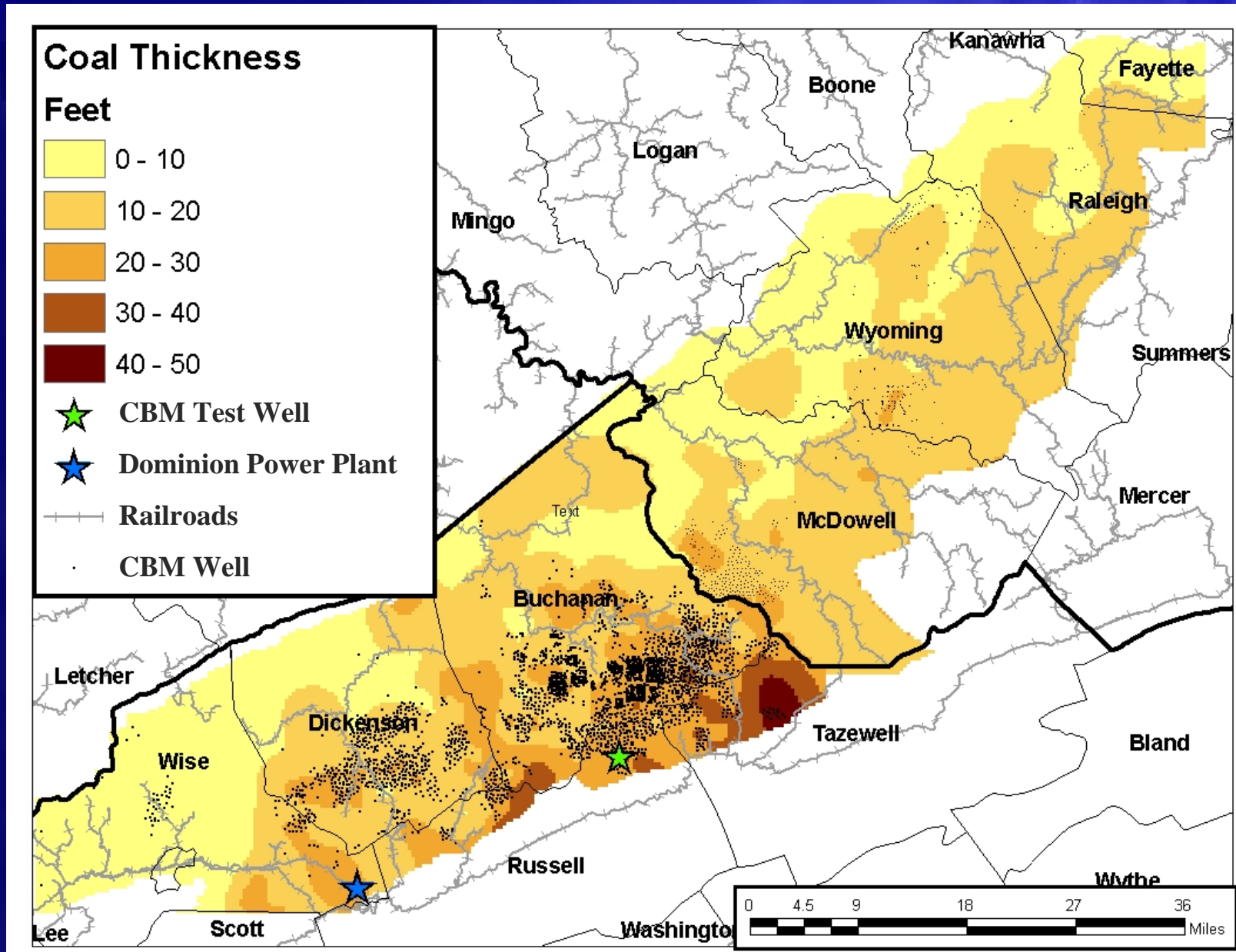


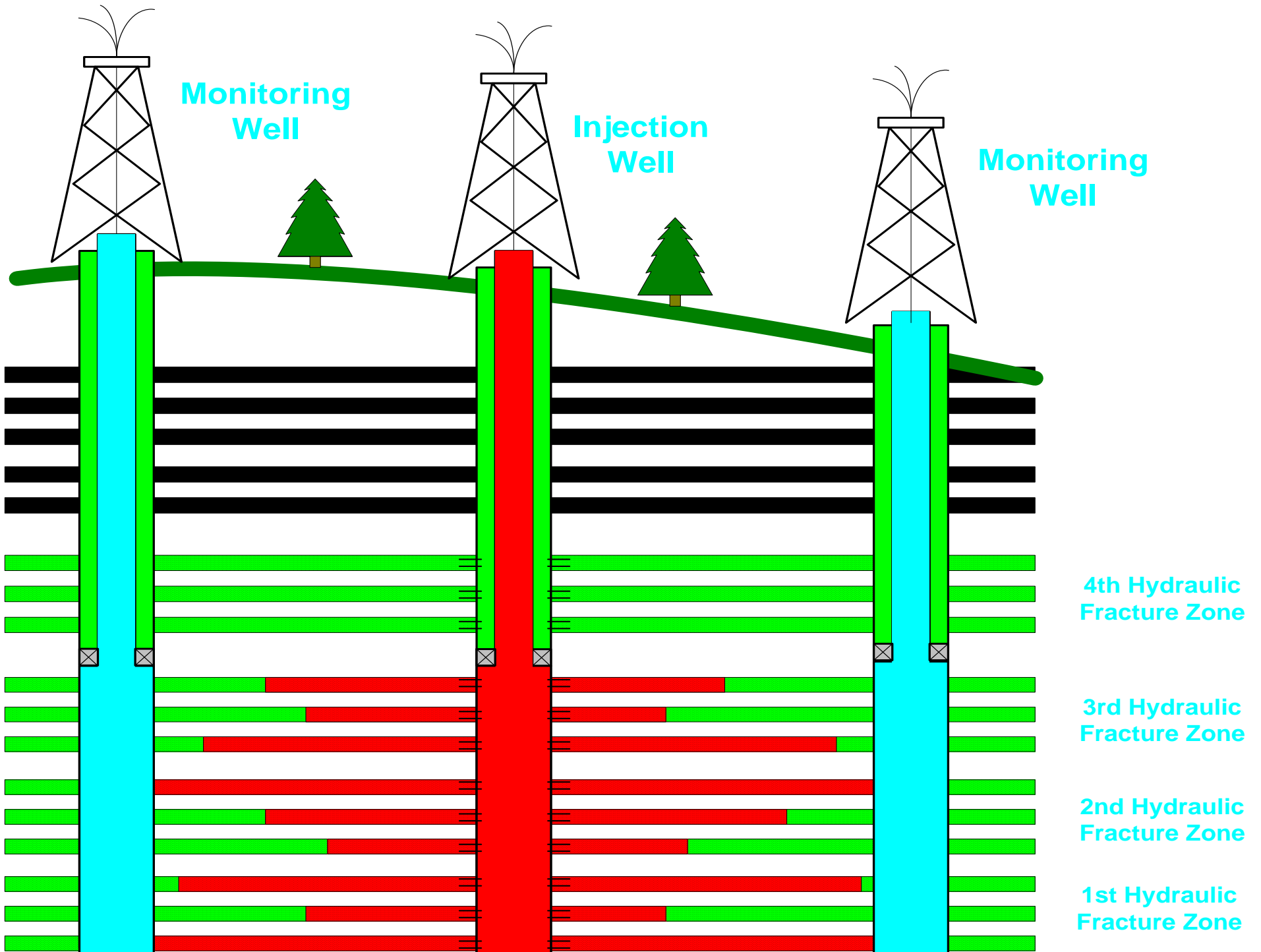
**Carbon
Sequestration
Validation
Phase Field
Tests**

Central Appalachian Field Test

Russell County, Virginia

CBM Test Well Site





Outreach



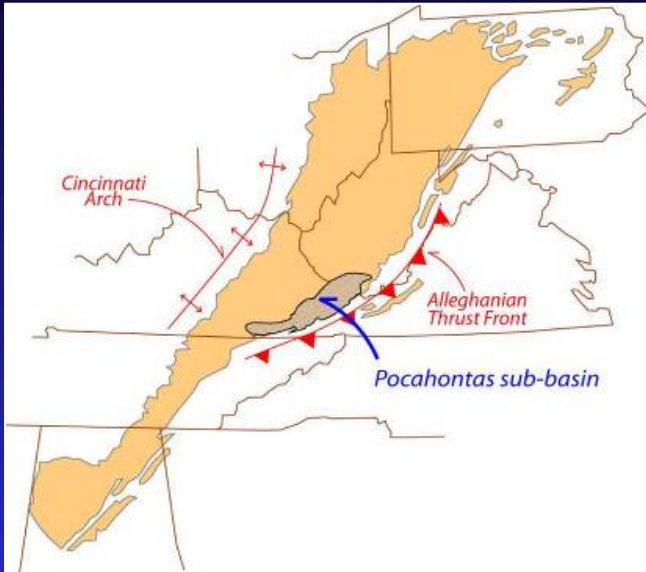
Groundbreaking and Site Visit



Large Volume Injection Sites in Central Appalachia- Task 10 Update

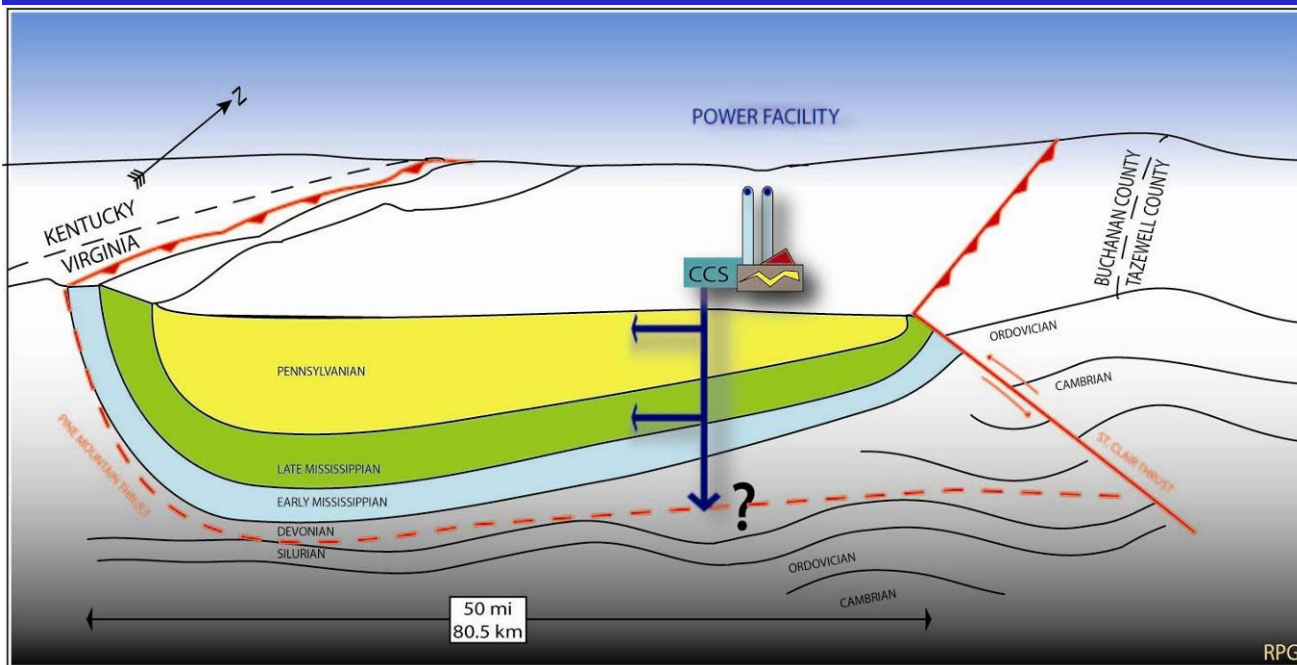
- Characterize potential large-volume test sites in Central Appalachia for coal seam sequestration and enhanced coalbed methane recovery
- Delineate and characterize saline aquifers in the region that could provide secondary carbon sequestration options
- Review and identify depleted or partially-depleted oil and gas fields that could support large-volume CO₂ injection tests
- Identify options for stacked storage reservoirs in Central Appalachia
- Select several test sites in Central Appalachia for a large-volume carbon sequestration test that can lead to commercial deployment.
- Evaluate test site operations, MVA program and site closure
- Implement public outreach and education

Geologic Setting, Task 10 Assessment Region



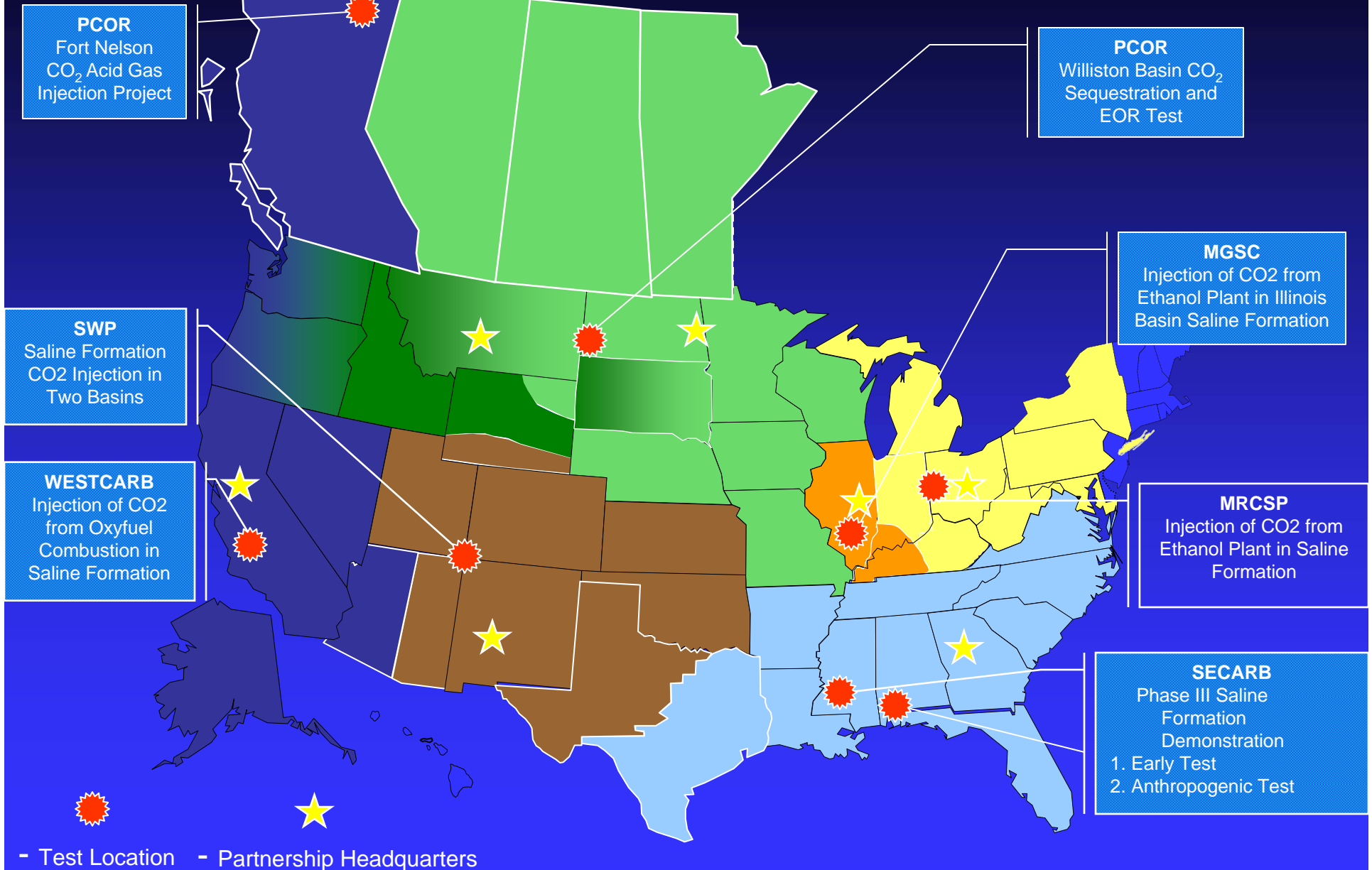
Objective – Investigate properties of geologic media for long term CO₂ storage in Central Appalachia

Subsurface information from oil, natural gas and coal operators allow VCCER researchers opportunities to explore CO₂ sequestration resources



Regional geophysical well log data is commonly available to characterize strata to depths > 5000 feet

Phase III: Deployment (Large-Scale Tests, 2008-2017)



**U.S. DOE
Clean Coal Power Initiative
(CCPI)**

**Demonstration of Advanced
Carbon Capture and Storage at the
Dominion Virginia City Hybrid Energy Center
Wise County, Virginia
(CCPIVA)**

Dominion News Release – *August 25, 2009*

- BLACKSBURG, Va. – A coalition led by **Virginia Tech's Virginia Center for Coal and Energy Research** (VCCER) has applied for federal stimulus funding to cover up to half of the estimated **\$580 million** cost of a carbon-capture and storage demonstration project proposed for a **power station being built by Dominion in Wise County, Va.**
- Carbon dioxide removed from the station's air emissions at the **Virginia City Hybrid Energy Center** would be moved by pipeline for permanent storage in unmineable coal seams and underground saline formations in the region
- A side benefit may be enhanced production of methane, the primary component of natural gas, from the coal seams.

Rendering of CCS Facility at Dominion's VCHEC



CCPIVA Economic Development Benefits to the Region

- \$162.8 million annual overall economic benefit to the region
- \$420 million spent in construction costs for the capture facility and pipeline
- 35.5 equivalent full-time employees (FTE) operating the carbon capture and storage facilities
- \$29 million in direct state and local revenues from the storage operations
- Generation of federal, state, and city/county tax revenue
- 2.5 Bcf of ECBM production, valued at \$17 million, estimated from the demonstration project injection
- Development of coal research infrastructure in the region

Long-term Benefits of CCPIVA

- Development of carbon emission technologies for power stations
- Continued viability of the coal industry
- Continued generation of affordable, reliable electricity produced from coal
- CCS with ECBM has the potential to add significant recoverable reserves and extend the life of gas fields in central Appalachia
 - ◆ ECBM could potentially increase coalbed methane reserves in Central Appalachian Basin by as much as 790 billion cubic feet (Bcf), valued at \$3 billion
- The ability to sustain environmentally sound use of coal and to expand natural gas production will contribute to the nation's energy security

The Question of Liability: A Major CCS Barrier

From the CCPIVA proposal submitted to DOE

2.2.5 Meeting DOE Objectives

...The timing is such that, by the conclusion of Phase 1 of the project in April of 2011, we will know if the Commonwealth of Virginia has passed appropriate legislation. If such legislation is not on the books at the Phase 1 decision point (April 2011), or if the sponsors are unable to secure private insurance to cover any gap in liability, CCPIVA will recommend to DOE that the project not continue into Phase 2.

CCS Liability legislation is Needed To:

- Reduce risks and liability associated with CCS research and demonstration
- Define responsibility and jurisdiction during operation and post-closure of CCS facilities
- Insure long term responsibility for geologic storage of CO₂
- Resolve questions of ownership of the geologic storage resource
- Virginia should act in a timely manner - Federal action would be preferable to ensure uniform treatment , but may take years to be enacted

Enactment of CCS Liability Legislation Would:

- Develop clean coal technologies that are critical for the continued use of coal
- Accelerate and enable development and deployment of carbon capture and storage
- Clear the way for further research by enhancing Virginia's eligibility for CCS grants
- Promote use of CO₂ for enhanced production of gas

Seven states, TX, WY, LA, MT, ND, IL and OK, have put such legislation in place and three states, WV, UT, and KS are moving to do so. Virginia needs to act to protect its interests.

Conclusions

- Large deployment tests are necessary to demonstrate and confirm CCS
- Large tests will provide sequestration “*assurance*” to the investor community seeking to fund energy project that can be impacted by CO₂-limiting legislation
- Absence of such tests in a region, or on a specific geologic formation, may delay sequestration demonstration and, therefore, deployment
- Liability legislation is urgently needed

The CCS “Road to Deployment” requires active engagement by all stakeholders