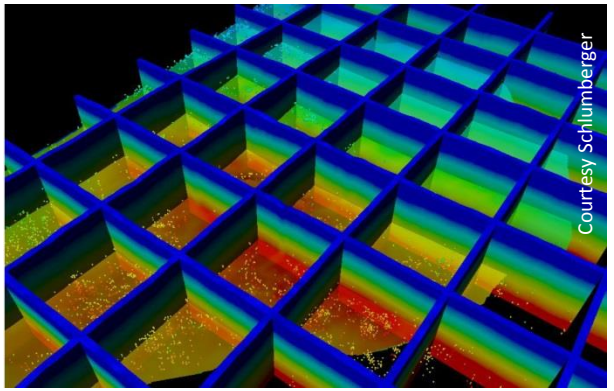
Geothermal Technologies Office Update

Geothermal Resources Council| September 29, 2014 | Portland, Oregon



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Douglas Hollett, Director

GTO Major Initiatives

New Geothermal Opportunities

- "Play Fairway" FOA
- Pathway to next-step drilling validation

Accelerating EGS

- Build upon R&D and demonstration project successes
- EGS R&D FOA
- Frontier Observatory for Research in Geothermal Energy (FORGE) FOA kicked off

Tackling Deployment Barriers

- Regulatory Roadmap: Streamlining
- National Geothermal Data System: leveraging access to data

Additive Value

- Low Temp Mineral Recovery FOA
- Hybrid systems

NEW: Subsurface Engineering Crosscut

- SubTER - Intra- and inter-agency effort to address common subsurface challenges and better leverage DOE R&D

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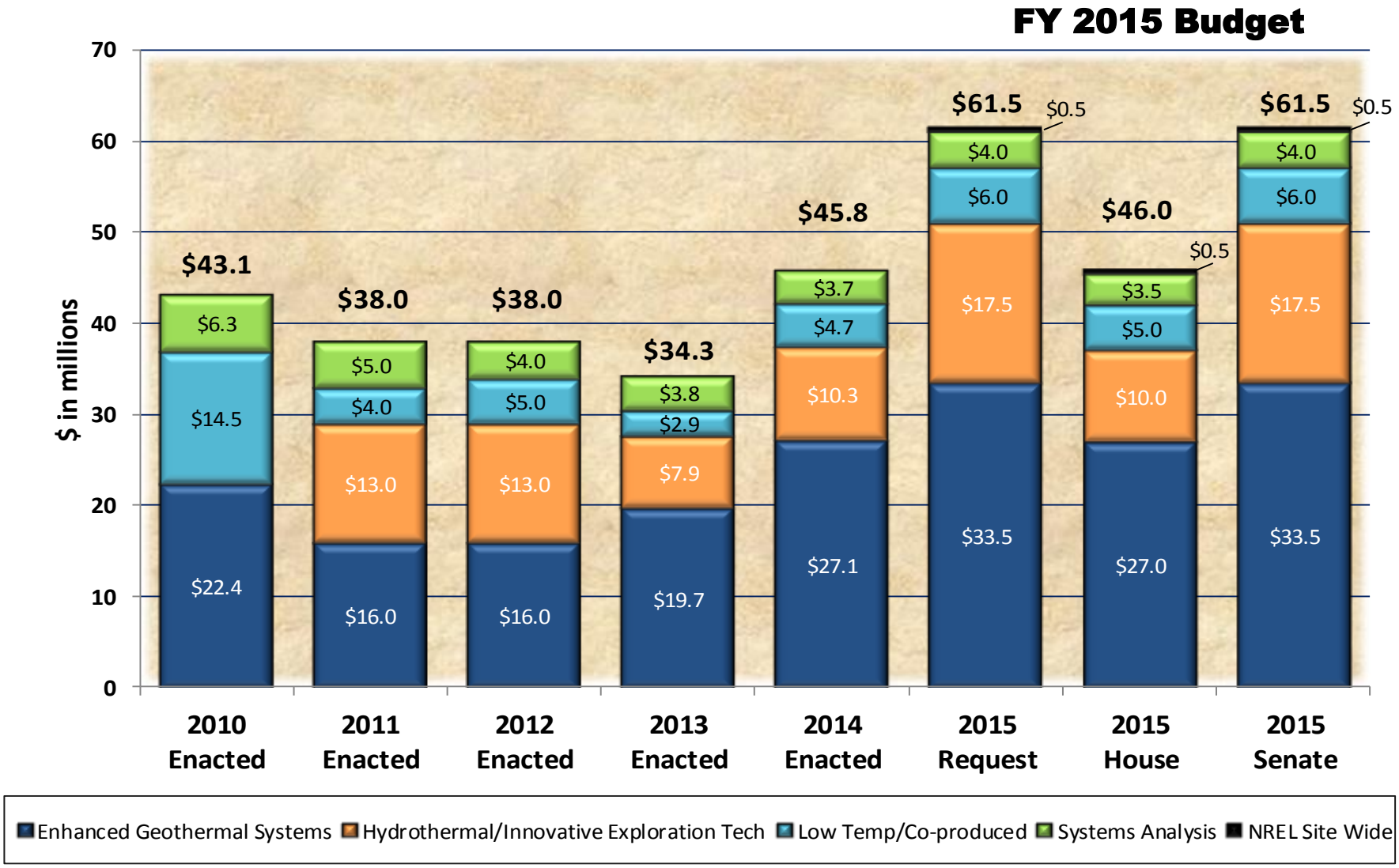
GTO Budget – FY 2010 to present



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New Selectees for GTO 2014 Funding Opportunities

TOTAL FEDERAL FUNDING: $18 M | 32 SELECTIONS

Play Fairway Analysis

FEDERAL FUNDING: $4 M
COSTSHARE: $ 0.6 M
TOTAL PROJECTS: 11

ATLAS GEOSCIENCES INC
Global Geothermal Exploration

RUBY MOUNTAIN

Utah State University 1888

Washington State Department of Natural Resources

Cornell University Founded by Ezra Cornell

University of California Davis

University of Nevada Reno 1874

EGI Energy & Geoscience Institute at the University of Utah

University of Hawai'i Mānoa

Los Alamos National Laboratory EST. 1943

Integrated EGS R&D

FEDERAL FUNDING: $9.7 M
COSTSHARE: $1.5 M
TOTAL PROJECTS: 12

Los Alamos National Laboratory EST. 1943

Berkeley Lab

Wisconsin University of Wisconsin–Madison

The Pennsylvania State University 1855

Cornell University Founded by Ezra Cornell

California State University Long Beach 1949

University of Nevada Reno 1874

The University of Oklahoma 1890

Sandia National Laboratories

ARRAY applied innovation · driving mission success

Mineral Recovery

FEDERAL FUNDING: $4 M
COSTSHARE: $1 M
TOTAL PROJECTS: 9

Pacific Northwest National Laboratory

Carnegie Mellon University Pittsburgh Pennsylvania 1900

Berkeley Lab

SIMBOL materials

Tusaar Corp

SRI International

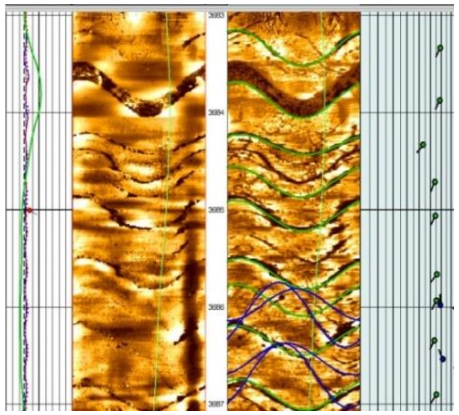
The University of California Davis

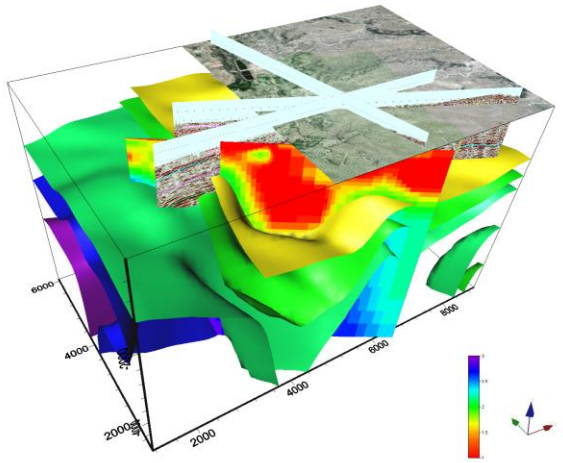
SOUTHERN RESEARCH INSTITUTE

What's Next for Hydrothermal?

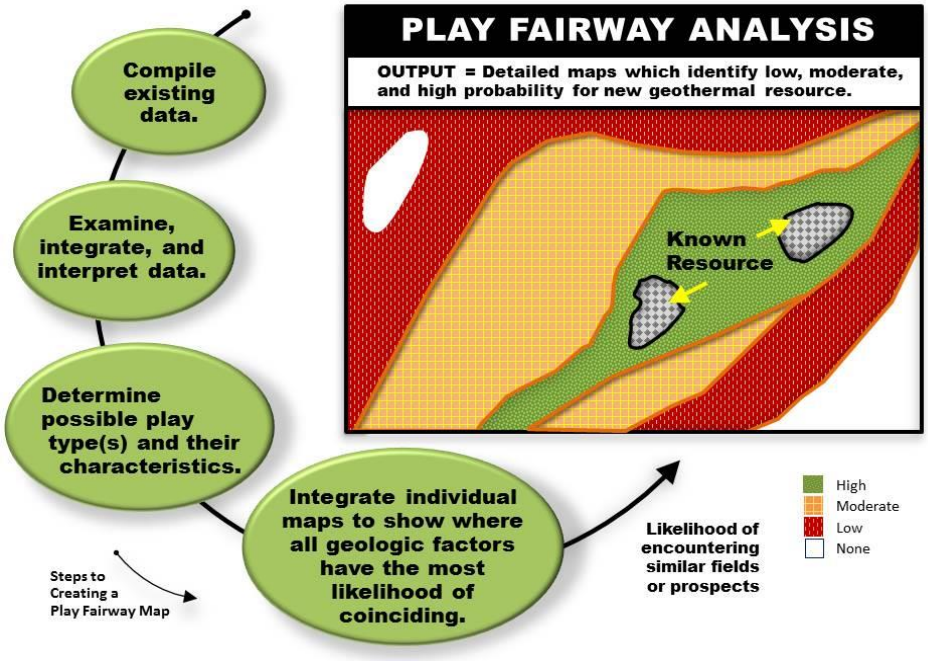
Tools, Maps, Analysis, "Plays"

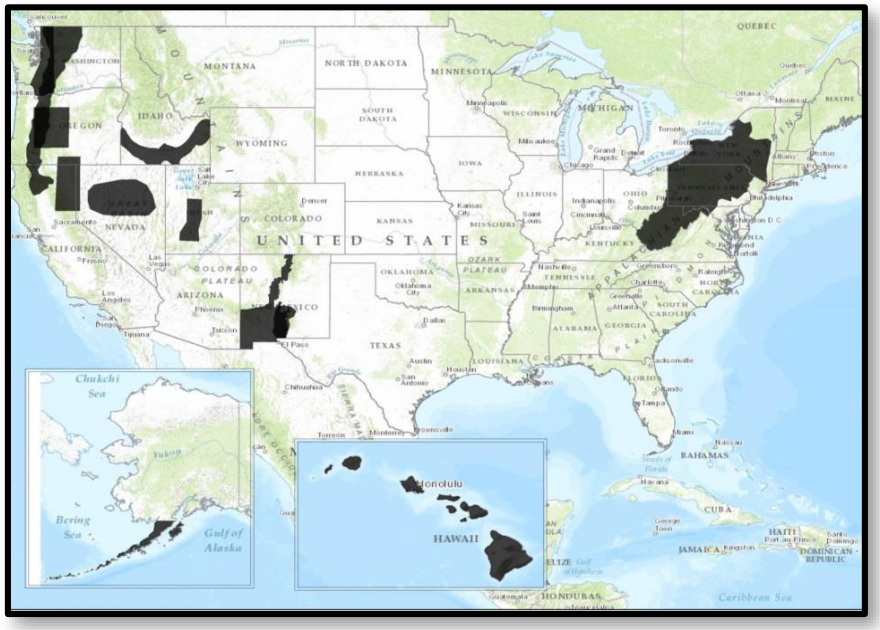
- **Advance Key Innovative Exploration Technologies (IET)**
  - Targeted drilling and geophysical techniques





- **Execute Play Fairway Analysis**
  - Observational, analytical integration, interpretation, basin and systems evolution





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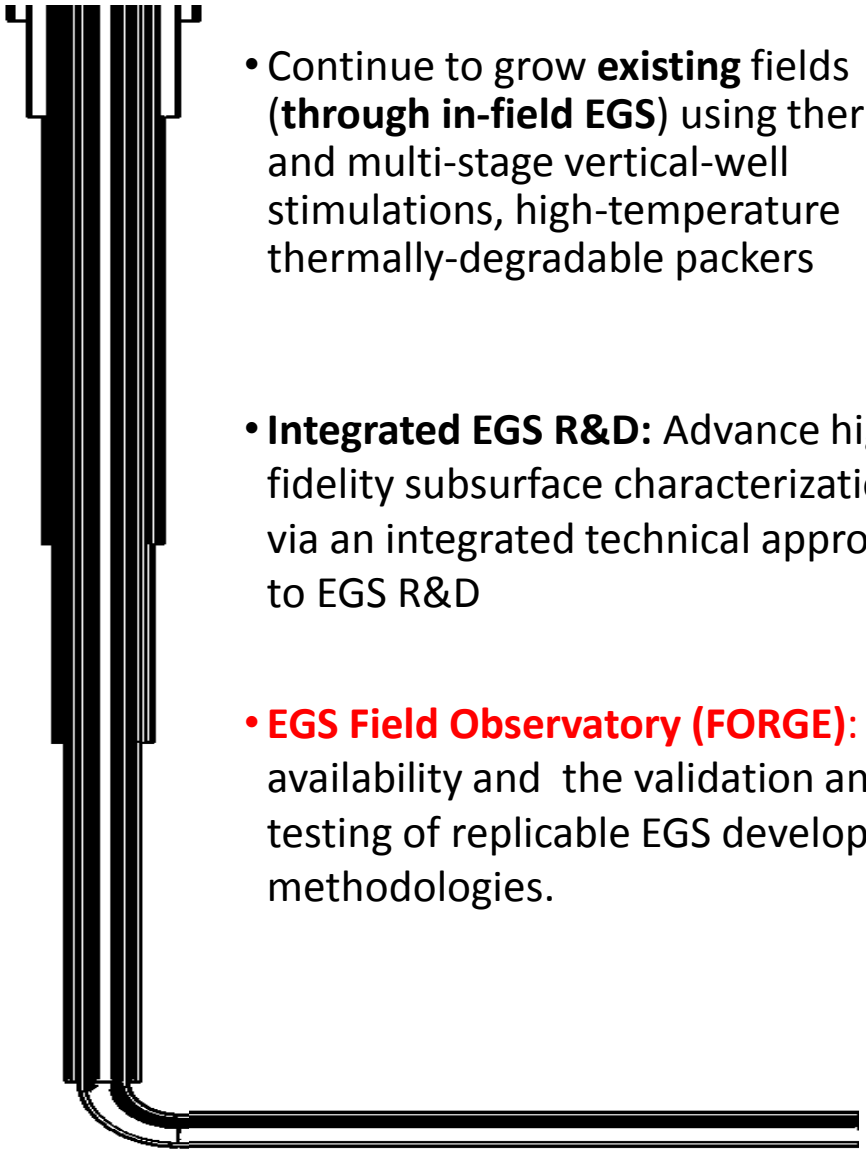
What's Next for EGS?

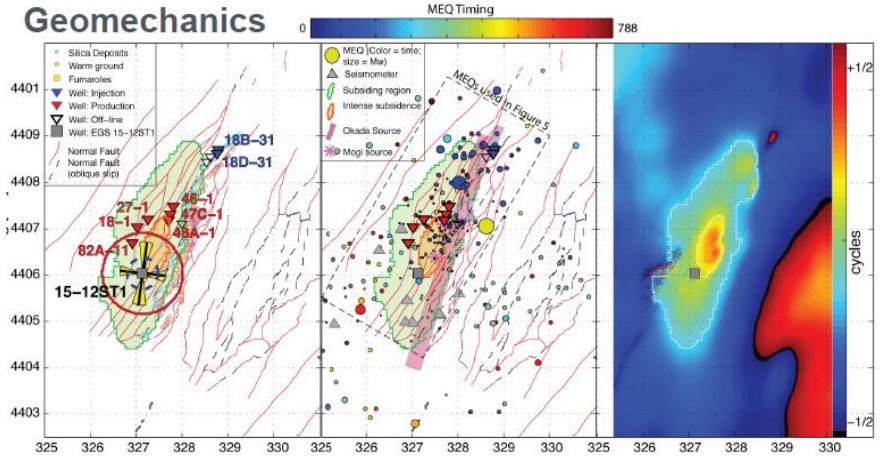
In-Field Stimulations, Horizontal Wells, Replicability



- Continue to grow **existing** fields (**through in-field EGS**) using thermal and multi-stage vertical-well stimulations, high-temperature thermally-degradable packers

- **Integrated EGS R&D:** Advance high-fidelity subsurface characterization via an integrated technical approach to EGS R&D

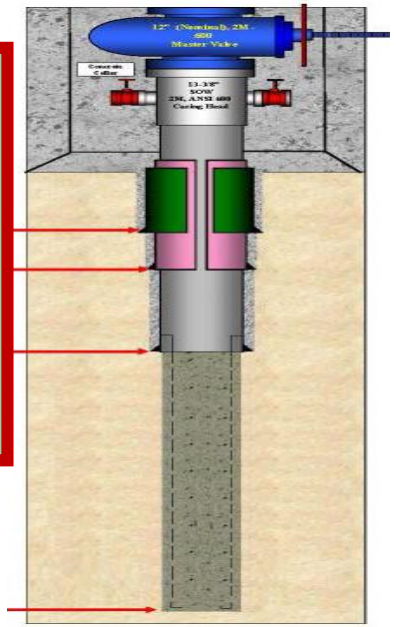
- **EGS Field Observatory (FORGE)**: Data availability and the validation and testing of replicable EGS development methodologies.



Re-completion of the well at Desert Peak

- *175-fold increase in well productivity*
- *additional 1.7 MW*
- *increased power output by nearly 40%.*

graphics courtesy of Ormat Technologies.



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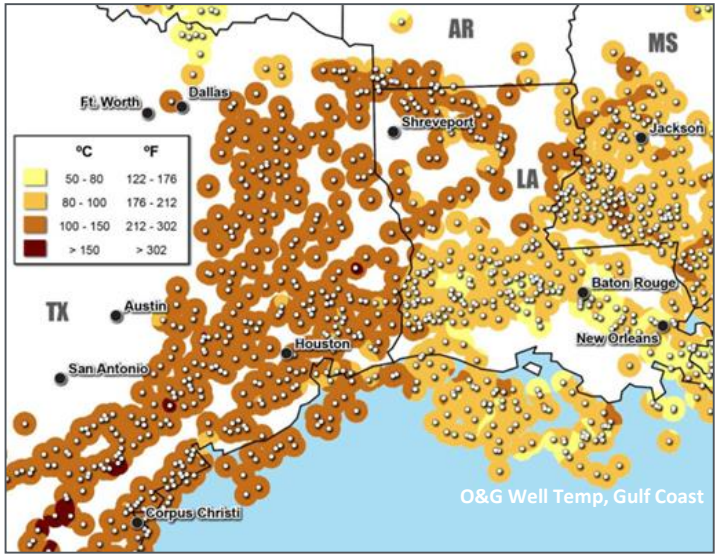
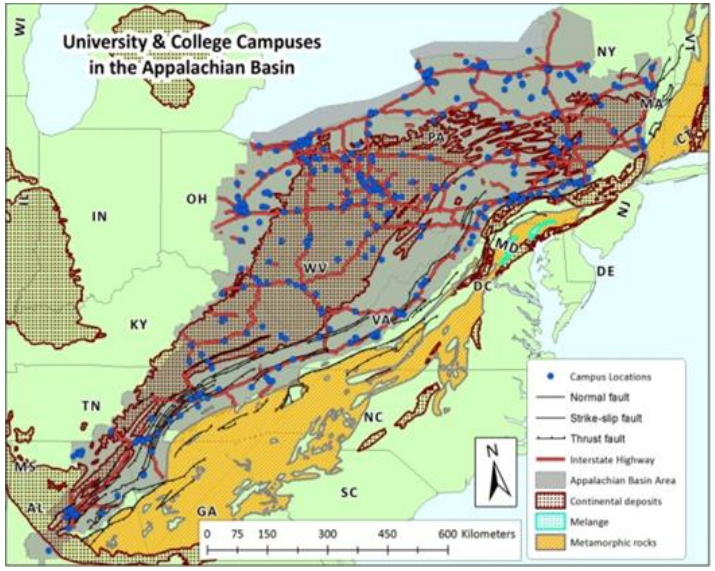
What's Next for Low Temp?

Materials Extraction, Direct-Use, Hybrid Systems





- **Low-Temperature Mineral Extraction** - Resource assessment and feasibility (additive value)
- Large-scale **Direct Use**: where does it make technical and commercial sense?
  - Use geothermal hot fluids for heating and cooling
  - Potential displacement of "traditional" baseload generation on site-by-site basis

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FORGE Funding Opportunity Announcement

$31 M for Initial Phases

FORGE

U.S. Department of Energy

FOA Issue Date:	**7/17/2014**
FOA Informational Webinar:	**8/05/2014**
Submission Deadline for Applications:	**11/12/2014**
Submission Deadline for Replies to Reviewer Comments:	**1/16/2015**
Expected Date for EERE Selection Notifications:	**3/30/2015**

FORGE Project Website: energy.gov/forge

Questions?

Email: DE-FOA-0000890-FORGE@netl.doe.gov

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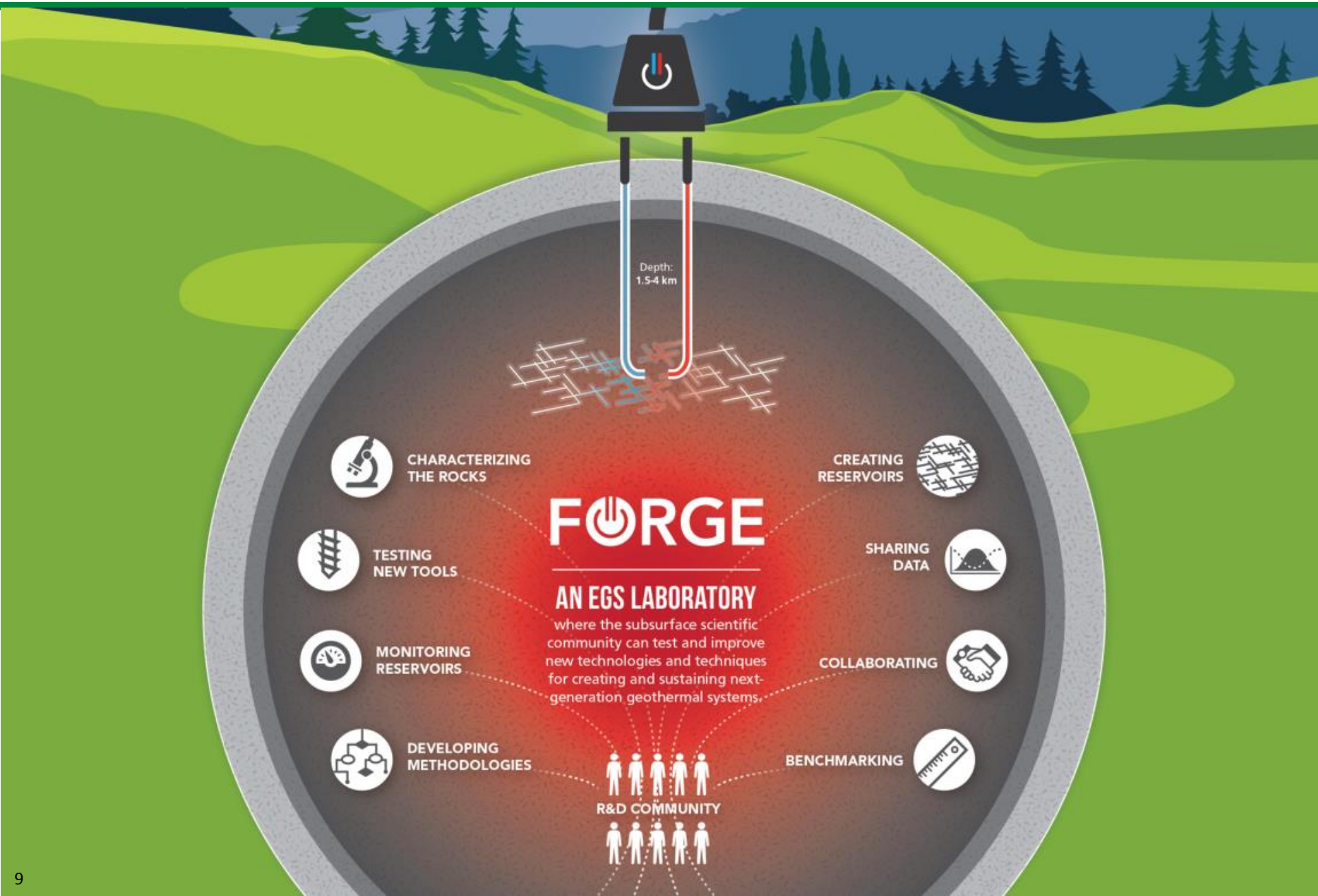
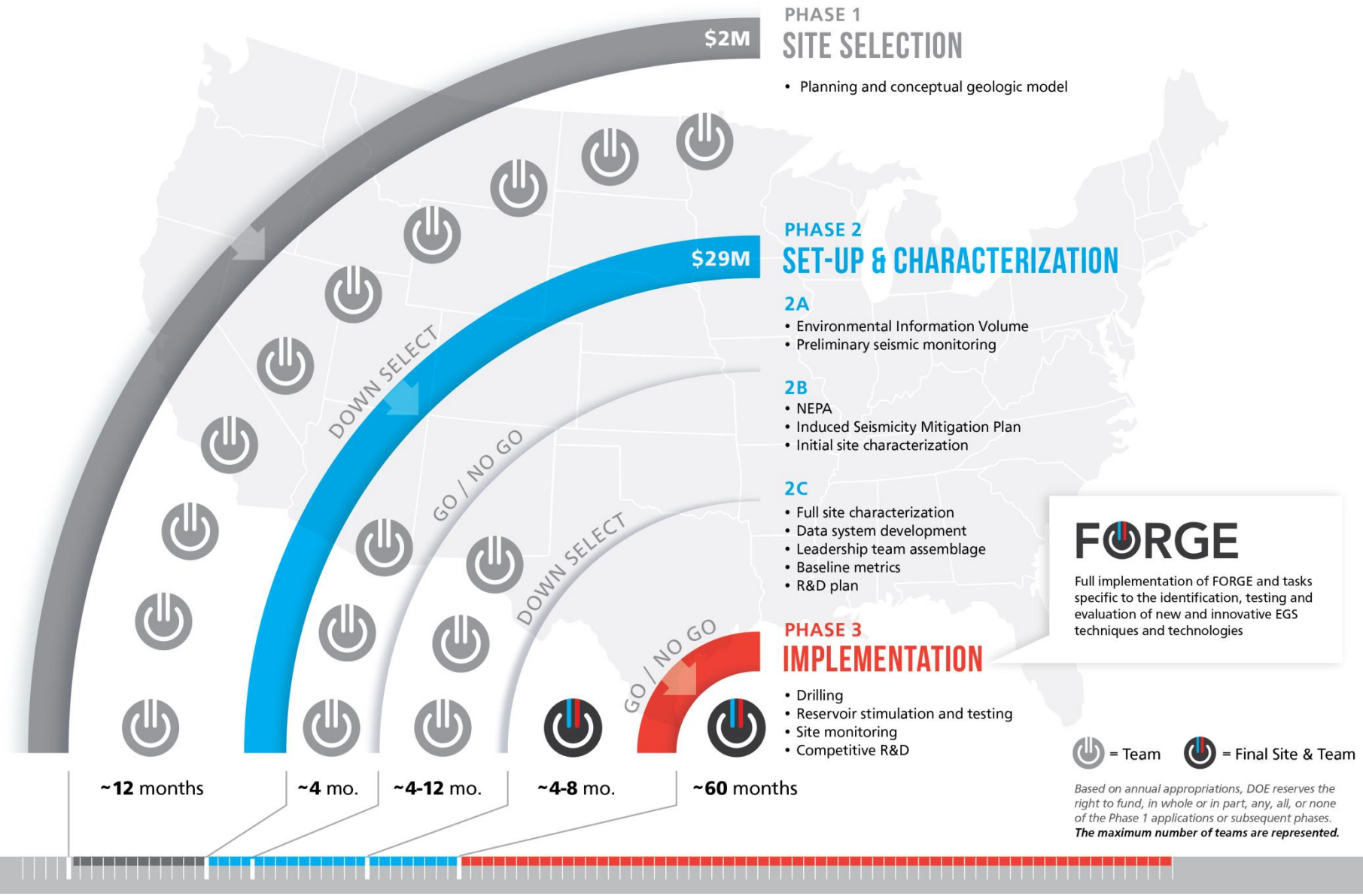
FORGE Overview



FORGE Structure – Phased Approach



PHASE 1
SITE SELECTION

- Planning and conceptual geologic model

PHASE 2
SET-UP & CHARACTERIZATION

2A
- Environmental Information Volume
- Preliminary seismic monitoring

2B
- NEPA
- Induced Seismicity Mitigation Plan
- Initial site characterization

2C
- Full site characterization
- Data system development
- Leadership team assemblage
- Baseline metrics
- R&D plan

PHASE 3
IMPLEMENTATION

- Drilling
- Reservoir stimulation and testing
- Site monitoring
- Competitive R&D

FORGE

Full implementation of FORGE and tasks specific to the identification, testing and evaluation of new and innovative EGS techniques and technologies

= Team = Final Site & Team

Based on annual appropriations, DOE reserves the right to fund, in whole or in part, any, all, or none of the Phase 1 applications or subsequent phases.
The maximum number of teams are represented.

Launch of the National Geothermal Data System

- "Best-in-class" data collection and usability effort
- Addresses a significant obstacle to geothermal development: lack of quantifiable data
- Nine million inter-operable GIS data points in 340 separate web feature and map services
- Complies with the Administration's Open Data Policy
- Supports the Energy Department's efforts to reduce cost and risks associated with widespread adoption of geothermal energy

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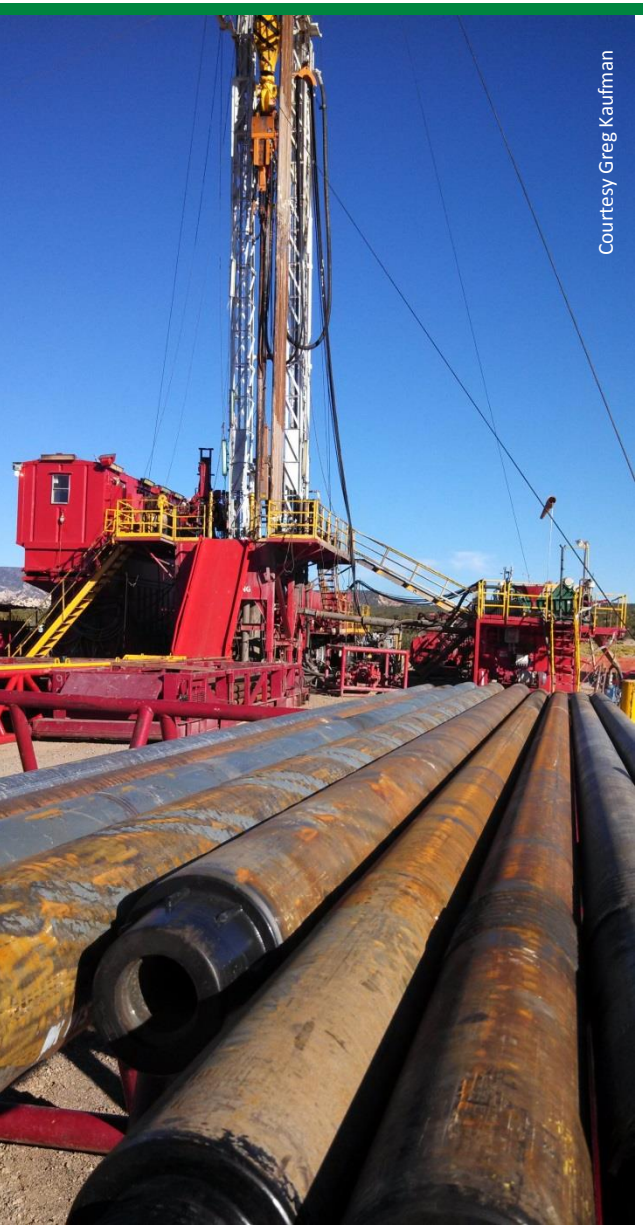
Key Results on Funded Projects 2014


Courtesy Greg Kaufman

Oregon Institute of Technology: Commissioned **1.5 MW** of newly-installed geothermal power on campus, from a $1 million GTO award with $4 million match by Johnson Controls.

Pagosa Verde: GTO's $3.9 million **geothermal exploration project in Colorado** is being matched by a $1.98 million state bond, with a bill signed by Colorado Gov. Hickenlooper in May 2014.

Stillwater Hybrid Geothermal-Solar: **First-in-the-world hybrid geothermal-solar** facility in Fallon, Nevada produces 33 MW geothermal and 26 MW photo voltaic. An additional 2 MW Concentrated Solar Power project is under construction. GTO, with Idaho National Lab and National Renewable Energy Lab, entered into agreement with Enel Green Power to explore potential and quantify the benefits of integrating geo energy with solar.

FastCAP: GTO's $2.2 million investment has succeeded in **development and commercialization** of a cutting-edge power system for geothermal exploration in high vibration, extreme drilling environments.

Surprise Valley Electrification Corp:* a non-profit rural cooperative, plans to go online with a low-temperature, **3 MW geothermal power plant** in the near future, funded with $2M in GTO Recovery Act funds, matched by a $3M Oregon Department of Energy Business tax credit. **Waste heat from the plant will be used for aquaculture, green house farming, and district heating.**

* Expected

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Key Results on Funded Projects 2014, *CONT'D*


Courtesy NREL

SNL Drilling: Developed and licensed a **first-of-a-kind, high-temperature** (480°F), elastomer-free drilling motor for use with pneumatic down-the-hole-hammers, for drilling in high temperature geothermal formations.

Raft River (Idaho) EGS Demonstration Project:* Will complete two phases of thermal stimulation that commenced in FY 2013 and will complete a **large injection volume hydraulic stimulation** of an existing sub-commercial well. Through this combination of wellbore thermal conditioning and hydraulic stimulation, this is targeted to become a commercial production/injection well.

Bradys (Nevada) EGS Demonstration Project:* Will have completed **final stimulation stages** by the end of FY.

AltaRock EGS Demonstration Project:* in Oregon will accomplish **re-stimulation of an existing well** and completing a production well into the stimulated reservoir.

* Expected

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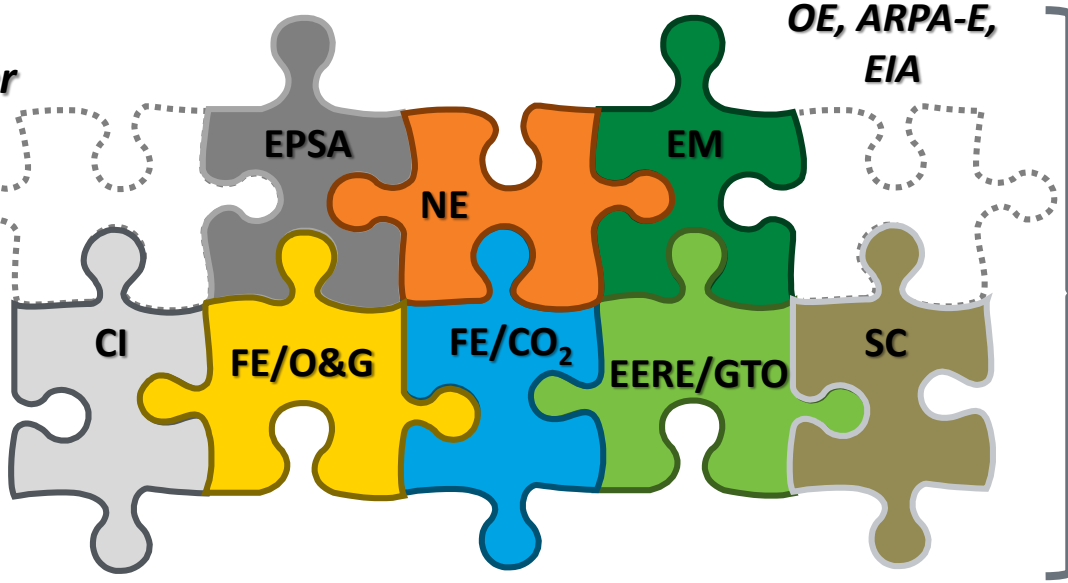
SubTER: Summary and Overview Review of Roles

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 FY15 spend plan and FY16 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

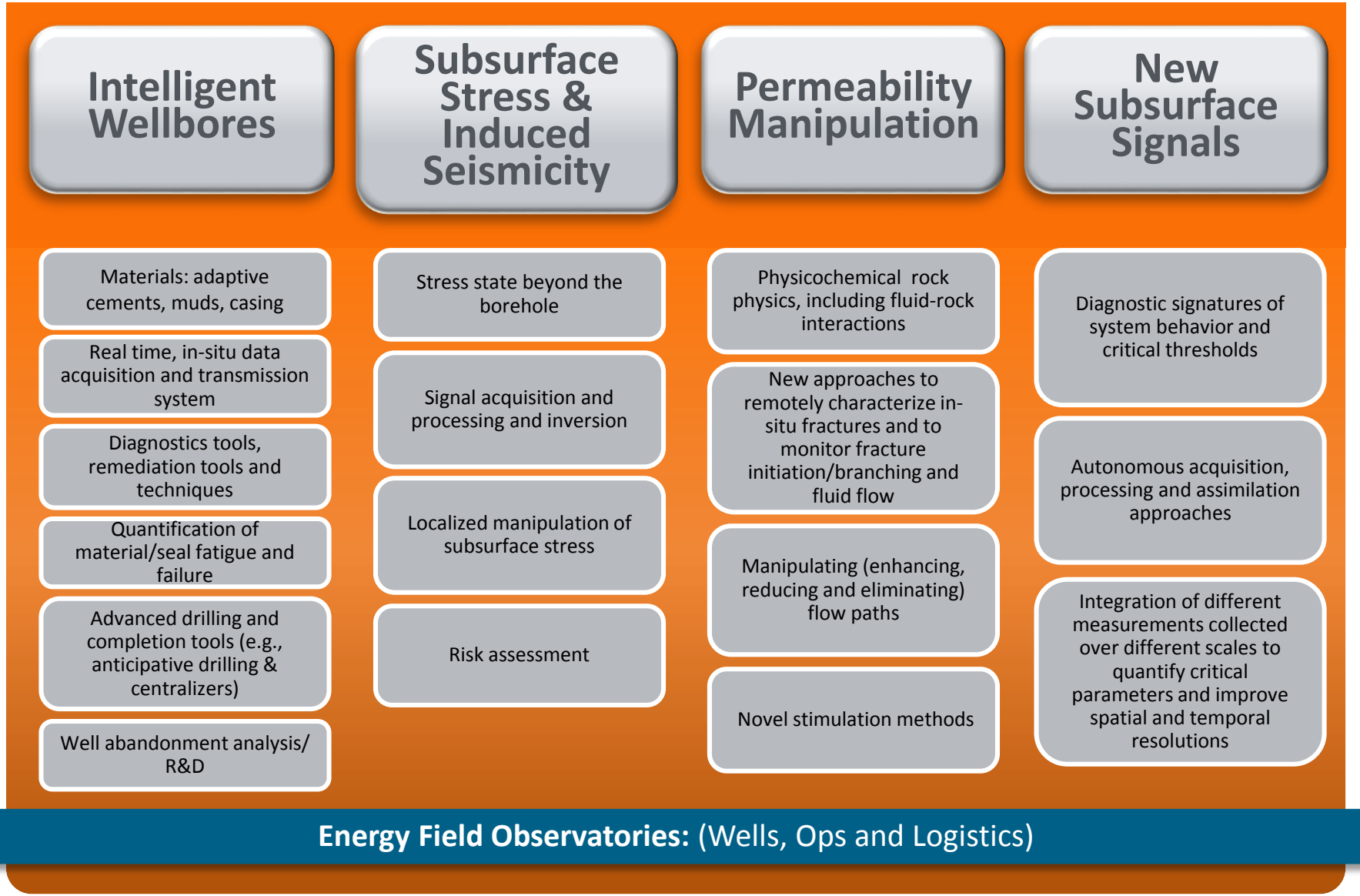
Fossil Energy/Carbon Storage
- Policy and technology: challenges of CO_2 storage to inform regulators, industry, and the public
- R&D: CO_2 offshore and onshore storage

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

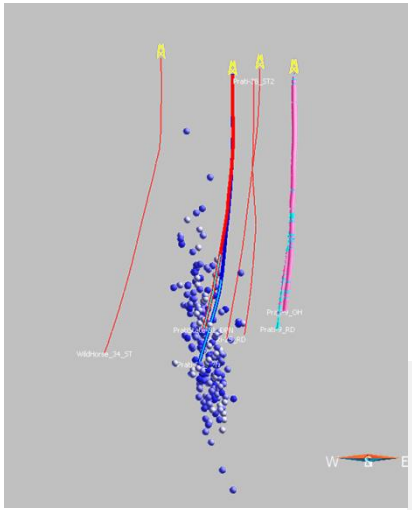
SubTER Crosscut: Pillars and Themes

Adaptive Control of Subsurface Fractures and Fluid Flow



Criticality of Core SubTER Themes

Subsurface Stress and Induced Seismicity



Induced Seismicity at The Geysers Geothermal Field (Calpine)

Approach to Date:

- Geothermal sector has proactively developed its own induced seismicity management protocol
- JASON Letter Report on ***State of Stress in Engineered Subsurface Systems,*** September 2014

> "JASON recommends that DOE take a leadership role in the science and technology for improved measurement, characterization, and understanding of the state of stress of engineered subsurface systems."

Increasing societal relevance of induced seismicity as EGS deployment grows, akin to oil and gas today

Subsurface Stress and Induced Seismicity Program:

- Improved stress measurements
- Broader data acquisition and sharing
- Advanced risk assessment tools

Outcomes:

- Improved understanding of the subsurface
- Mitigation and reduced risk
- Improved resource identification and development
- Safe scale up

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Energy Department Announces Student Competition Winners!

GTO sponsored two Student competitions in 2014 to engage and inspire College & university students in geothermal research.

VOTE for your **favorite!** ***People's Choice Award*** **Ballots** available in the GRC lobby and at **Booth 445-447!**

Winners in this year's *GeoEnergy is Beautiful* competition:

1st Place: *Truckee Meadows Community College*

2nd Place: *University of Texas – Pan American*

3rd Place: *University of Mississippi*

Winners in this year's Case Study Challenge:

1st Place: *Colorado School of Mines*

2nd Place: *University of North Dakota*

3rd Place: *University of North Dakota*

TMCC Truckee Meadows Community College

SCHOOL OF MINES 1874 COLORADO

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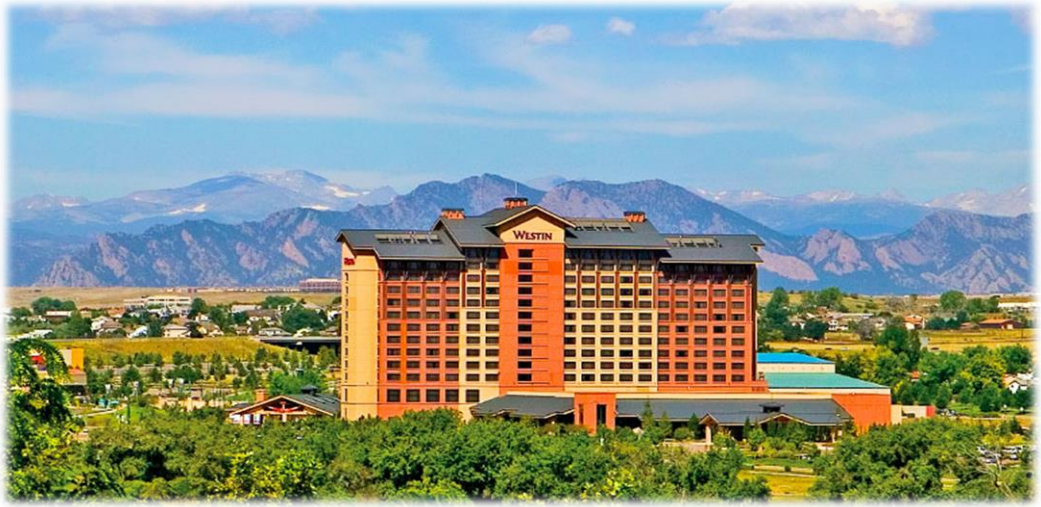
What's Next for GTO



- ***Stop by our Booth at the GEA Expo: #445-447***
- Check out our **Play Fairway** project at **Tuesday's Poster Session, 4-6 pm**
- **Meet the students** at **Tuesday's Poster Session, 4-6 pm**

- ***Watch for Upcoming Events !***
- **Peer Review**, May 11-15 at the Westminster Westin, Denver
- Energy Department **Geothermal Vision Study**
- **Crosscutting Subsurface Initiative Town Hall** at the **American Geophysical Union,** 12/15-19, San Francisco

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