SAND2015-2269PE

Exceptional service in the national interest

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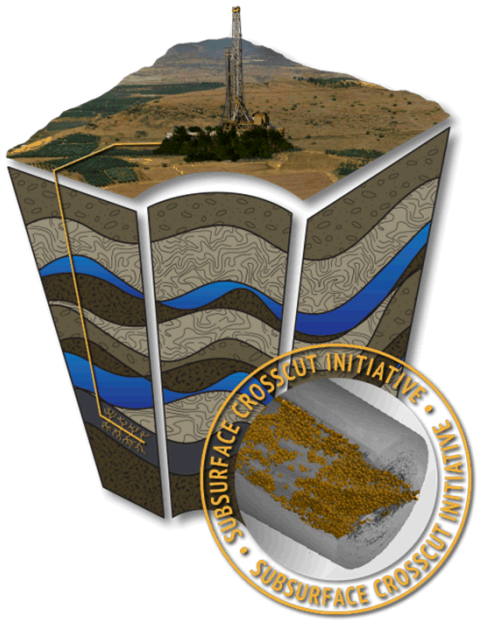

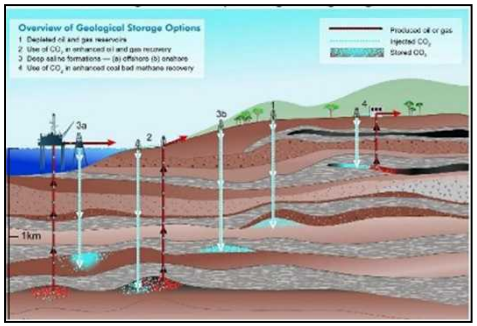

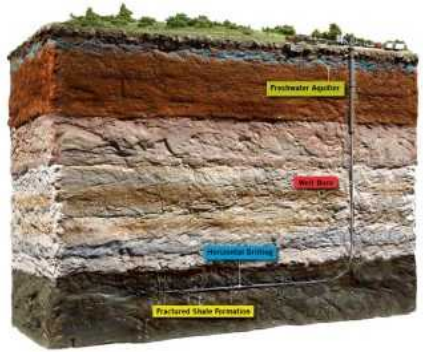

Subsurface Crosscut Initiative

Marianne C. Walck, Ph.D.
Director – Geoscience, Climate and Consequence Effects Center

March 3, 2015

U.S. DEPARTMENT OF ENERGY | NNSA

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Subsurface Crosscut Initiative

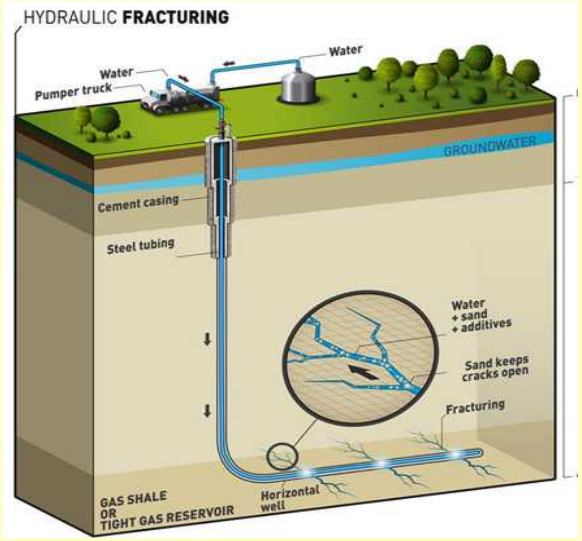
Marianne Walck (SNL)
Susan Hubbard (LBNL
National Laboratory Subsurface Crosscut Team &
DOE SubTER Tech Team

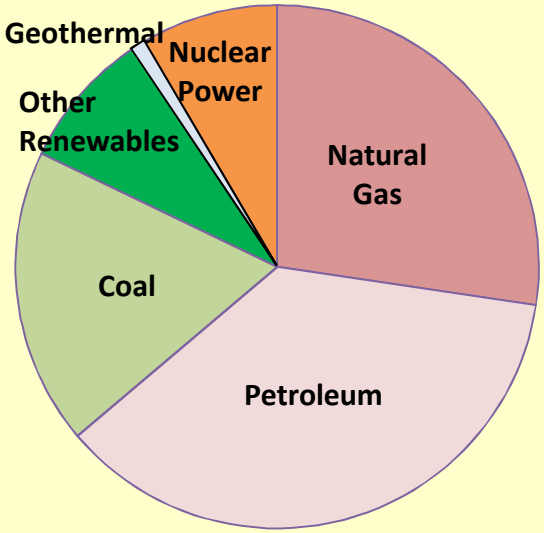
Big Idea Red Team Review
March 2, 2015

November 2014 Subsurface Scoping Meeting, Denver

Mastery of the Subsurface needed for US Energy Security

Shale hydrocarbon production

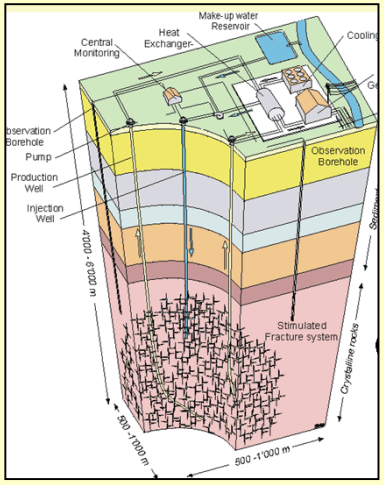




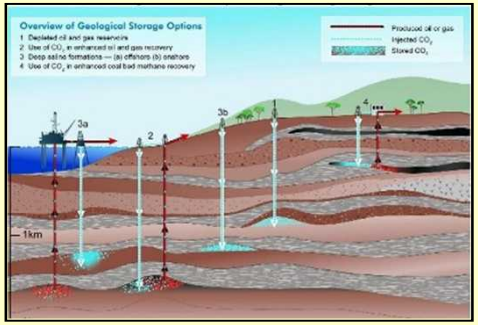
Primary Energy Use by Source, 2012

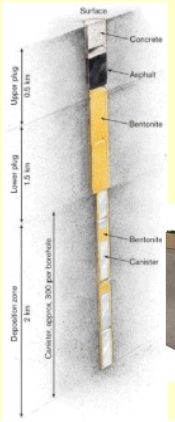
Quadrillion Btu [Total U.S. = 95.1 Quadrillion Btu]

Enhanced geothermal energy

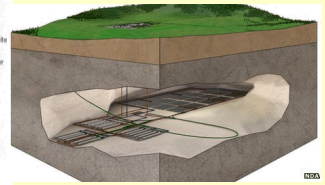


Safe subsurface storage of CO_2

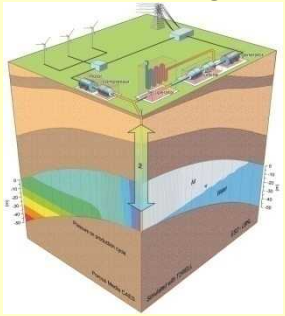




Safe subsurface storage of nuclear waste



Compressed Air Energy Storage



2014: DOE Subsurface Tech Team: SubTER Common Subsurface Challenges

Discovering, Characterizing, and Predicting

Efficiently and accurately locate target geophysical and geochemical responses, finding more viable and low-risk resource, and quantitatively infer their evolution under future engineered conditions

Accessing

Safe and cost-effective drilling, with reservoir integrity

Engineering

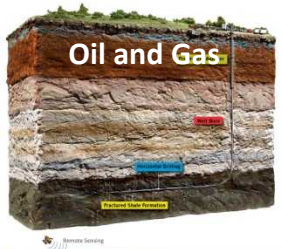
Create/construct desired subsurface conditions in challenging high-pressure/high-temperature environments

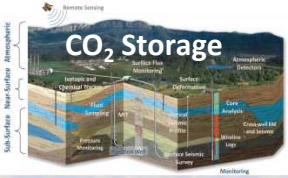
Sustaining

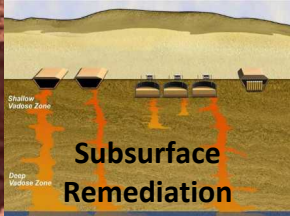
Maintain optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution

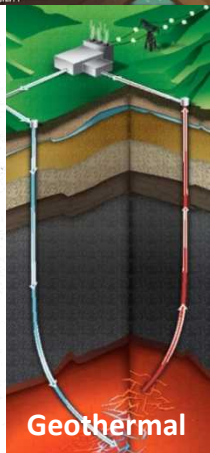
Monitoring

Improve observational methods and advance understanding of multi-scale complexities through system lifetimes



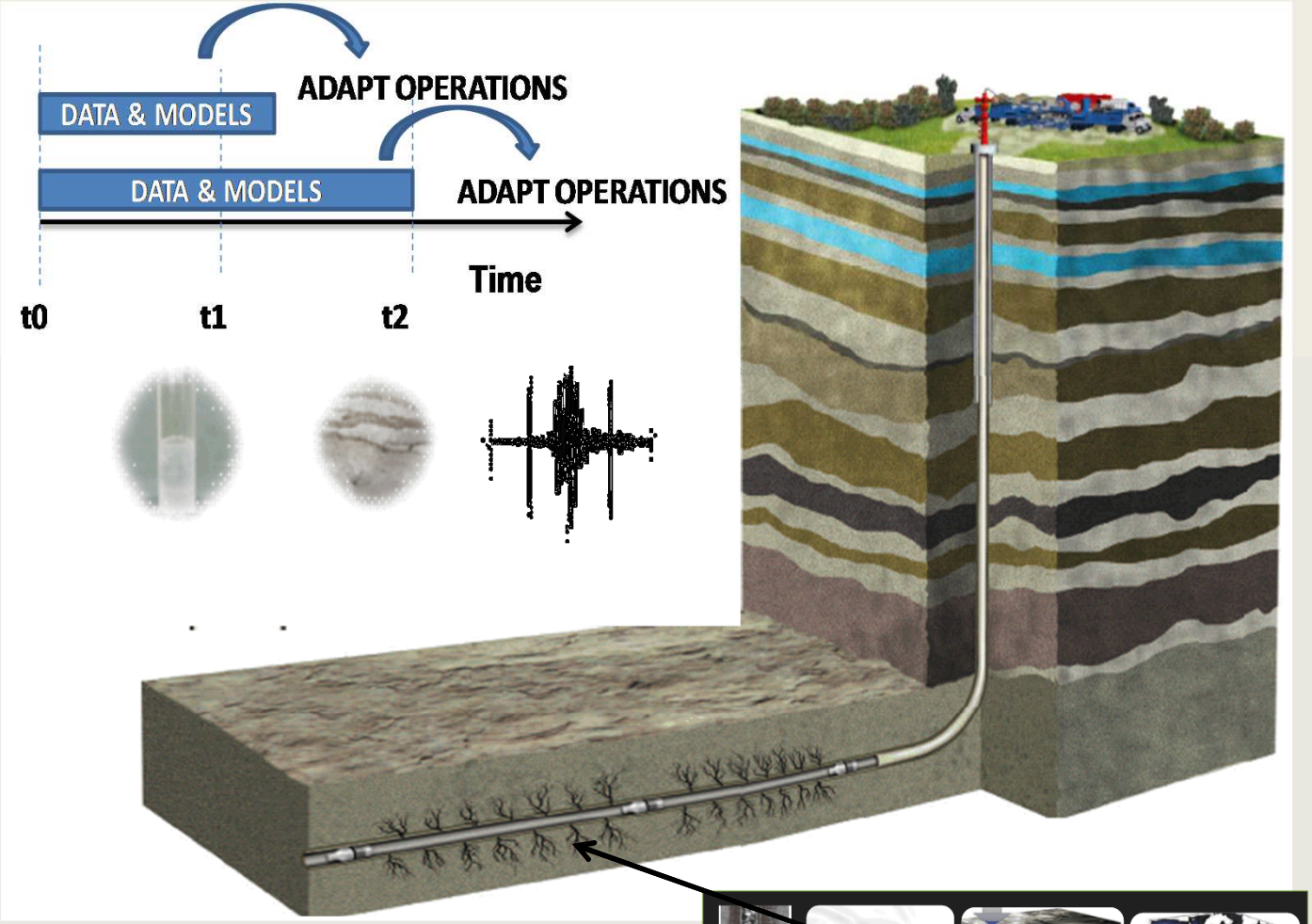




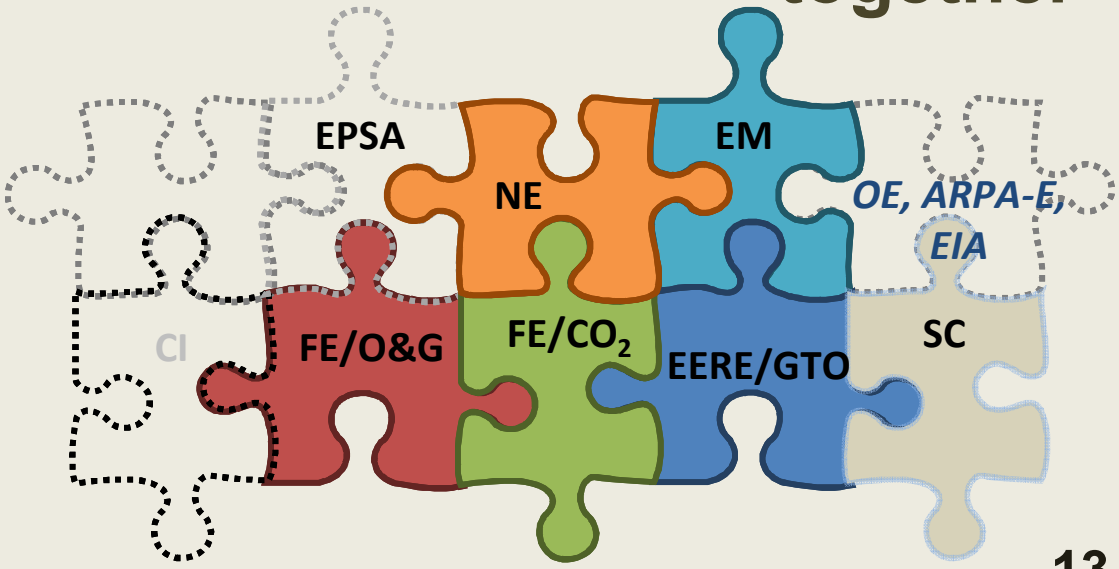


The Big Idea: "Adaptive Control of subsurface fractures, reactions and flow"

A Grand Challenge



The Crosscut Team and the Big Idea come together

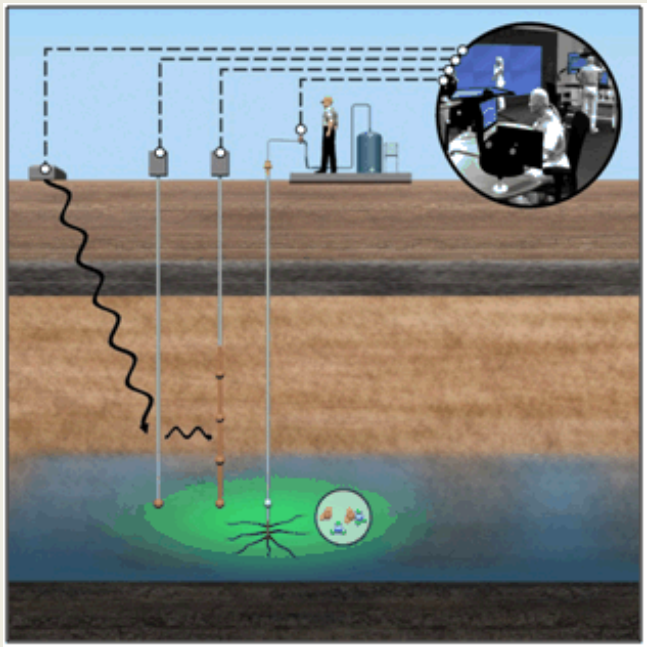


13 National Laboratories

Argonne NATIONAL LABORATORY
BERKELEY LAB Lawrence Berkeley National Laboratory
BROOKHAVEN NATIONAL LABORATORY
INL Idaho National Laboratory
Lawrence Livermore National Laboratory
Los Alamos NATIONAL LABORATORY EST. 1943
NETL
NREL NATIONAL RENEWABLE ENERGY LABORATORY
OAK RIDGE National Laboratory
Pacific Northwest NATIONAL LABORATORY
Sandia National Laboratories
SLAC NATIONAL ACCELERATOR LABORATORY
SRNL

Subsurface Vision
Adaptive Control of Subsurface Fractures and Fluid Flow

ENERGY SECURITY
- Increase U. S. electrical production from geothermal reservoirs
- Increase U.S. unconventional oil and natural gas production



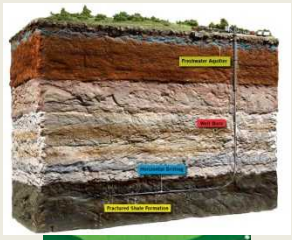
ENVIRONMENTAL SECURITY
- President's Climate Action Plan: Safely store CO_2 to meet GHG emissions reduction targets
- Safe storage/disposal of nuclear waste
- Reduced risk of induced seismicity
- Protect drinking water resources

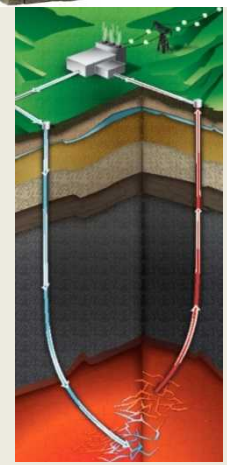
ECONOMIC SECURITY
- Retain U. S. subsurface leadership
- Increase revenues (taxes and royalty) to Federal, State, and local governments
- Increased public confidence in subsurface energy sector

Preliminary 10-year Metrics

Double hydrocarbon production from tight reservoirs.

- Increase longevity of US energy security
- Cut in Half
  - The number of wells drilled
  - the emissions associated with extraction and truck use
  - Water use for tight reservoir production

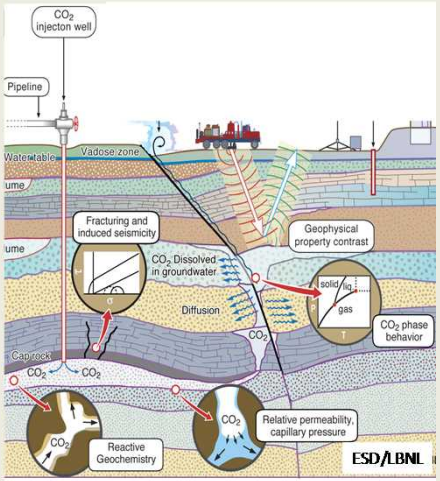


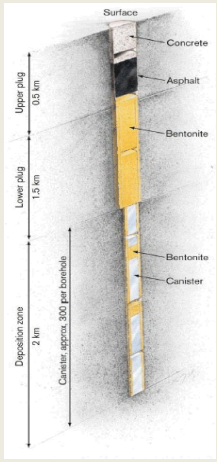


Achieve order-of-magnitude increase in U. S. electrical production from geothermal reservoirs

Establish practical feasibility of **deep borehole disposal** for specialty nuclear wastes

Double confidence level in safe subsurface storage of CO2





SubTER Progress

National Labs

Big Ideas Summit March 7 2014

White Papers May 2014

FY14 Seed projects initiated

Lab Rep Scoping Meeting Nov 2014

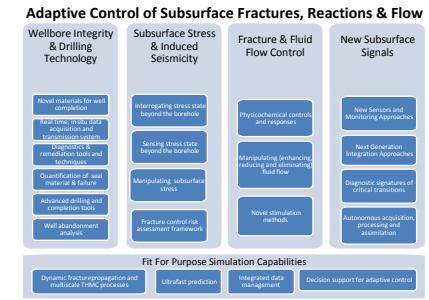
FY15 project proposals

Town Hall

- **Initiated unifying "system of labs" approach with common vision, message and sense of purpose**
- **Developed effective partnership between labs and DOE**

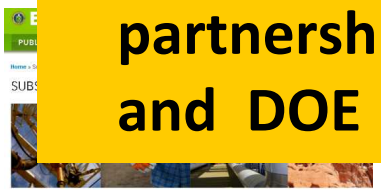
2015

QTR



DOE

Crosscut framework identified



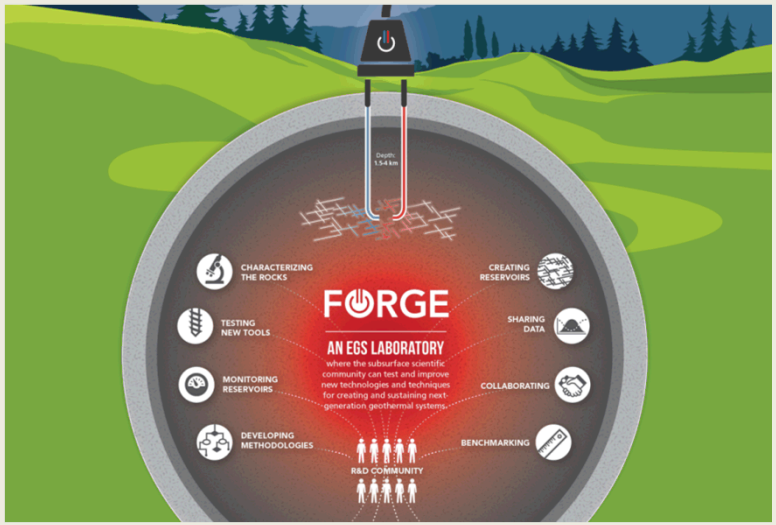
Subsurface Briefings to Staffers

Forge FOA released

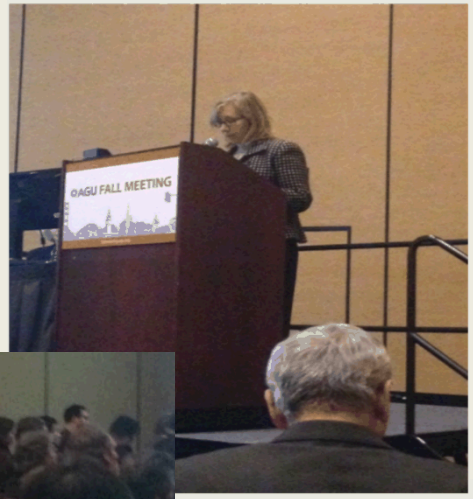
Example 2014 Outreach, Feedback & Activities

JASON report: 9/14. Recommended **"DOE take a leadership role in developing engineered subsurface systems, addressing major energy and security challenges of the nation."**

"Recent interest in fracturing organic-rich mudstones has **revealed our profound ignorance of the physical and chemical properties of these rocks**. We are injecting 100 billion gallons of water into them every year, while not even knowing whether water imbibition aids or impedes hydrocarbon production..... I would advocate for cooperation" (Schlumberger fellow)



FORGE Field Observatory FOA: Required for tfield esting, validation, and ultimately adoption of subsurface technologies



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Subsurface Crosscut Research Framework

Adaptive Control of Subsurface Fractures and Fluid Flow

Intelligent Wellbore Systems	Subsurface Stress & Induced Seismicity	Permeability Manipulation	New Subsurface Signals
Improved well construction materials and techniques	Measurement of stress and induced seismicity	Physicochemical fluid-rock interactions	New sensing approaches
Autonomous completions for well integrity			
Ne… w…			…e
Rem…			
Fit-f… and… (e.g. anticipative drilling, centralizers, monitoring)	Applied risk analysis of subsurface manipulation	Novel stimulation methods	Diagnostic signatures and critical thresholds
HT/HP well construction / completion technologies			

The Subsurface Crosscut Ramps Up

- FY14 Kickstart: $2M investment in seedling projects
- FY15 ~$6M opportunity to propose high priority, integrated and collaborative projects
- FY16 expected launch: President's Budget Request includes $244M for SubTER; ~$100M new funds

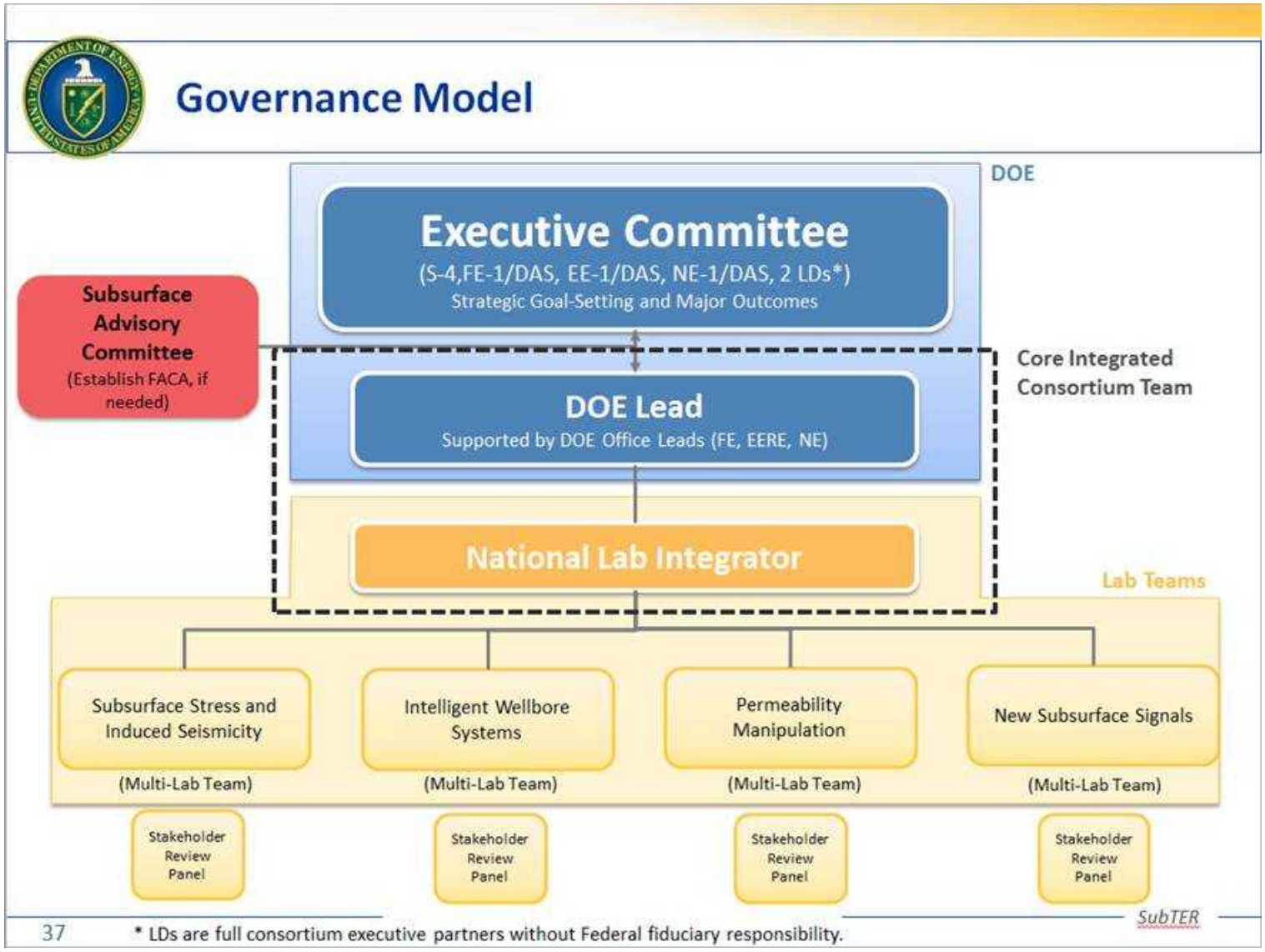
Energy Field Observatories

Fit For Purpose Simulation Capabilities

SubTER in FY2016 President's Budget Request

	Wellbore Integrity	Subsurface Stress and Induced Seismicity	Permeability Manipulation	New Subsurface Signals	Ongoing Subsurface-Related R&D	TOTAL
Defense Environmental Cleanup, TOTAL	---	---	---	---	8,000	8,000
Headquarters Operations: Technology Development	---	---	---	---	2,000	2,000
Idaho National Laboratory	---	---	---	---	3,000	3,000
Richland/Hanford: Hanford Site	---	---	---	---	3,000	3,000
Energy Efficiency and Renewable Energy, TOTAL	---	10,000	8,000	8,000	45,000	71,000
Geothermal Technologies: Enhanced Geothermal Systems	---	5,000	---	---	34,000	39,000
Geothermal Technologies: Hydrothermal		5,000	8,000	8,000	11,000	32,000
Fossil Energy Research & Development, TOTAL	11,788	23,888	5,071	9,687	70,084	120,518
Carbon Storage: Advanced Storage R&D	5,000	7,384	---	5,000	---	17,384
Carbon Storage: Storage Infrastructure	---	---	---	---	60,084	60,084
Carbon Storage: Sub-Disciplinary Storage R&D	5,600	15, 316	3,888	3,500	---	28,300
Crosscutting Research: Coal Utilization Science	1,188	1,188	1,187	1,187	---	4,750
Natural Gas Technologies: Environmentally Prudent Development	---	---	---	---	10,000	10,000
Nuclear Energy, TOTAL	26,000	---	---	---		26,000
Fuel Cycle R&D: Used Nuclear Fuel Disposition	26,000	---	---	---		26,000
Science, TOTAL	---	---	---	---	5,000	**5,000**
Basic Energy Sciences: Chemical Sciences, Geosciences, and Biosciences					5,000	5,000
Total, Subsurface Technology and Engineering	37,788	33,888	13,071	17,687	141,584	**244,018**

Latest proposed SubTER model from DOE



FY 2015 Schedule

Activities	Nov-Dec 2014	Jan-Feb 2015	Mar-Apr 2015	May-Jun 2015	Jul-Aug 2015	Sep-Oct 2015	Nov 2015
Subsurface Crosscut Scoping Meeting • 13 labs and DOE participated • Technical planning for program elements							
Labs support DOE on SubTER elements in QTR • Substantive narrative for web appendix							
FY15 AOP Opportunity for Labs ($6M, multi-lab projects)							
Outreach: Professional Societies, universities, industry							
2nd Subsurface Crosscut Scoping Meeting							
Develop Technical Plan for FY16							
SubTER Community Workshop (Academia and Industry) • Includes Published workshop report							
SubTER Launch							

Subsurface Control for a Safe, Effective and Environmentally Responsible Energy Future

- Facilitates innovation to address **climate change** and reduce greenhouse gas emissions
  - Safe storage of CO_2
  - Increased deployment of renewable energy (geothermal)
  - Reduction of fugitive methane emissions through improved wellbore technologies, etc.
- Addresses challenges and opportunities with **water** management
- Drives innovation to improve **safety** associated with subsurface energy operations
- Advances new concepts for safe and responsible disposal of **nuclear waste**
- Increased recovery factors from tight formations can vastly increase the longevity of US **energy security**
- Implementation of a **new collaborative model** to tackle an energy "grand challenge" faced by multiple sectors

U.S. DEPARTMENT OF ENERGY | Office of the Under Secretary for Science and Energy

Energy Department Subsurface Crosscut

Addressing Common Subsurface Challenges

The ability to master the subsurface continues to elude researchers and practitioners working on a variety of energy production and storage applications. The DOE is implementing a new collaborative model to tackle this "energy grand challenge" through a coordinated RD&D strategy. Common challenges faced by the participating offices include:

1. **Discover, Characterize, and Predict**
   - accurately characterizing the subsurface using integrated geophysical and geochemical technologies
   - Quantitatively inferring subsurface evolution under current and future engineered conditions
   - Finding viable, low-risk resources
2. **Access**
   - safe, cost-effective reservoir integrity
3. **Engineer**
   - Creating/constructing desired subsurface conditions in challenging high-pressure/high-temperature environments
4. **Sustain**
   - maintaining optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution
5. **Monitor**
   - improving observational methods to advance understanding of multi-scale complexities through system lifetimes

The SubTER technical team identifies and facilitates crosscutting RD&D and policy activities for DOE, to enable programs with common technical challenges to work together toward solutions. The SubTER crosscut reports to the Under Secretary for Science and Energy and leverages program budget priorities to better plan for investment and assistance. While each of the offices brings new activities to the table, the sector benefits as a whole from crosscutting solutions. Partnerships include Departmental programs and offices, labs, academia, and industry, as well as synergies across federal agencies.

Subsurface Technology and Engineering Research, Development, and Demonstration (SubTER) Crosscut

Subsurface energy sources satisfy over 80% of total U.S. energy needs. Finding and effectively exploiting these resources while mitigating impacts of their use constitute major technical and socio-political challenges. Still, the opportunities are vast. Next generation advances in subsurface technologies will enable increases in domestic natural gas supplies, as well as 100+ GWe of clean, renewable geothermal energy. The subsurface provides hundreds of years of safe storage capacity for carbon dioxide (CO_2), and opportunities for environmentally responsible management and disposal of hazardous materials and other energy waste streams. The subsurface can also serve as a reservoir for energy storage for power produced from intermittent generation sources. These opportunities have immediate connection to societal needs and administration priorities. Clean energy deployment and CO_2 storage are critical components of the President's Climate Action Plan, necessary to meet the 2050 greenhouse gas (GHG) emissions reduction target. Increasing domestic energy supply from greater hydrocarbon resource recovery, in a sustainable and environmentally sound manner, are also Administration goals that enhance national security and fuel economic growth.

Who's Involved?

Representing the geosciences, research, modeling, technology development, policy, and stakeholders, the participating program offices include:

- Fossil Energy-Oil and Gas
- Fossil Energy-CO_2 Storage
- EERE-Geothermal Technologies Office
- Nuclear Energy
- Environmental Management
- Office of Science
- ARPA-E
- Office of Electricity
- Energy Policy & Systems Analysis
- Congressional & Intergovernmental Affairs
- Energy Information Administration

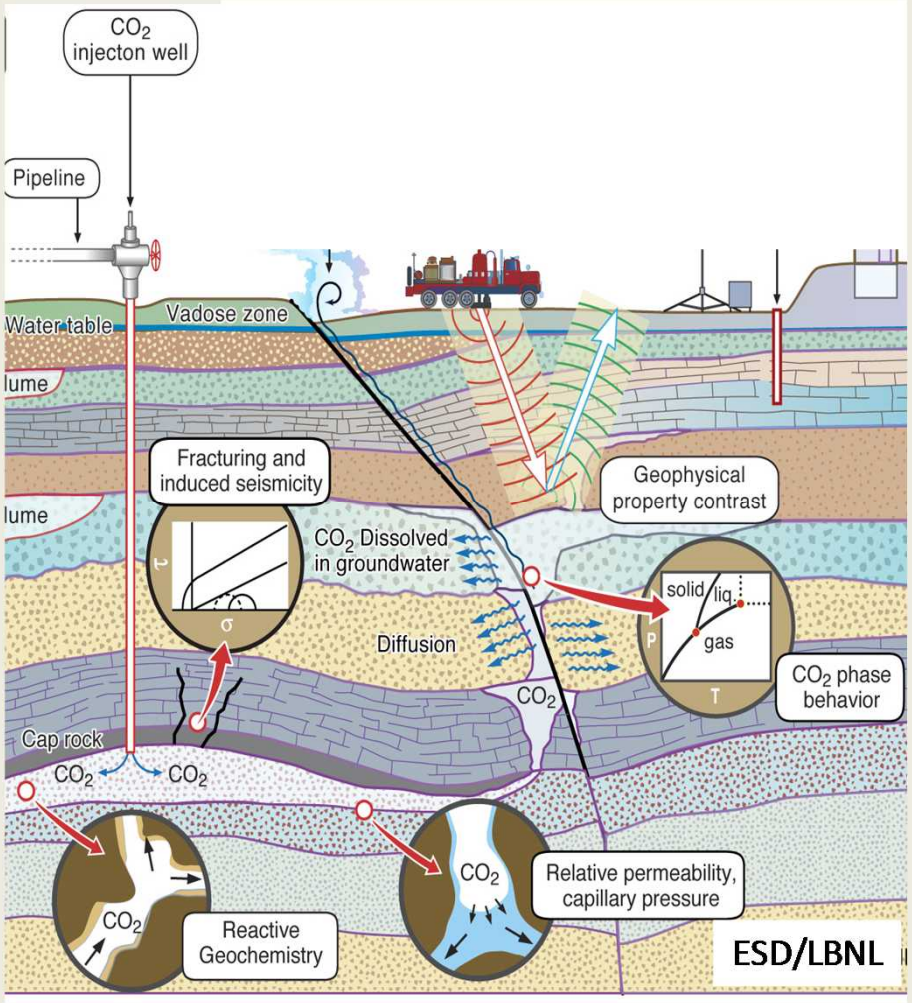
THANK YOU

For More Information:
energy.gov/subsurface-tech-team

Thank You

Many Common Subsurface Challenges

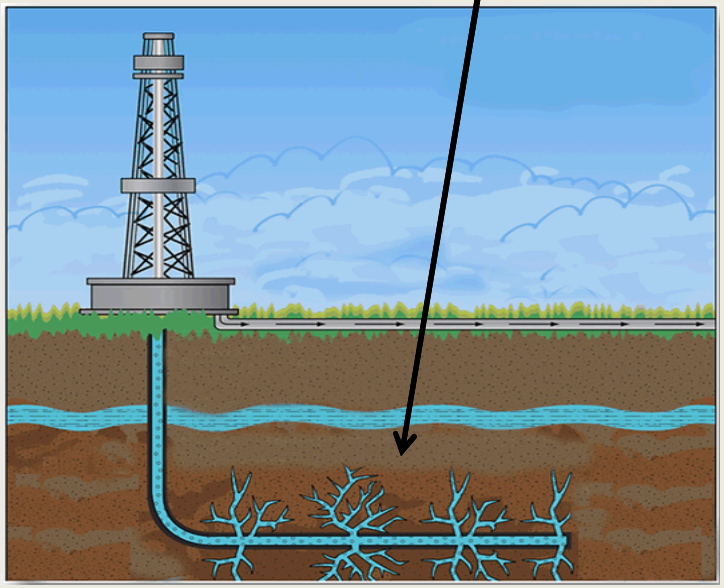
Reduce risk and cost of energy waste storage



Geological Carbon Sequestration

More with Less: Improve efficiency & minimize environmental impact of energy production

Fracture processes mineral-organic interactions flow



Shale Gas Production

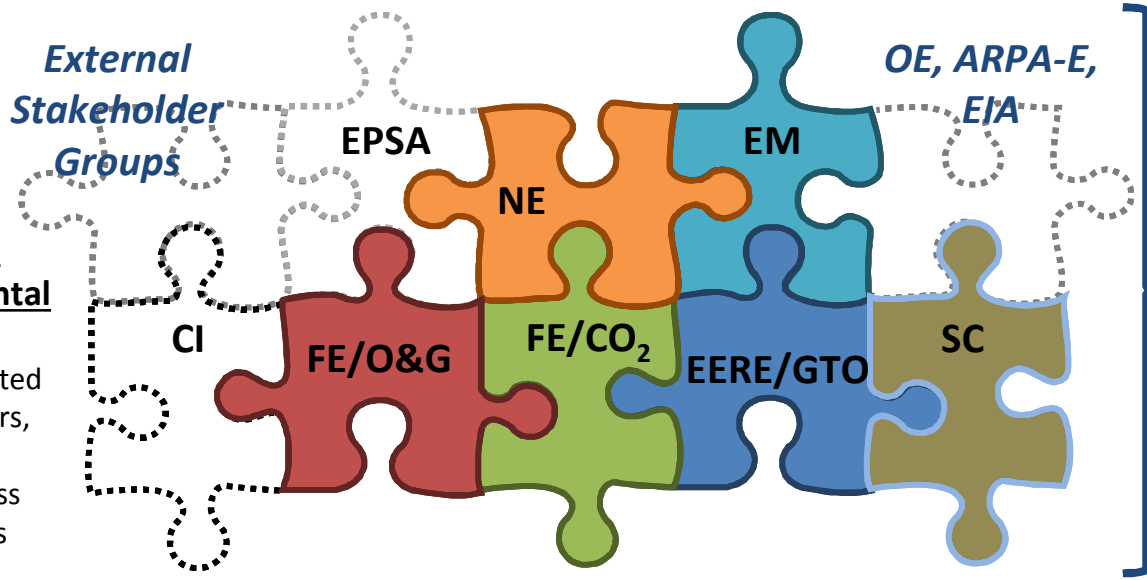
Who Is Involved: DOE & NLs

Energy Policy & Systems Analysis
- Advisement: Secretary of Energy
- Policy: low-carbon and secure energy economy
- Technical assistance: States and local entities

Nuclear Energy
- Policy and technology: disposition of used nuclear fuel and waste
- R&D: deep borehole disposal concept

Environmental Management
- Modeling and tools: subsurface evaluation and characterization
- Cleanup: nuclear weapons legacy

Congressional & Inter-governmental Affairs
- Interactions: elected officials, regulators, and stakeholders
- Information access for change agents



SubTER Tech Team
- Encompasses relevant offices
- Reports to Under Secretary for Energy and Science
- Identifies and facilitates crosscutting subsurface R&D and policy priorities for DOE
- Develops collaborative spend plan and funding scenarios

Fossil Energy/Oil & Gas
- R&D and access: clean, affordable traditional fuel sources
- R&D: drilling, well construction and integrity, and hydraulic fracturing technologies

Fossil Energy/Carbon Storage
- Policy and technology: challenges of CO_2 storage to inform regulators, industry, and the public
- R&D: CO_2 offshore and onshore storage

Energy Efficiency & Renewable Energy/ Geothermal Technologies Office
- R&D: locate, access, and develop geothermal resources
- R&D: access, create, and sustain enhanced geothermal systems (EGS)

Science
- Basic research: geology, geophysics, and biogeochemistry
- Expertise: subsurface chemistry, complex fluid flow