2ND ANNUAL ENERGY & INNOVATION CONFERENCE

Track 1A: Oil & Gas Production and Utilization—Overview

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The Need:
Energy portfolio is projected to remain anchored by fossil.

Energy Demand 2008

84% Fossil Energy

Coal 22% | Gas 24% | Oil 37% | Nuclear 8% | Renewables 8%
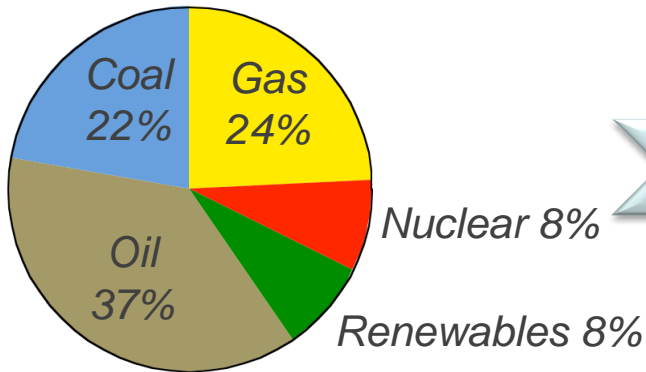
+ 14%
United States →

Energy Demand 2035

78% Fossil Energy

Coal 21% | Gas 24% | Oil 33% | Nuclear 8% | Renewables 14%

81% Fossil Energy

Coal 27% | Gas 21% | Oil 33% | Nuclear 6% | Renewables* 13%
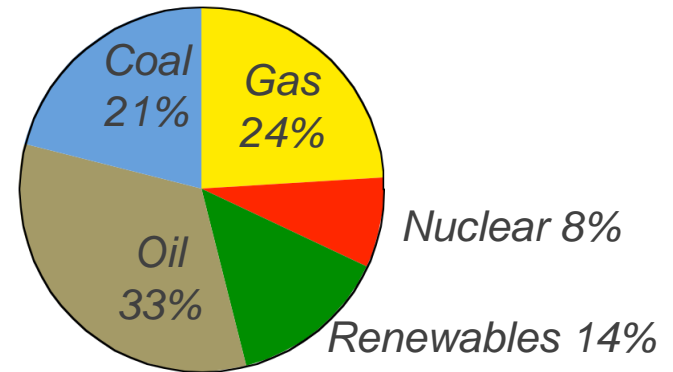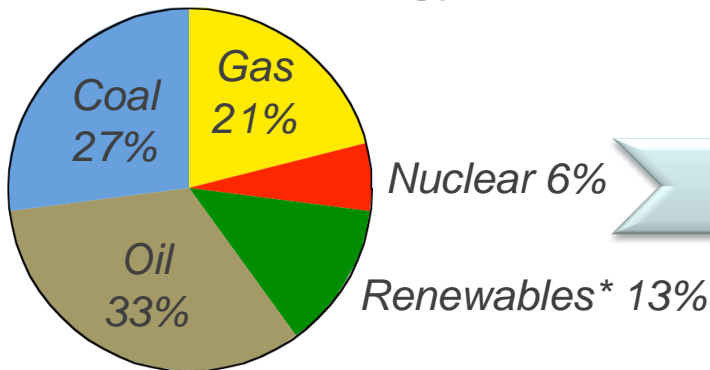
+ 47%
World →

79% Fossil Energy

Coal 29% | Gas 22% | Oil 28% | Nuclear 8% | Renewables* 15%

NETL-RUA

Primarily traditional biomass, wood, and waste.
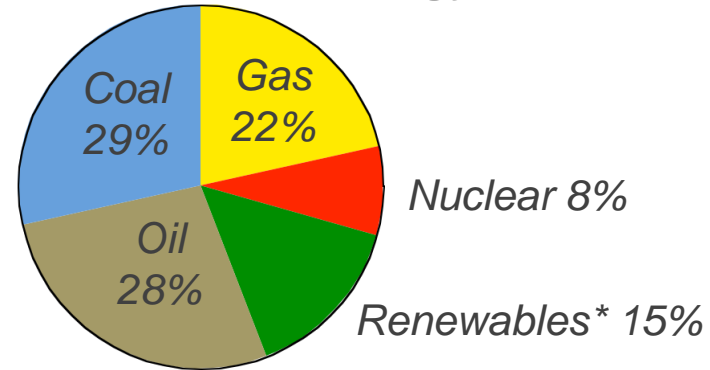
AEO2012: U.S. crude oil production increases; U.S. net imports fall (in reference case)

Figure 112. Domestic crude oil production by source, 1990-2035 (million barrels per day)

Figure 55. U.S. production of tight oil in four cases, 2000-2035 (million barrels per day)

Figure 114. Net import share of U.S. petroleum and other liquids consumption in three cases, 1990-2035 (percent)

Annual Energy Outlook 2012
with Projections to 2035
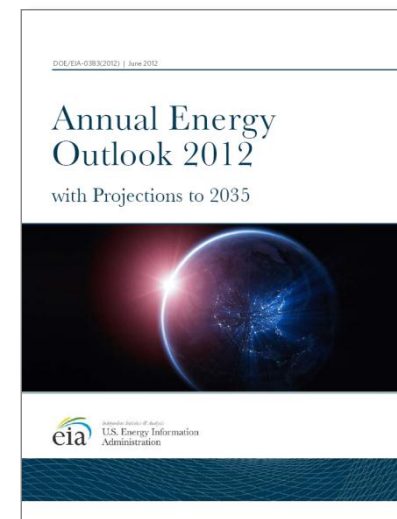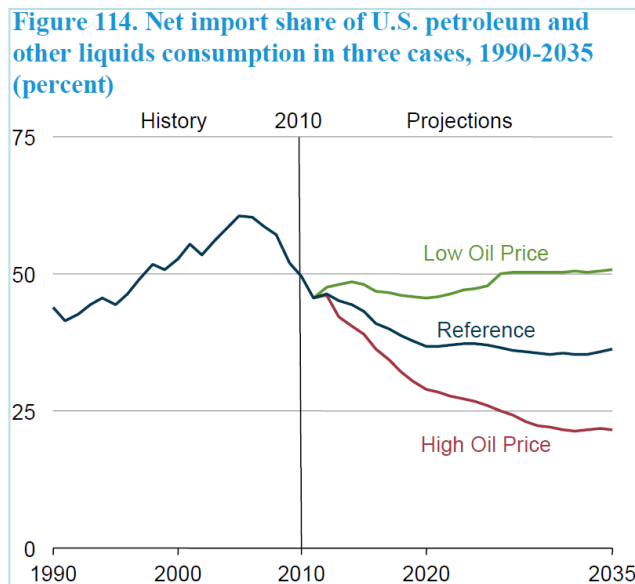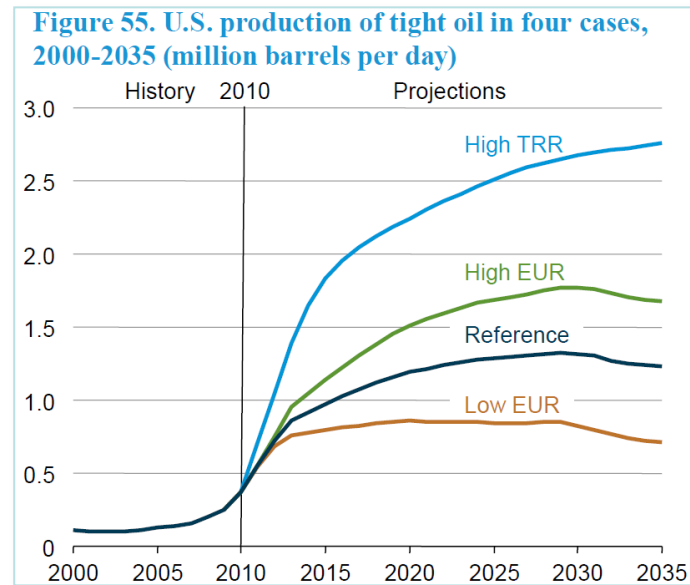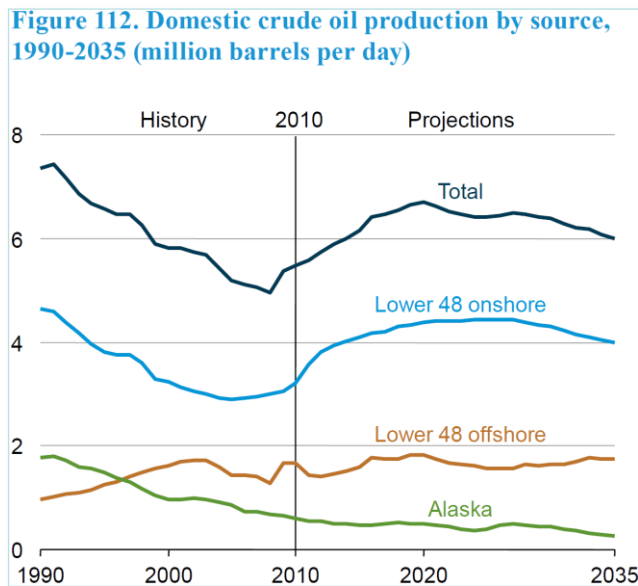
Source: EIA, Annual Energy Outlook 2012

AEO2012: Shale gas provides largest source of growth in U.S. natural gas supply; U.S. become a net exporter

Figure 107. Natural gas production by source, 1990-2035 (trillion cubic feet)

Figure 106. Total U.S. natural gas production, consumption, and net imports, 1990-2035 (trillion cubic feet)
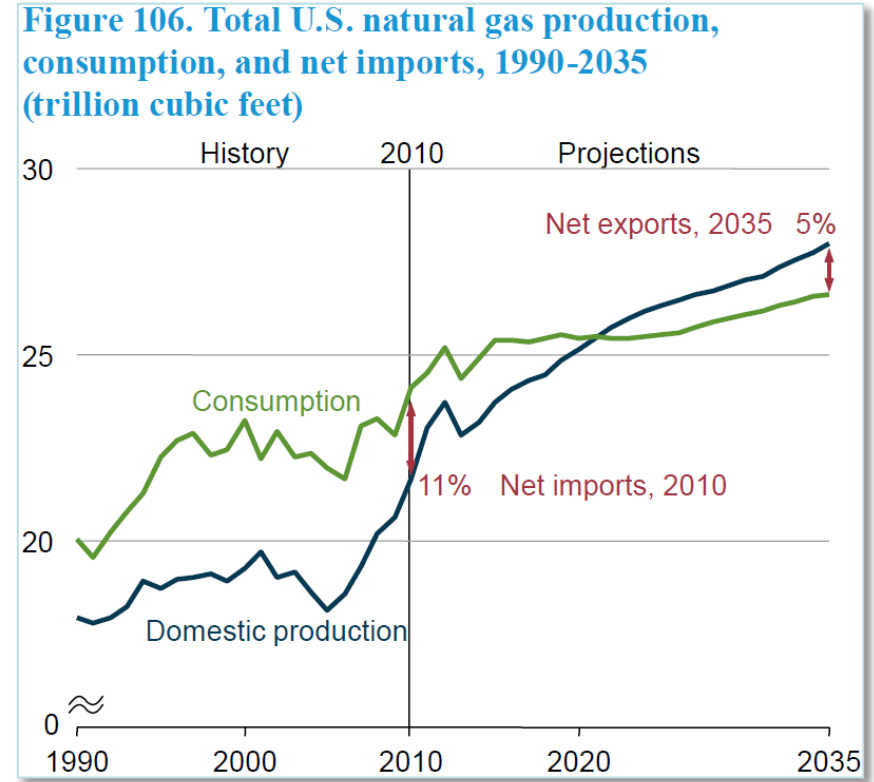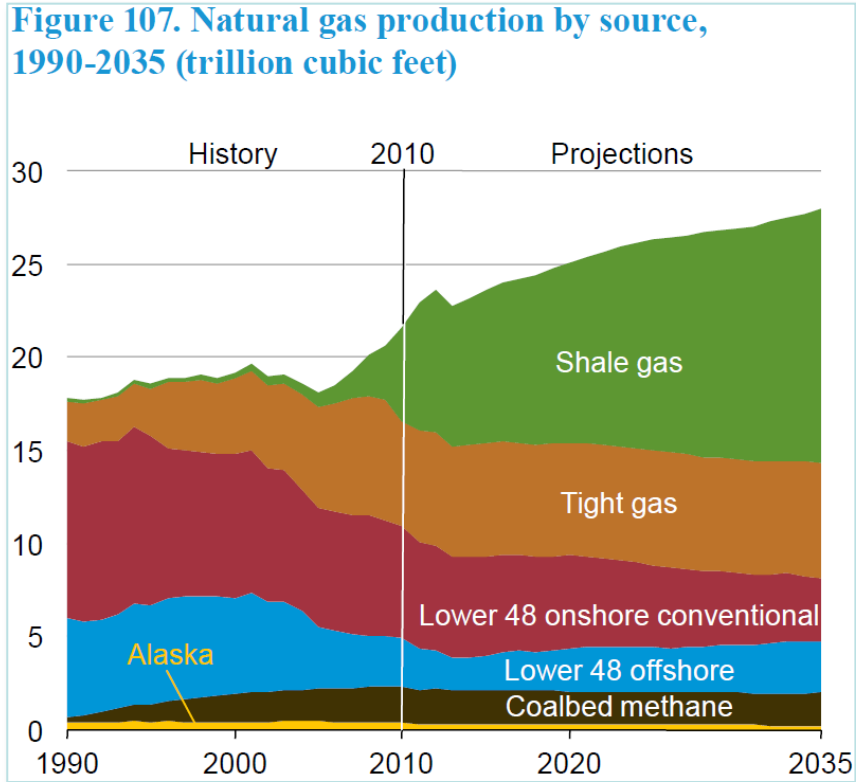
Unconventional U.S. Fossil Resources

- shale gas and other tight gas

- tight oil

- ultradeepwater hydrocarbons

- next generation CO_2-EOR; residual oil zone

- next generation enhanced gas recovery

- heavy oil; tar sands

- oil shale

- methane hydrate

Common Technical Challenges

- Efficient engineering of the subsurface
  - *Result:* fewer wells; lower impact
  - *Key technical issues:* predictable fracture propagation; lower usage of potable water; efficient drilling; improved recovery—improved reservoir modeling; improved monitoring; improved mobility control (CO_2)

- Effective isolation of reservoir
  - *Result:* confidence in environmental stewardship
  - *Key technical issues:* wellbore integrity; predictable fracture propagation; high-resolution subsurface imaging

- Environmental monitoring
  - *Result:* confidence in environmental stewardship
  - *Key technical issues:* abandoned wellbores; limited publically available data; protection of groundwater and air quality; interpretation of complex background signals—need for baseline data; methods to fingerprint signals

Four Decades of Shale-Gas R&D

Generating the information necessary to unlock the "next" key domestic natural gas resources by characterization, technology development, & environmental monitoring.

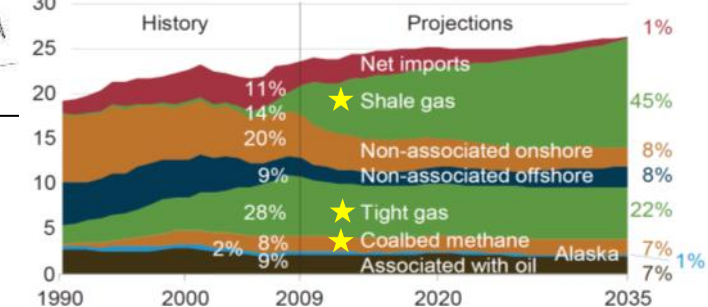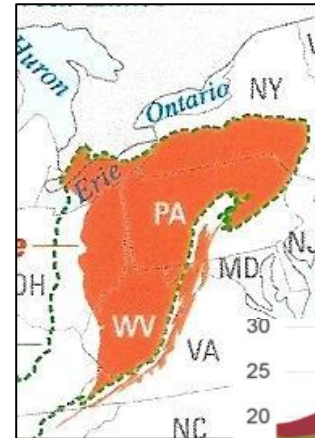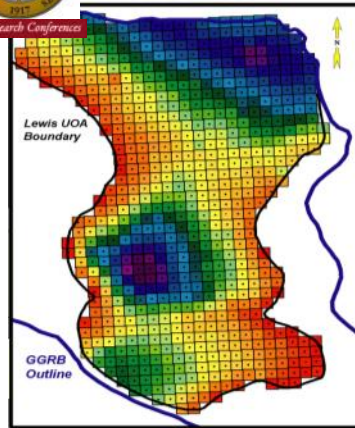Current R&D is ensuring *environmentally sustainable development* of domestic natural gas resources through:

- Field studies on environmental baselines
- Leading multi-institutional & multi-organizational research teams at sites

DOE Eastern/Western Gas Shale Program

R&D in the early 2000's developed **environmental technology & refined assessments** *for:*

- Shale gas
- Tight gas
- Coal-bed methane

R&D in the '70s–'90s provided the **technology base** to unlock new gas resources :

- Advanced drilling & completion (e.g., directional drilling, fracturing, stimulation)
- Resource potential and key properties

U.S. dry gas production (trillion cubic feet per year)

History	Projections
Net imports	1%
11% Shale gas	45%
14%	
20% Non-associated onshore	8%
9% Non-associated offshore	8%
28% Tight gas	22%
2% 8% Coalbed methane	7%
9% Associated with oil / Alaska	7% 1%

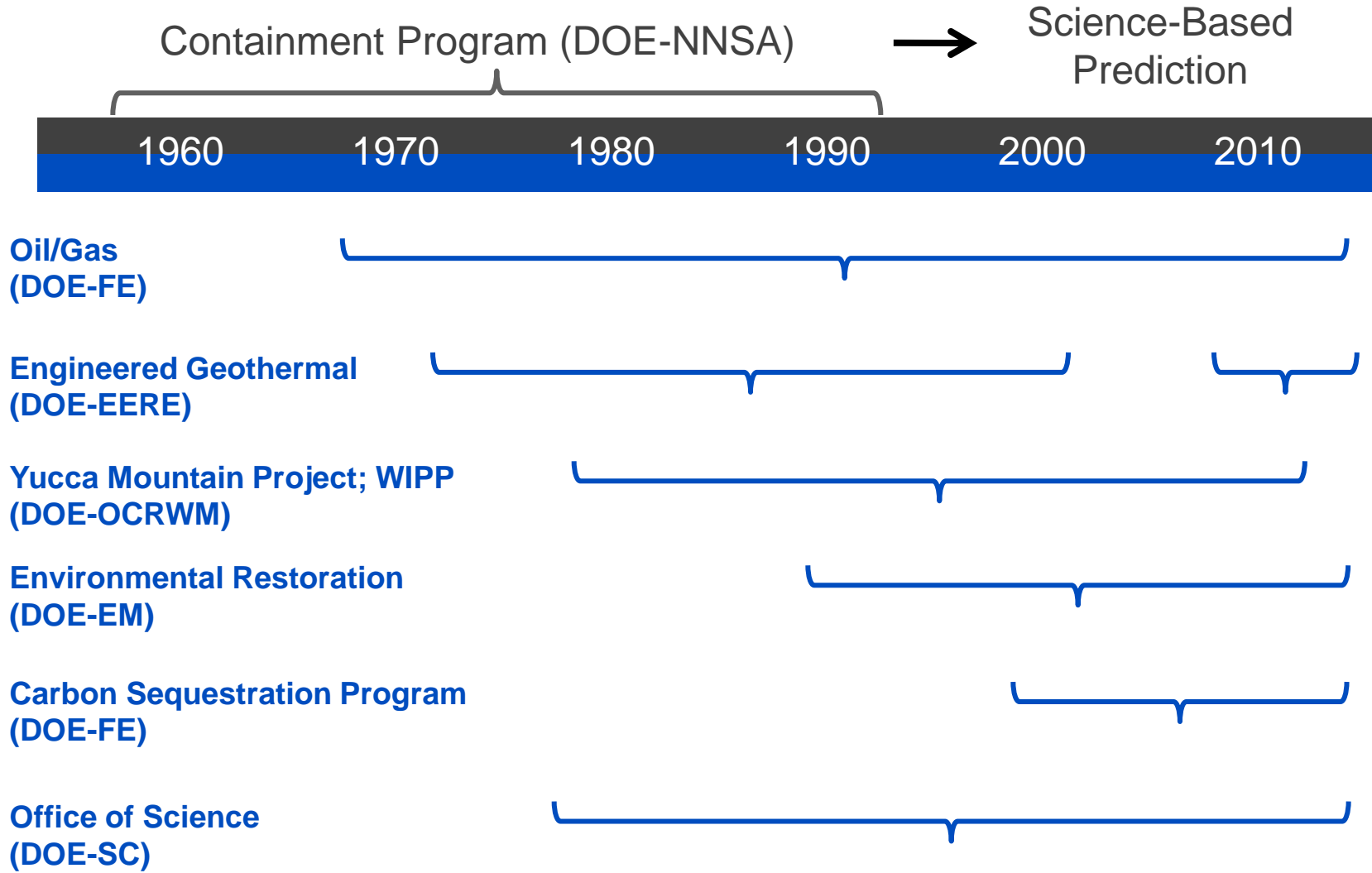1990   2000   2009   2020   2035

NETL-RUA

DOE core competency in Engineered–Natural Systems stems from investments for containment and protection of the environment.
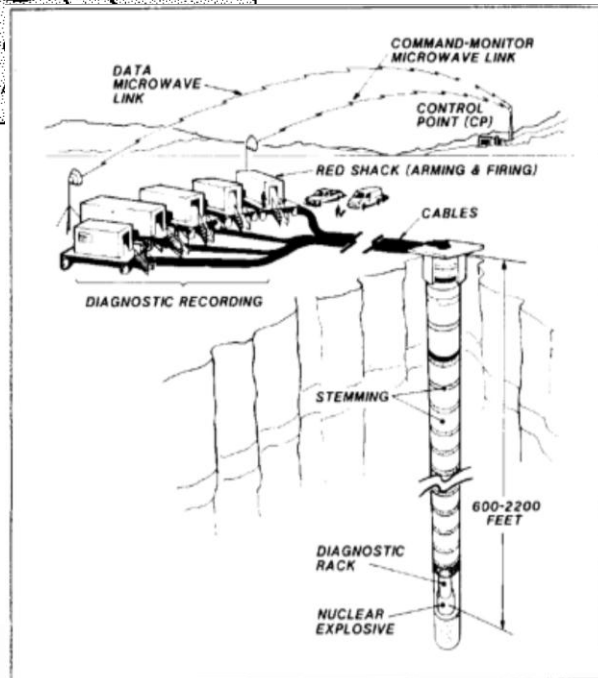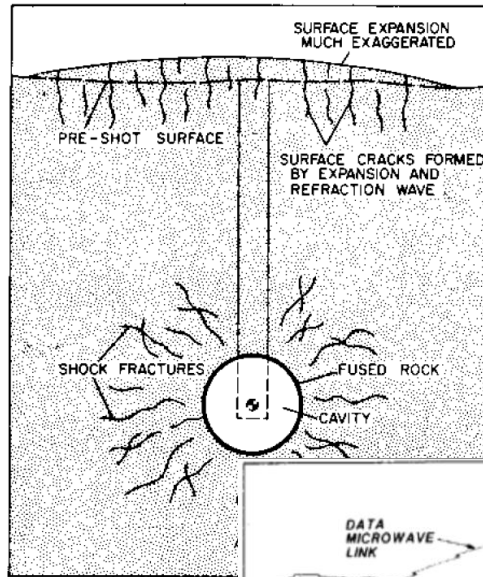
- **science-based prediction of system performance**
  - ➢ engineered-natural system

- **prediction of fluid flow in porous & fractured media**
  - ➢ gas flow; fluid flow
  - ➢ geomechanical response
  - ➢ contaminant transport

- **geomaterials properties**
  - ➢ behavior in extreme conditions (experiments/theory)
  - ➢ geomechanics

- **wellbores**
  - ➢ drilling technologies
  - ➢ stemming for containment under extreme conditions (wellbore completion)

- **monitoring and diagnostics**
  - ➢ geophysics (seismic) & advanced imaging
  - ➢ atmosphere signals

DOE core competency in Engineered–Natural Systems has been honed through leveraging with several energy and environment initiatives.


Containment Program (DOE-NNSA) → Science-Based Prediction

1960   1970   1980   1990   2000   2010

Oil/Gas (DOE-FE)

Engineered Geothermal (DOE-EERE)

Yucca Mountain Project; WIPP (DOE-OCRWM)

Environmental Restoration (DOE-EM)

Carbon Sequestration Program (DOE-FE)

**Office of Science (DOE-SC)**

NETL-RUA

# NETL-RUA Portfolio in Geological/Environmental Sciences

*Science/engineering research of natural systems to enable
the clean production & utilization of fossil energy*

- **Core Capabilities:**
  - Multiscale Assessments
  - Multiphase Fluid Flow
  - Geomaterials Science
  - Strategic Monitoring of Natural System Behavior
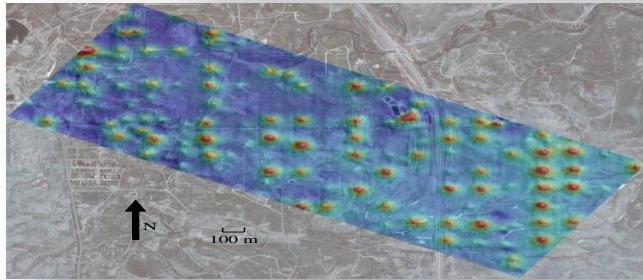 - Geospatial Data Management & Assessment
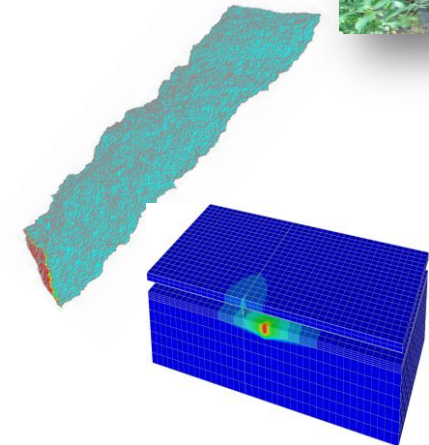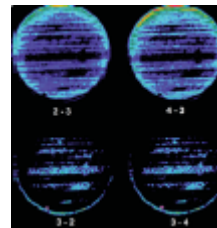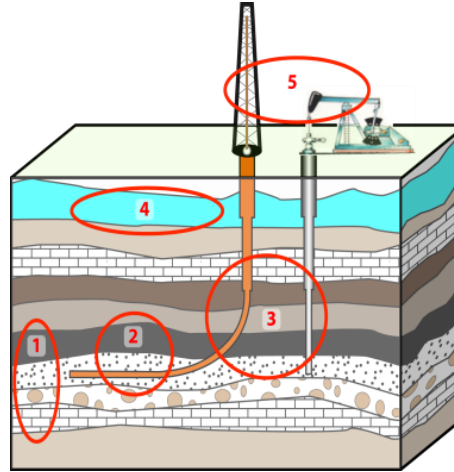
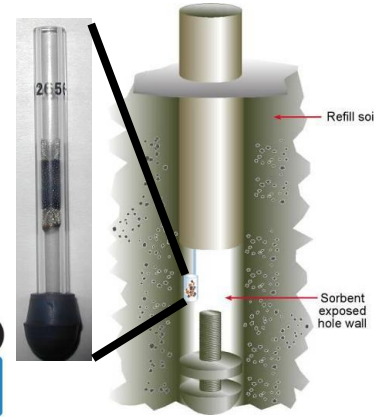# Although much of research portfolio is early-stage, …
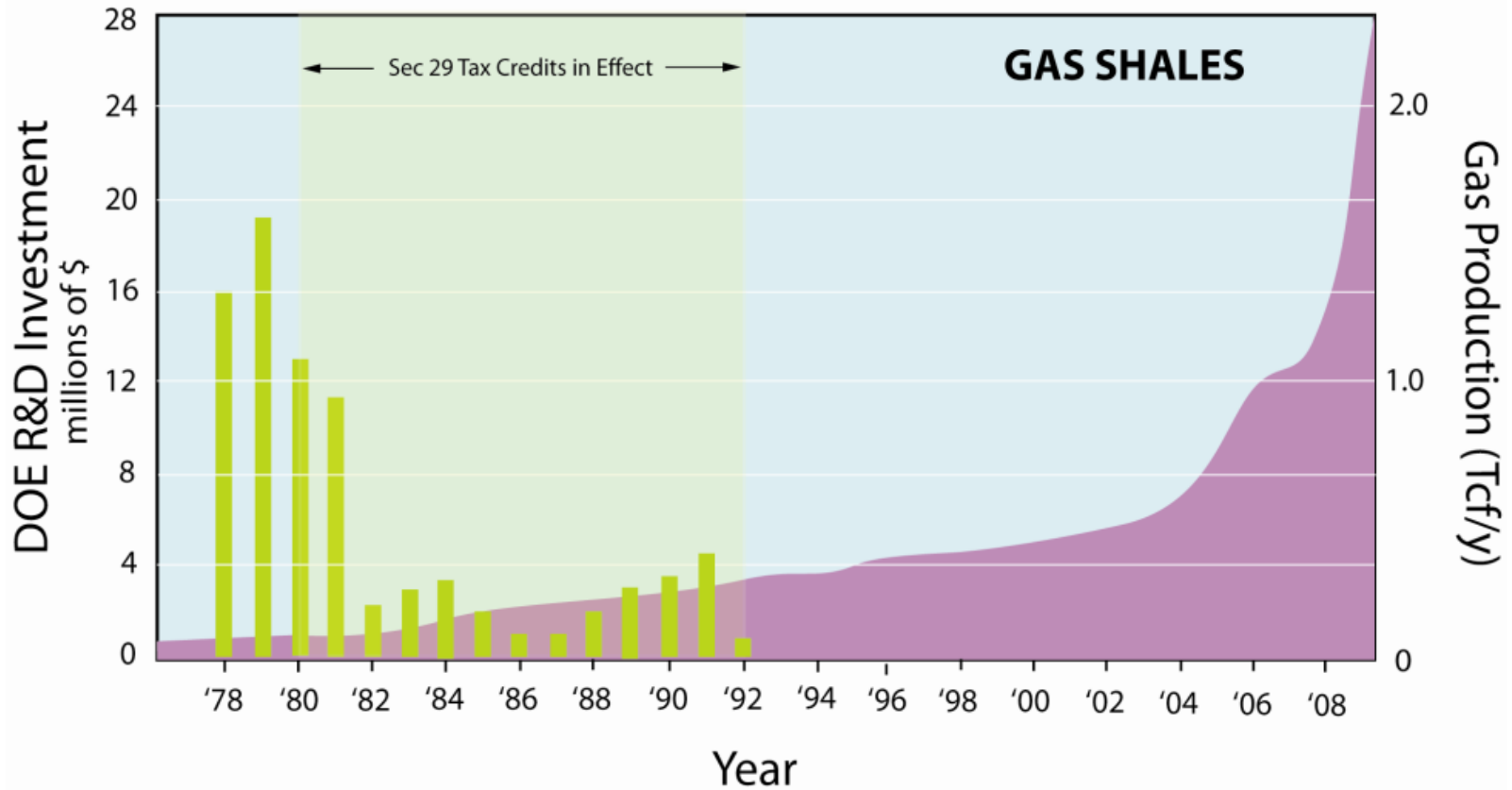
DOE programs in unconventional gas established the science/technology foundations for surprising growth in domestic unconventional resource
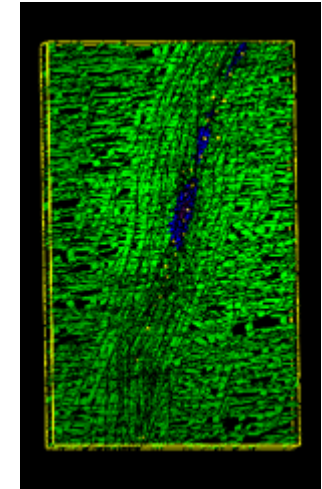
NETL-RUA applied-basic research portfolio includes technologies with near-term application
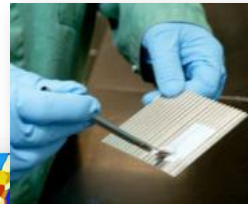

Monitoring Technologies

Natural & Anthropogenic Tracers

Advanced Reservoir Simulation

Materials Research, Design, Development

Drilling

NETL-RUA

Track 1A presentations cover three broad areas plus an emerging initiative.

- Monitoring of Natural Systems
  (Alexandra Hakala)

- Wellbores & Drilling
  (Brian Strazisar)

- Advanced Simulation Tools for
  Reservoir Performance
  (Grant Bromhal)

- Partnering for Innovation:
  Shale Energy Resources Alliance
  (George Darakos)

  - **technology development**
  - **joint research**
  - **partnering for data collection**

NETL-RUA

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– **abandoned wellbores**

– **geochemical tracers**

– **geophysical imaging (reservoirs, fractures)**

– **baseline data**

NETL-RUA

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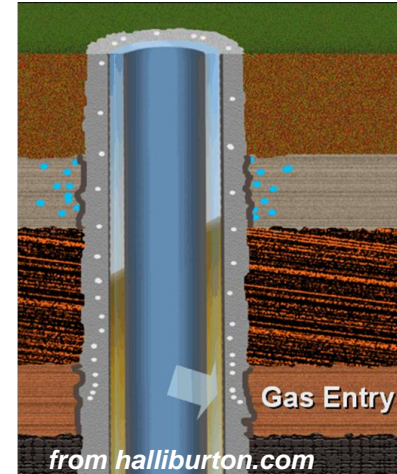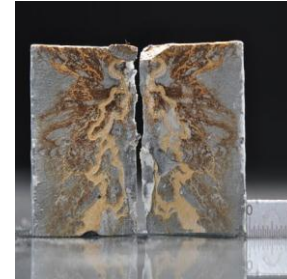
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from halliburton.com

Gas Entry

– **wellbore integrity**

– **zonal isolation**

– **cement properties** *in situ*

– **long-term cement integrity**

– **drilling dynamics and efficiency**

NETL-RUA

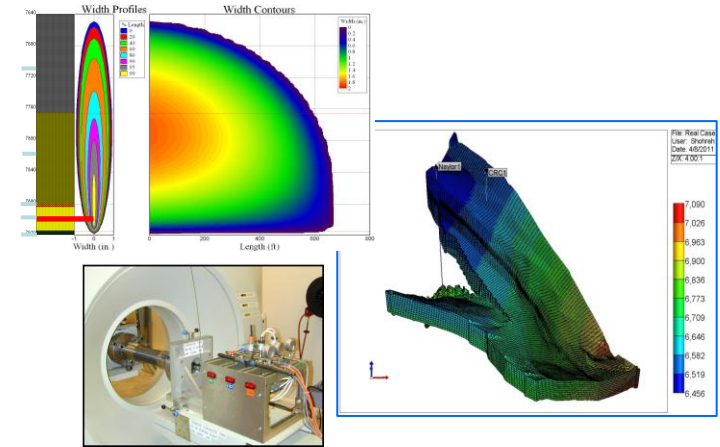# Track 1A presentations cover three broad areas plus an emerging initiative.

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- **fluid flow on fractures**

- **fracture propagation**

- **model validation/calibration**

- **efficient reduced-order models for UQ**

- **risk assessment**

- **data portal**

NETL-RUA

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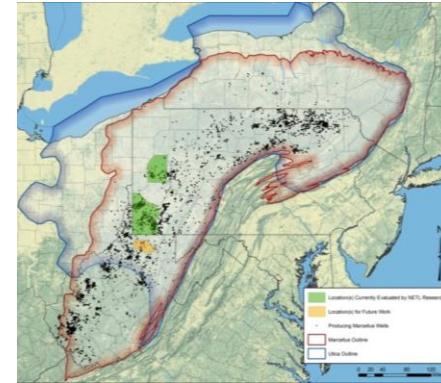
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  – **air quality**

  – **stray gas & wellbore integrity**

  – **water resources & waste mitigation**

Posters Related to Track 1A

Air Monitoring—Mike McCawley (WVU)

Reservoir Structure Visualization and Fracture Characterization—
   Dengliang Gao (WVU)

Foam Cement Stability—Barbara Kutchko (NETL)

Cement Fracture Flow—Julie Vandenbossche (Pitt)

Reservoir Fluid Behavior in Deep Formations: Equations of State—
   Athanasios Karamalidis (CMU)

Reactive Transport Modeling for Cement Property Alteration—
   Leopold Brunet (PSU)

Fracture Flow—Dustin Crandall (URS)

Geomechanics Related to Shale Gas and/or CO_2—Hema Siriwardane (WVU)

Surrogate Models (based on Artificial Intelligence)—
   Amirmasoud Kalantari (WVU)

*CO_2 Storage Potential & Enhanced Natural Gas Recover in Depleted
   Shale*—Bob Dilmore (NETL)

NETL-RUA

Track 3A (Industry Research & Development)

How government, universities, and industry can work to together to address upstream R&D needs.

- **Chair: George Darakos, U.S. DOE/NETL**
- **Paul Ziemkiewicz, WV Water Research Inst.**
- **John Cramer, Nabors Well Services**
- **Josh Hickman, EdgeMarc Energy**
- **Richard Winschel, CONSOL Energy**
- **Rick Hammack, U.S. DOE/NETL**