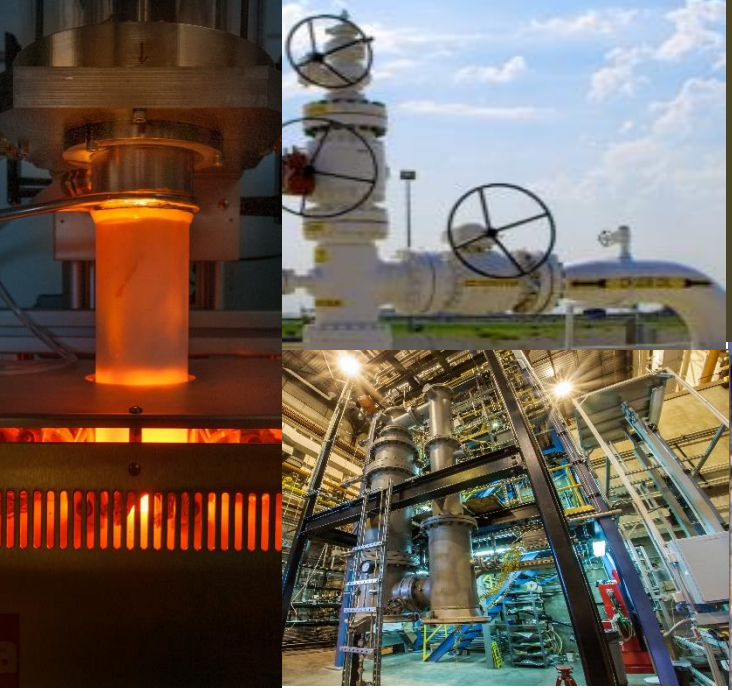




U.S. DEPARTMENT OF ENERGY

Office of Fossil Energy and SubTER Overview

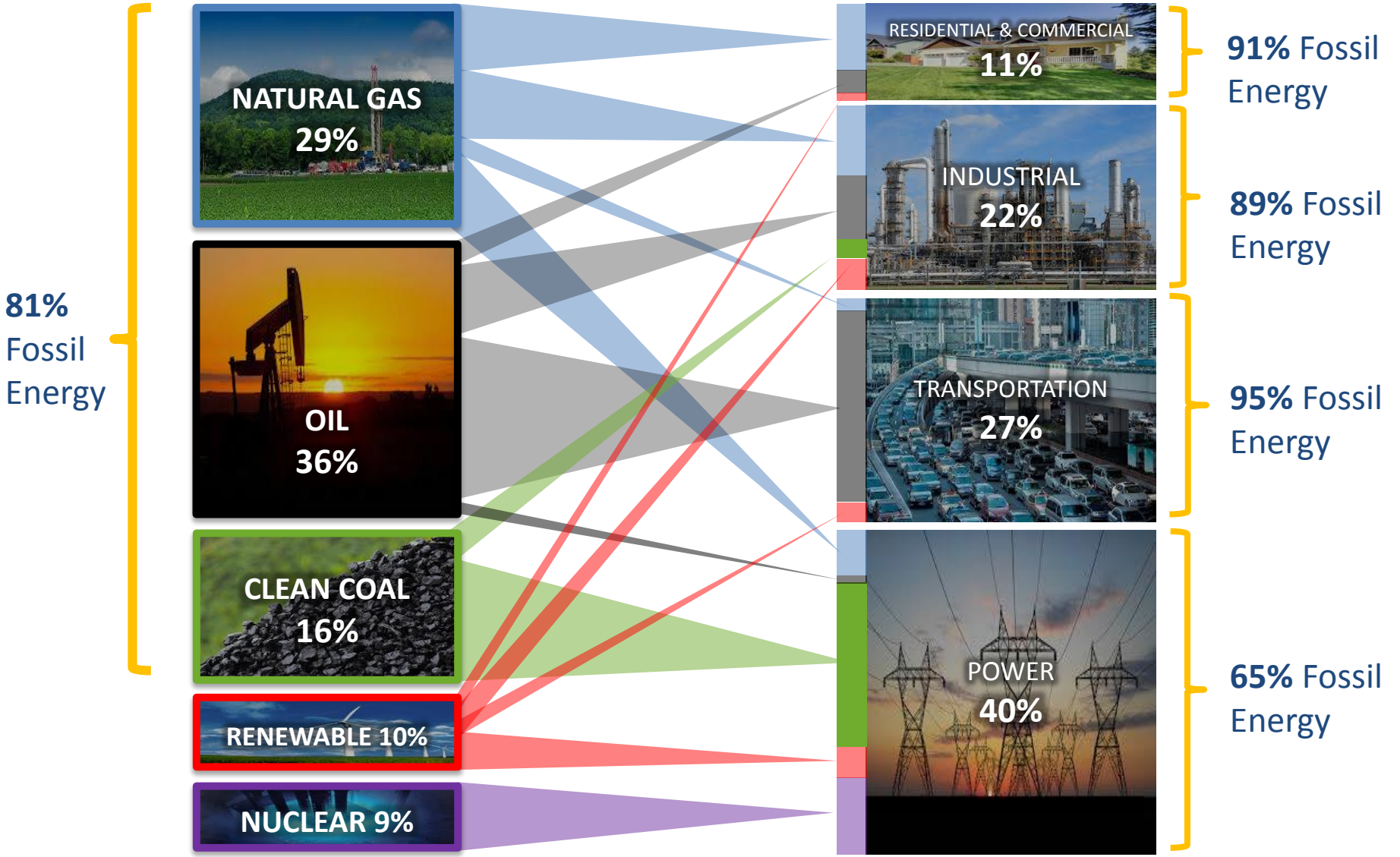
Carbon Storage and Oil & Gas Technologies Review Meeting

August 16, 2016

Doug Hollett

Principal Deputy Assistant Secretary

Fossil Energy Critical in All Domestic Sectors

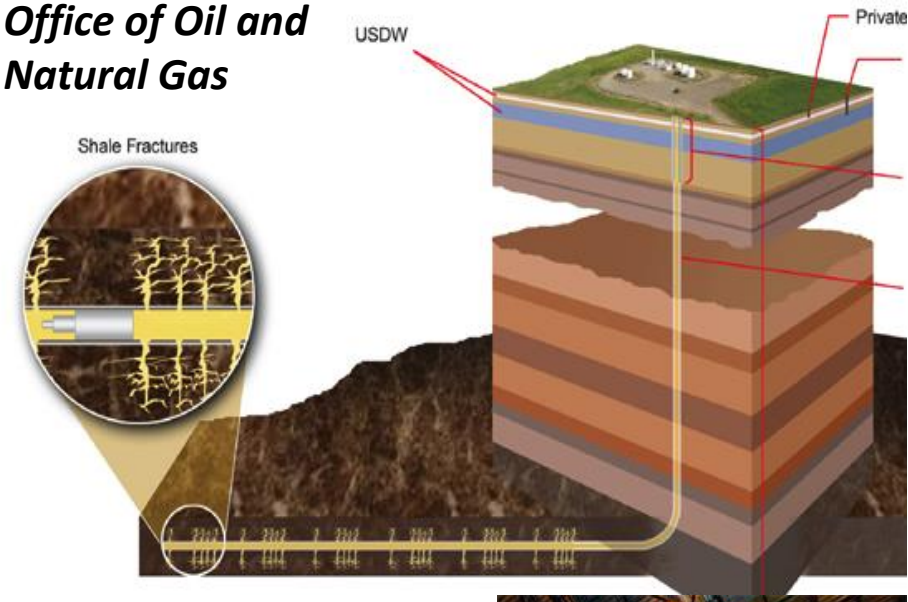


EIA, *Annual Energy Outlook 2015*, Reference Case.

DOE Office of Fossil Energy

Office of Clean Coal and Carbon Management

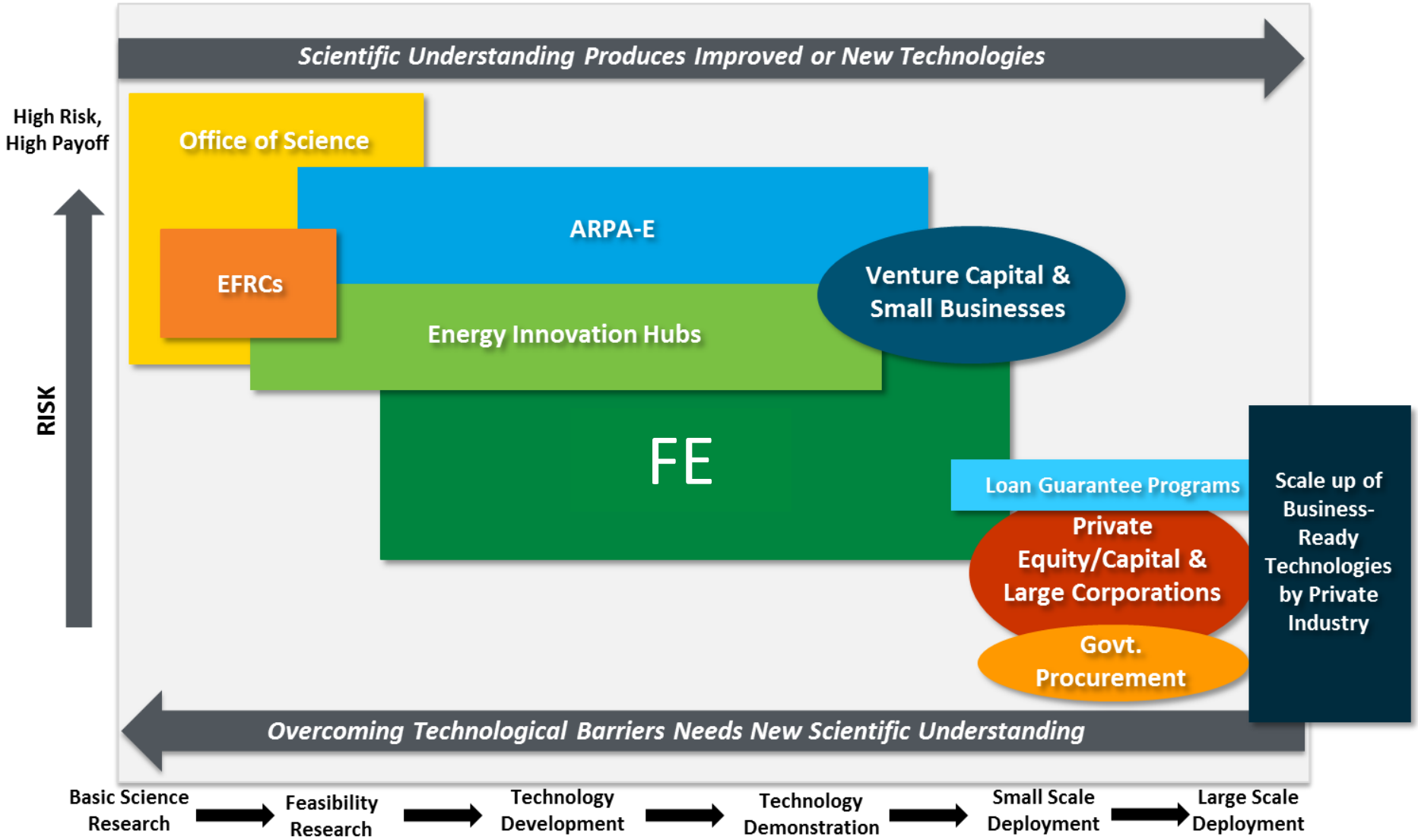
Office of Oil and Natural Gas



Office of Petroleum Reserves

National Energy Technology Laboratory

The Department of Energy and FE



FE Key Goals and Priorities

Accelerate a Commercial Pathway to CCS

- Innovation CCS
- Advanced Carbon Technologies R&D
- Domestic and international partnerships
- Reduce deployment barriers

Advance Safe and Environmentally Prudent Oil & Gas Resource Production and Transport

- R&D on water and air quality, induced seismicity
- Emissions mitigation and quantification
- Gas hydrates

Modernizing the Strategic Petroleum Reserves Program

Natural Gas Trade Regulation

Department of Energy RD&D Crosscuts

- Intra-agency efforts to address common science and engineering challenges across the energy spectrum
  - Subsurface Technology and Engineering (SubTER)
  - Supercritical CO2
  - Energy Water
  - Advanced Materials
  - Grid Modernization

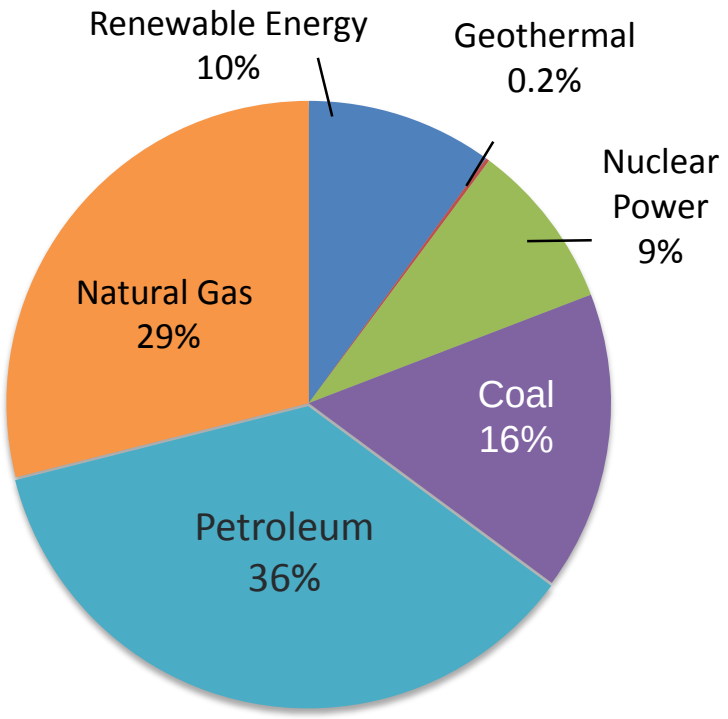
Meeting the President's Energy Goals

- "I committed this country to the tireless task of **combating climate change and protecting this planet for future generations**….a strong global agreement….that reduces global carbon pollution and sets the world on a course to a low-carbon future….[W]e succeeded.

- "[T]his agreement sends a powerful signal that the world is firmly committed to a low-carbon future. And that has the potential to **unleash investment and innovation in clean energy** at a scale we have never seen before. "

- President Obama, December 12, 2015

Subsurface is a Foundation of our Energy Economy



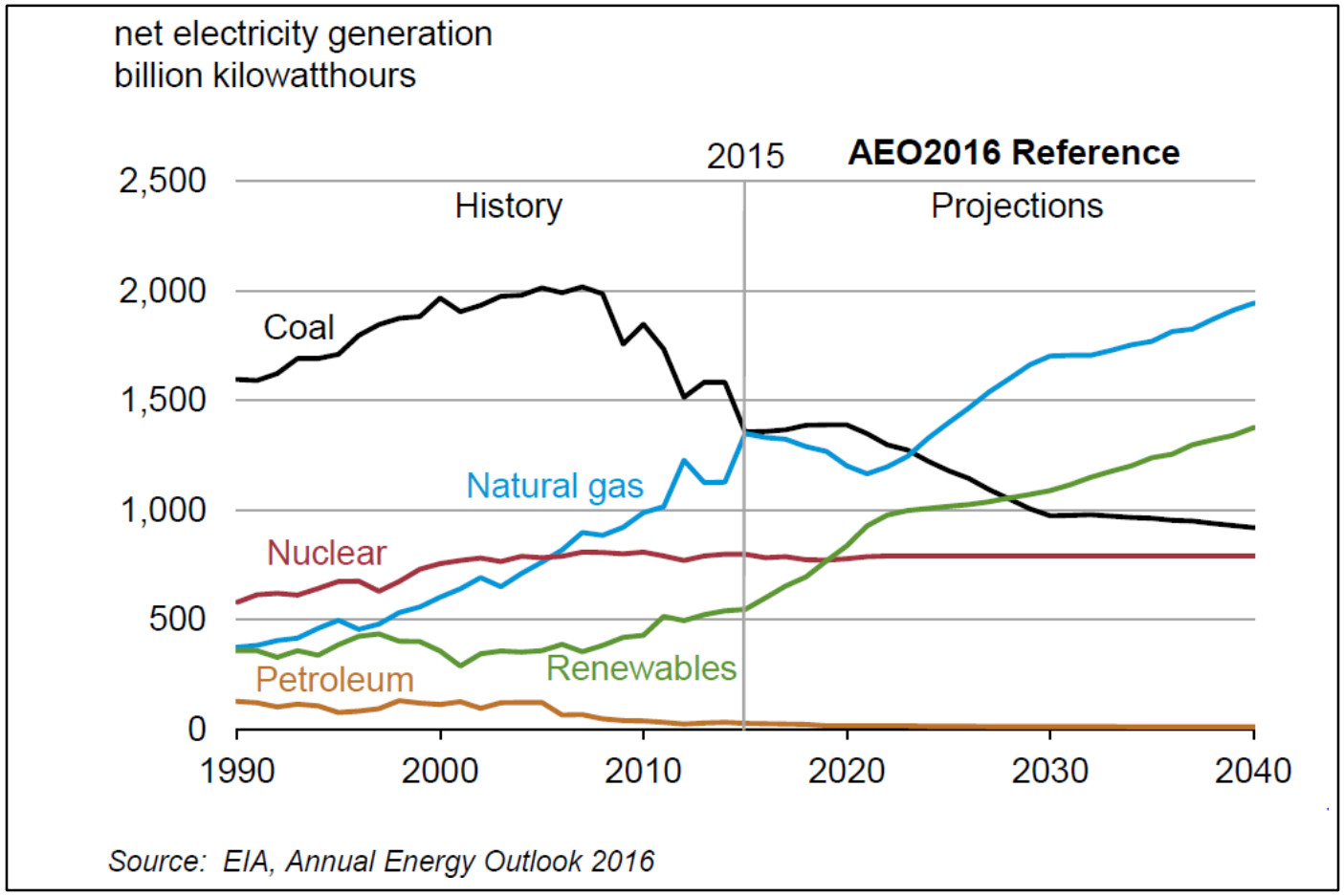
U.S. Primary Energy Use by Source, 2015

Quadrillion Btu [Total U.S. = 97.7 Quadrillion Btu]

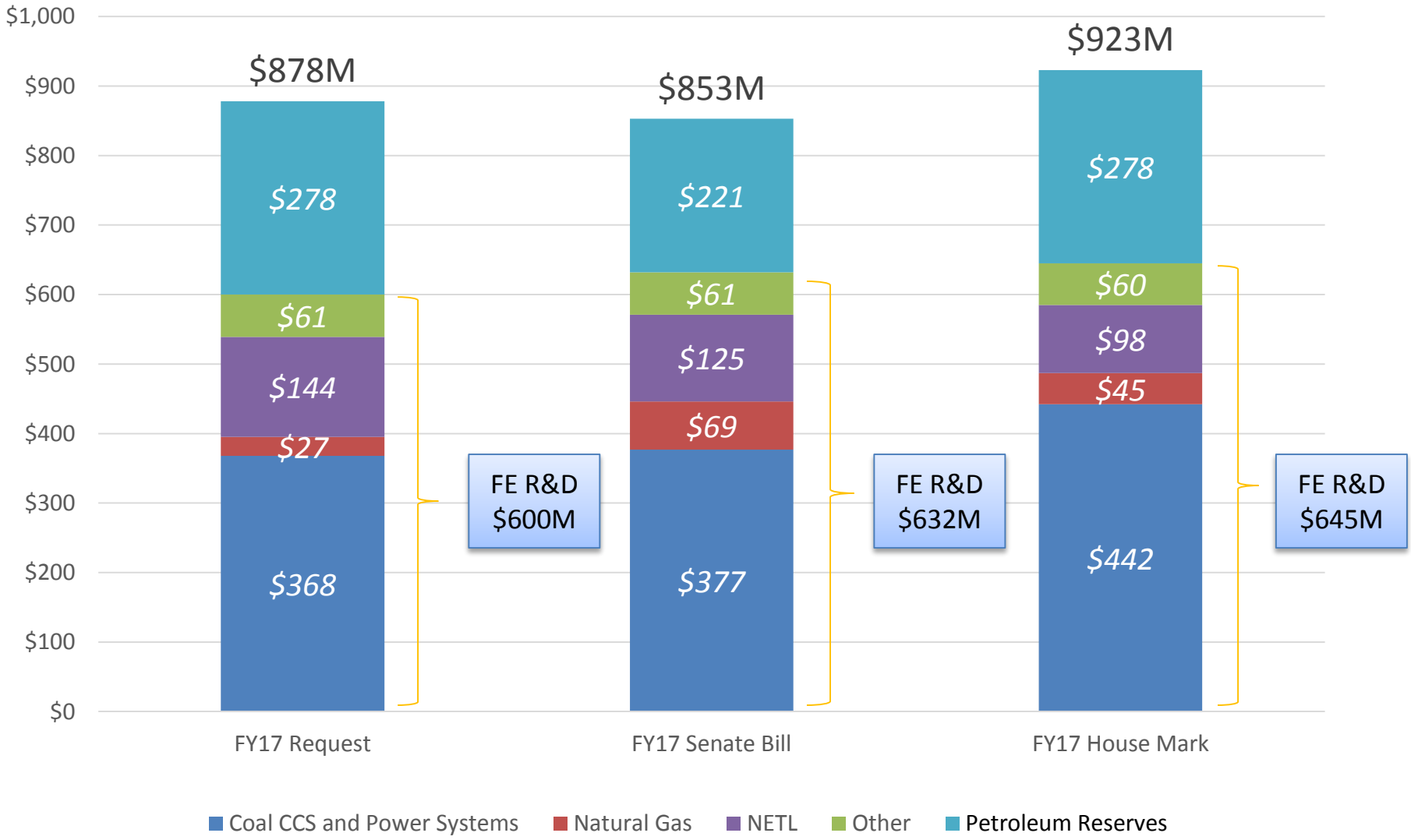
- Majority of our energy landscape
- Production, storage, sequestration, environmental impacts, climate
- Requires greater resolution and understanding, leading to greater levels of control, to continue the evolution to a clear energy economy
- Primary challenges relate to fluid flow in porous and fractured media in the subsurface

Subsurface is a Foundation of our Energy Economy

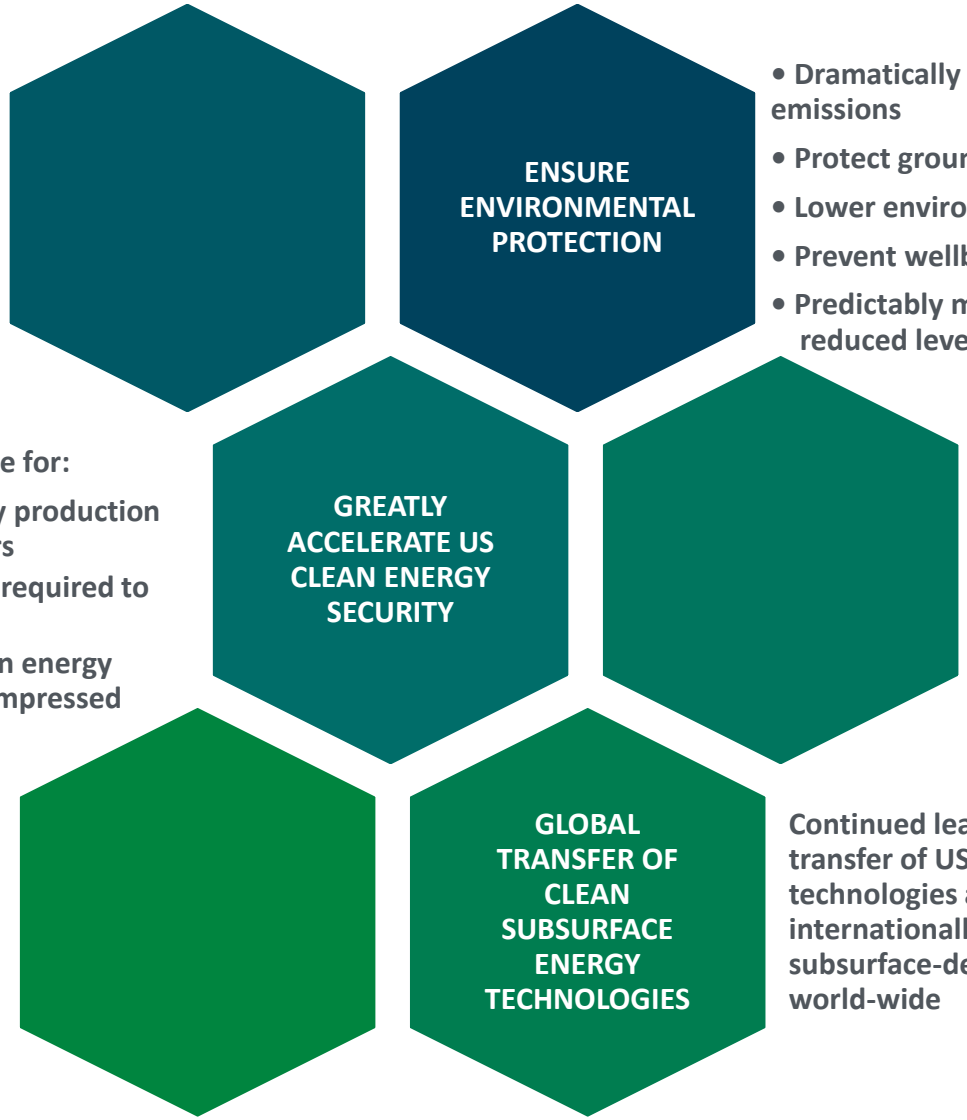
Even with large scale growth of gas-generated electric power generation and declining reliance on coal, reliance on subsurface remains a critical issue into the future.



Fossil Energy FY17 Budget Request *(in millions)*



Goals and Strategy FY18-22 – Mission Innovation



- Dramatically reduce fugitive methane emissions
- Protect groundwater
- Lower environmental footprint of drilling
- Prevent wellbore-based catastrophes
- Predictably manipulate subsurface with reduced levels of induced seismicity

Enable safe use of subsurface for:

- 5x increase in clean energy production from geothermal reservoirs
- Large-scale storage of CO_2 required to offset GHG emissions
- Large-scale storage of clean energy streams such as H_2 and compressed air

Continued leadership and transfer of US subsurface energy technologies and knowledge internationally, enabling clean subsurface-derived energy, world-wide

SubTER Science and Technology Pillars

Wellbore Integrity

- Improved Well Construction Materials and Techniques
- Autonomous Completion for Wellbore Integrity Monitoring
- New Diagnostics for Wellbore Leakage
- Remediation Tools and Technologies
- Fit-for-Purpose Drilling and Completion Tools
- High-Temperature and Pressure Well Construction and Completion Technologies

EE, FE, NE, EM

Subsurface Stress & Induced Seismicity

- State of Stress – Measurement and Manipulation
- Induced Seismicity - Measurement and Manipulation
- Relate Stress and Induced Seismicity to Permeability
- Applied Risk Analysis to Assess Impact of Subsurface Manipulation

EE, FE, SC

Permeability Manipulation

- Manipulating Physiochemical Fluid-Rock Interactions
- Manipulating Flow Paths to Enhance/Restrict Fluid Flow
- Characterizing Fracture Dynamics and Fluid Flow
- Novel Stimulation Technologies

EE, FE, SC, NE

New Subsurface Signals

- New Sensing Approaches
- Integration of Multi-Scale, Multi-Type Data
- Diagnostic Signatures and Critical Thresholds
- Adaptive Control Processes

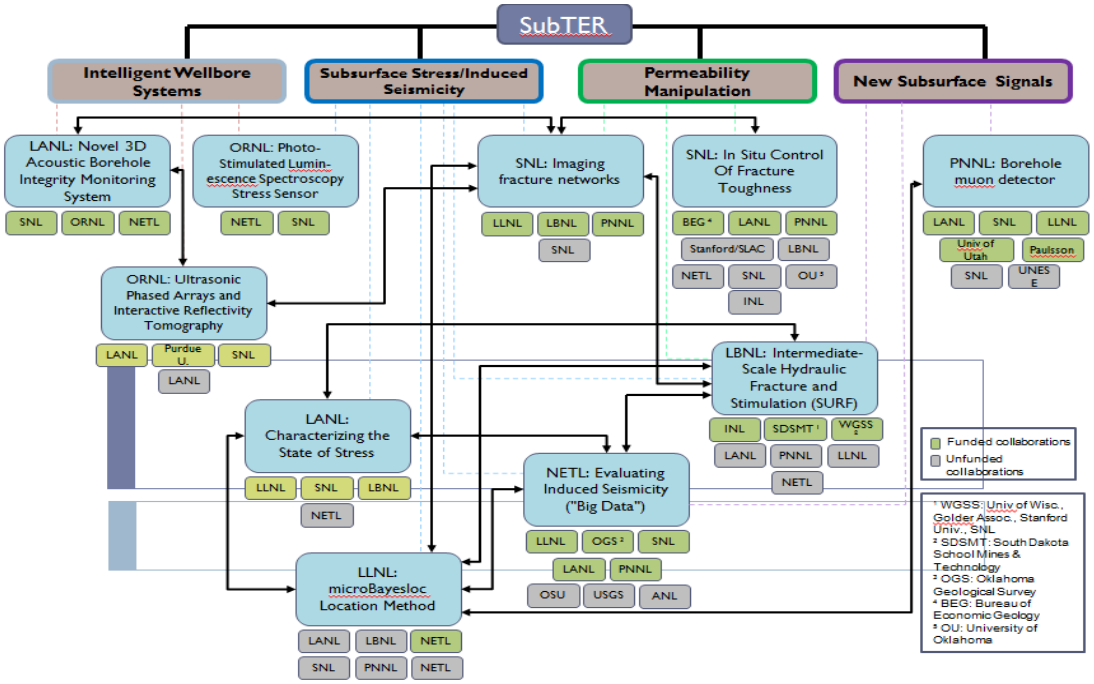
EE, FE, NE, SC, EM

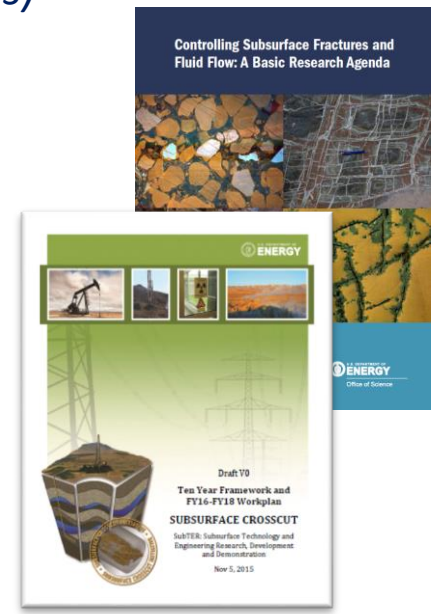
Grand Challenge: ***Advanced Imaging of Geophysical and Geochemical Signals in the Subsurface***

- *Subsurface fractures and flow*
- *Subsurface stress distribution and dependent seismicity*
- *Physical and chemical changes in rock-fluid systems*

SubTER Highlights 2015-2016

- **National Lab pillar-focused R&D projects underway ("Saplings")**
- **Office of Science Roundtables lead to $33.8M FY17 EFRC budget request**
- **FY16 Joint Competitive R&D FOA (EERE and FE) $9M**
  - Development of Technologies for Sensing, Analyzing, and Utilizing Novel Subsurface Signals
- **Draft National Lab Multi-Year Workplan** *(under review by Programs)*
  - 10 year framework with 2 and 5 year intermediate goals





FY15-16 SubTER Lab Projects “Saplings”

- Evaluating the State of Stress Beyond the Borehole - LANL
- Development of Novel 3D Acoustic Borehole Integrity Monitoring System - LANL
- Intermediate-Scale Hydraulic Fracture and Stimulation Field Laboratory in a Deep Mine for the Investigation of Induced Seismicity and Fracture Flow - LBNL
- Development of MicroBayesloc Location Method - LLNL
- Evaluating Induced Seismicity with Geoscience Computing & Big Data – A Multi-Variate Examination of the Cause(s) of Increasing Induced Seismicity Events - NETL
- Photo-Stimulated Luminescence Spectroscopy Stress Sensor For In-Situ Stress and Behind Casing Cement Integrity Measurements - ORNL
- Ultrasonic Phase Arrays and Interactive Reflectivity Tomography for Nondestructive Inspection of Injection and Projection Wells - ORNL
- Imaging Fracture Networks Using Joint Seismic and Electrical Change Detection Techniques - SNL
- Borehole Muon Detector for Tomography of Subsurface Reservoirs - PNNL

SubTER Highlights 2015-2016 *(cont.)*

SubTER Industry Roundtable held in Houston, February 2016, with broad participation and support for SubTER mission

BAKER INSTITUTE
for entrepreneurship, creativity and innovation

FY 2016 Key Accomplishments

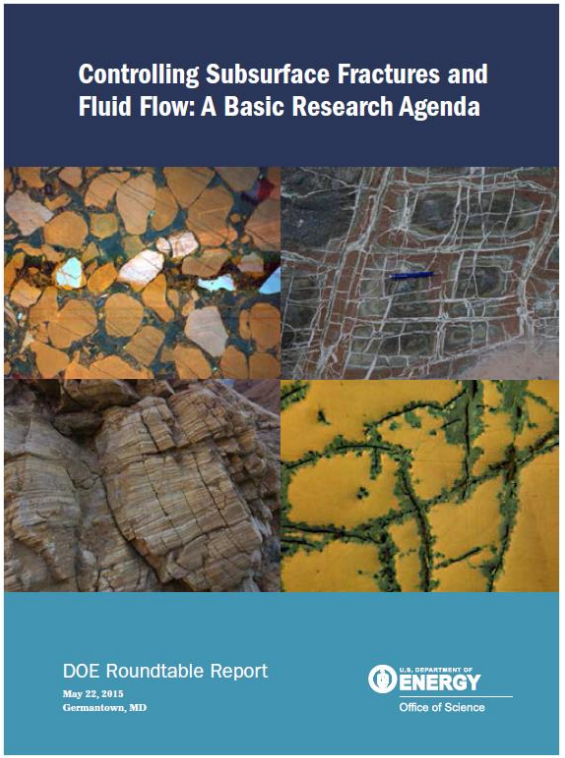
- GTO and FE's Carbon Storage program released the first joint DOE SubTER FOA with a total $9 M available for funding titled: Development of Technologies for Sensing, Analyzing, and Utilizing Novel Subsurface Signals in Support of the Subsurface Technology and Engineering (SubTER) Crosscut Initiative.

- Stakeholder engagement continues with a series of public briefings at multiple Industry professional society annual meetings, and through an Industry Roundtable hosted by the National Labs discussing the SubTER Multi Year Work Plan (MYWP).

- The SubTER Tech Team continues to collaborated with industry and academia by securing funding for and initiating membership to a Joint Industry Partnership the Advanced Energy Consortium (AEC).

Bureau of Economic Geology — AEC Advanced Energy Consortium

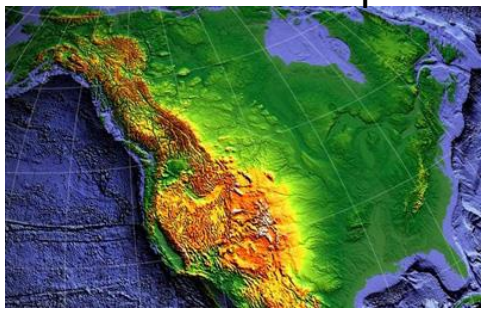
- The SubTER Tech Team continues to maintain collaboration among the National Labs and DOE wide by hosting the "Sapling Tech Talk" webinar series.



- DOE published the Grand Challenge Roundtable Report, focusing on the challenge of imaging geophysical and geochemical signals in the subsurface.

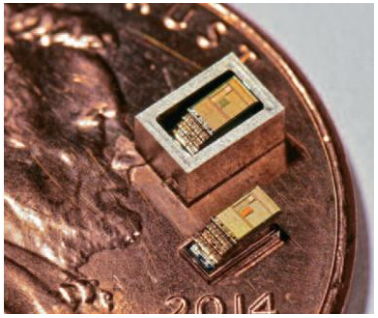
SubTER Connections With Outside Efforts

NSF - EarthScope



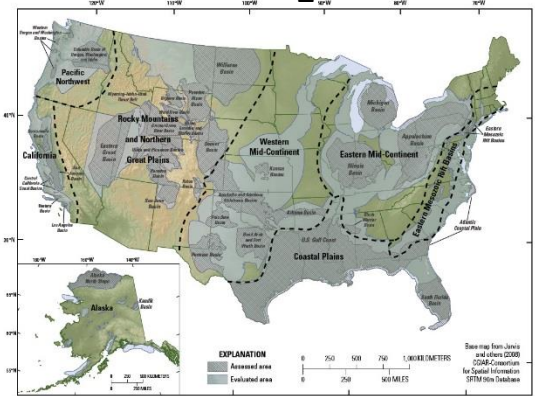
NSF program to study the structure and evolution of the North American continent and the processes that cause earthquakes

Bureau of Economic Geology (BEG) – Advanced Energy Consortium (AEC)



Field testing prototype multi-sensing microsystems down hole to gather information about reservoirs (in progress)

USGS – CO_2 Storage



U.S. Geological Survey (USGS) evaluation of the technically accessible storage resource (TA_{SR}) for carbon dioxide (CO_2)

SubTER Complements These Efforts

- Subsurface Stress and Induced Seismicity
- New Subsurface Signals
- Permeability Manipulation

Implementation of a new **collaborative model** to tackle an energy "grand challenge" faced by **multiple sectors**

Imaging geophysical and geochemical signals in the subsurface

SubTER Timeline

Efforts Accelerating into 2017 and Beyond

Lab R&D
FE & EE
$2M

2014

Lab Saplings
FE & EE
$6M

2015

New Signals FOA
FE& EE - $9M
Saplings - $1.9M

2016

Combined Request:
$72.3 M
($33.8 EFRC)

2017

Fiscal Year

Calendar Year

2014

- Big Ideas Summit I
- Seedling Work Began

2015

- SubTER Retreat
- AGU Townhall
- Big Ideas Summit II
- Sapling Work Began
- SubTER Retreat
- Science Roundtables
- Lab Plan briefing to DOE

2016

- Industry Roundtable
- Big Ideas Summit III
- New Signals Awards to be Made

2017

SubTER What's Next

Current Status

FY 16 FOA selections July '16

- **70 applications, primarily academic teams (with labs, industry)**
- **Roughly 7 new projects, $9-11M total to be selected**
- **Joint FE-EERE FOA (1st)**

Saplings review August '16, Pittsburgh

- **Technical learnings and successes**

Committed to Univ. Texas AEC Consortium FY16

- **Joint FE-EE-SC support**
- **Nanotechnologies, sensors, signals**

Geological Society of America Pardee Symposium Oct '16

- **Premier technical / scientific forum in the geosciences**

Outlook for FY17

- **Final SubTER Multi-Year RD&D Plan**
- **Lab call for new projects**
- **Academic-Industry focused FOA #2 (pending final FY17 budget)**
- **NSF: Positioned to issue solicitations which could use DOE Field Sites (FORGE, Shale Demos etc) as the R&D platform**
- **USGS: Formal collaboration on Induced Seismicity hazard studies**

Dwindling Industry Investment in Subsurface R&D

Increased Benefit of Government Role

- Major oil companies have cut R&D spending since 2013
- Biggest impact on independents and non-integrated
- Few sector labs - R&D partnerships are rapidly losing funding
- Narrow interest: subsea, remote technologies, operational focus, shales
- Industry increasingly in niche sectors

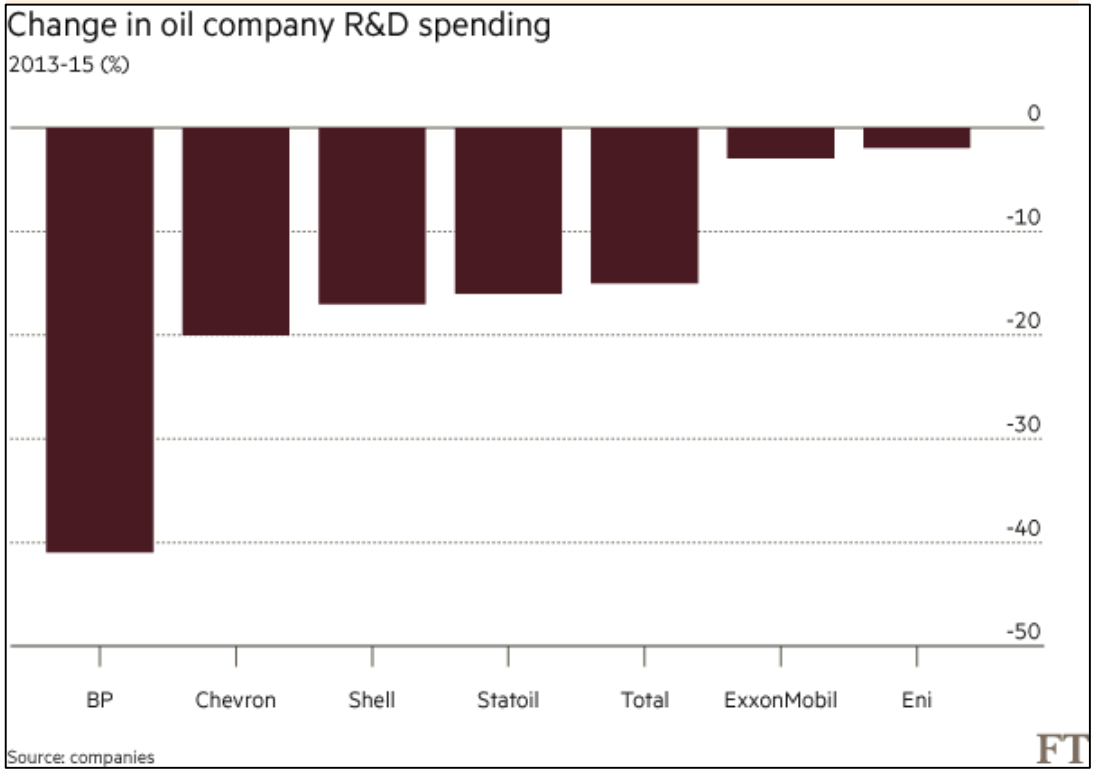
"Industry collaboration with SubTER will be driven by issues that require broader knowledge and capital investment than any one company can supply, and/or on topics associated with future regulations (such as induced seismicity)."

-- SubTER Industry Roundtable, 2015

May 15, 2016 6:47 pm

Research cutbacks hit oil groups' ability to invest

Ed Crooks in New York , Financial Times



U.S. DEPARTMENT OF ENERGY

Impact of Reduced Industry Funding on Subsurface R&D

5 core DOE labs: loss of $35M in combined program and SPP funding, 2014-16

Loss of roughly $150-225M/year in Subsurface R&D throughout the sector, combined labs and universities

- Impact on innovation, new technologies
- Immediate and long term workforce impact
- Declining enrollments and drop in supported research

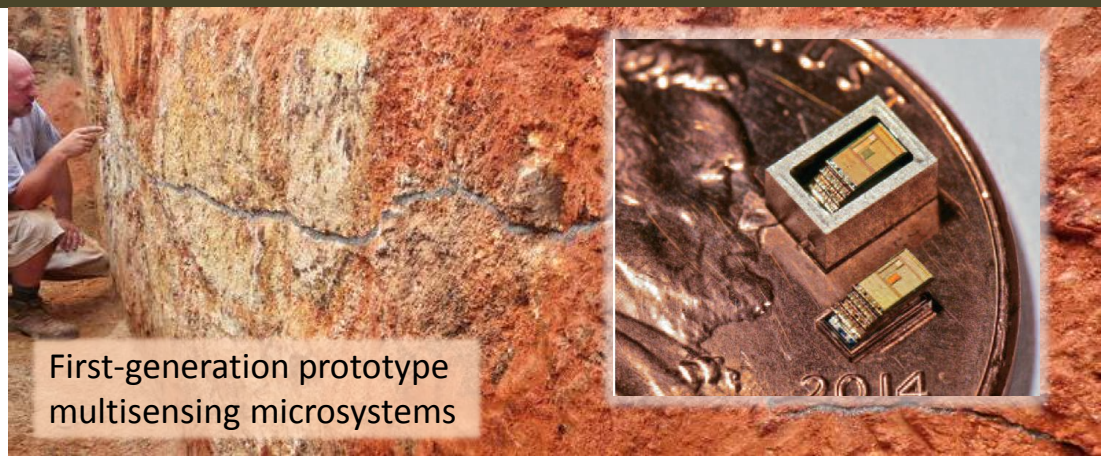
Recalibration of federal role?

Final Questions

- **Lab centric vs university vs industry?**
- **Annual funding levels?**
- **Options for new pillars?**
- **Finding the proper federal role**
- **New funding/R&D models?**

SubTER Connections With Outside Efforts – Advanced Energy Consortium (AEC)

- AEC has created a new scientific space by combining nantechnology with subsurface energy applications
- AEC funds over 30 universities- leveraging fundamental research and moving into applied real-world applications
- SubTER is exploring avenues for leveraging AEC R&D



First-generation prototype multisensing microsystems

Four Research Areas:
Mobility - Contrast Agents - Nanomaterial Sensors - Micro-fabricated Sensors

Examples of Use Cases of particular interest to SubTER Crosscut:

1) Contrast agents for fracture network mapping
   EM contrast agents help identify location of proppants and fluids in fractures near the wellbore and in the interwell space with greater accuracy than current technology allows
2) Subsurface autonomous nanosensor devices
   Developing micro-electronic sensors capable of making temperature, pressure, pH, and/or resistivity measurements for logging, hydraulic fracturing and coiled tubing applications