U.S. DEPARTMENT OF
ENERGY

Office of
**ENERGY EFFICIENCY &
RENEWABLE ENERGY**

Geothermal Technologies Office: Update

September 16, 2019

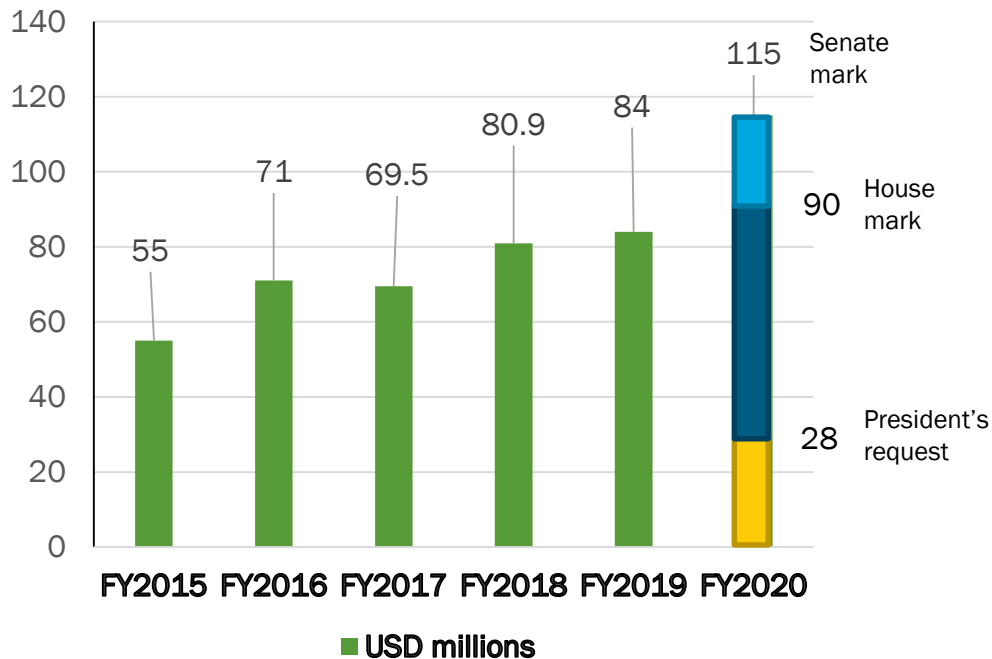## Dr. Susan G. Hamm, Ph.D.
Director

Image: Calpine

GTO Budget Overview & Major Activities

GTO Appropriations + FY 2020

Major **FY 2018-FY 2019** activities to reduce costs and increase affordability include the following:

- EGS Frontier Observatory for Research in Geothermal Energy (**FORGE**)
- Play Fairway Analysis
- Efficient Drilling for Geothermal Energy
- Machine Learning for Geothermal Energy
- State of Stress & Lost Circulation

Major proposed **FY 2020** activities to reduce costs and increase affordability (included in the President's Request) include the following:

- FORGE & Wells of Opportunity
- Reservoir Thermal Energy Storage (RTES)
- Machine Learning for Geothermal Energy
- Subsurface R&D

GeoVision Report

GEO VISION

Harnessing the Heat Beneath Our Feet

U.S. DEPARTMENT OF **ENERGY**
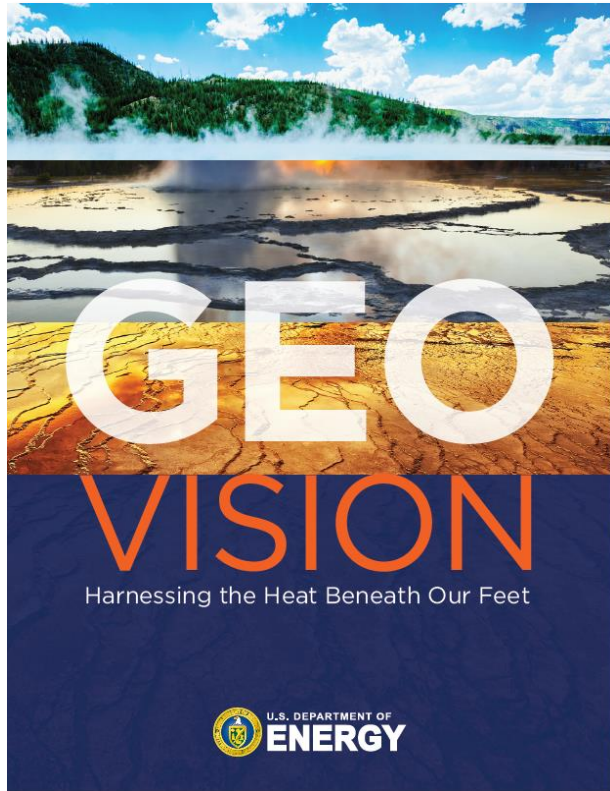
www.energy.gov/geovision

GeoVision technical sessions: Tuesday, September 17 / 8:00 AM & 10:10 AM / Catalina

- America could potentially achieve a <u>26-fold increase</u> in geothermal generation, representing 8.5% of total U.S. electricity generation in 2050 (60 GWe capacity).

- Streamlined permitting and regulation alone could <u>double</u> geothermal capacity.

- Potential rise in geothermal heat pump installations from 2 million to <u>28 million</u>.

- Potential increase in district heating installations from 21 to <u>17,500</u> installations nationwide.

- <u>Technology innovation is essential</u> – it improves our understanding of subsurface conditions, helps to reduce risk, and accelerates growth of domestic geothermal power.

FORGE [Frontier Observatory for Research in Geothermal Energy]

What's next?

- Phase 3 launch pending a Go/No-Go decision.
- Phase 3 will encompass five years of unprecedented domestic research in Enhanced Geothermal Systems (EGS).
- Pending the Go/No-Go decision, initial solicitations for FORGE R&D are anticipated this fall.

UTAH FORGE
U.S. Department of Energy

Booth 417

FORGE update sessions
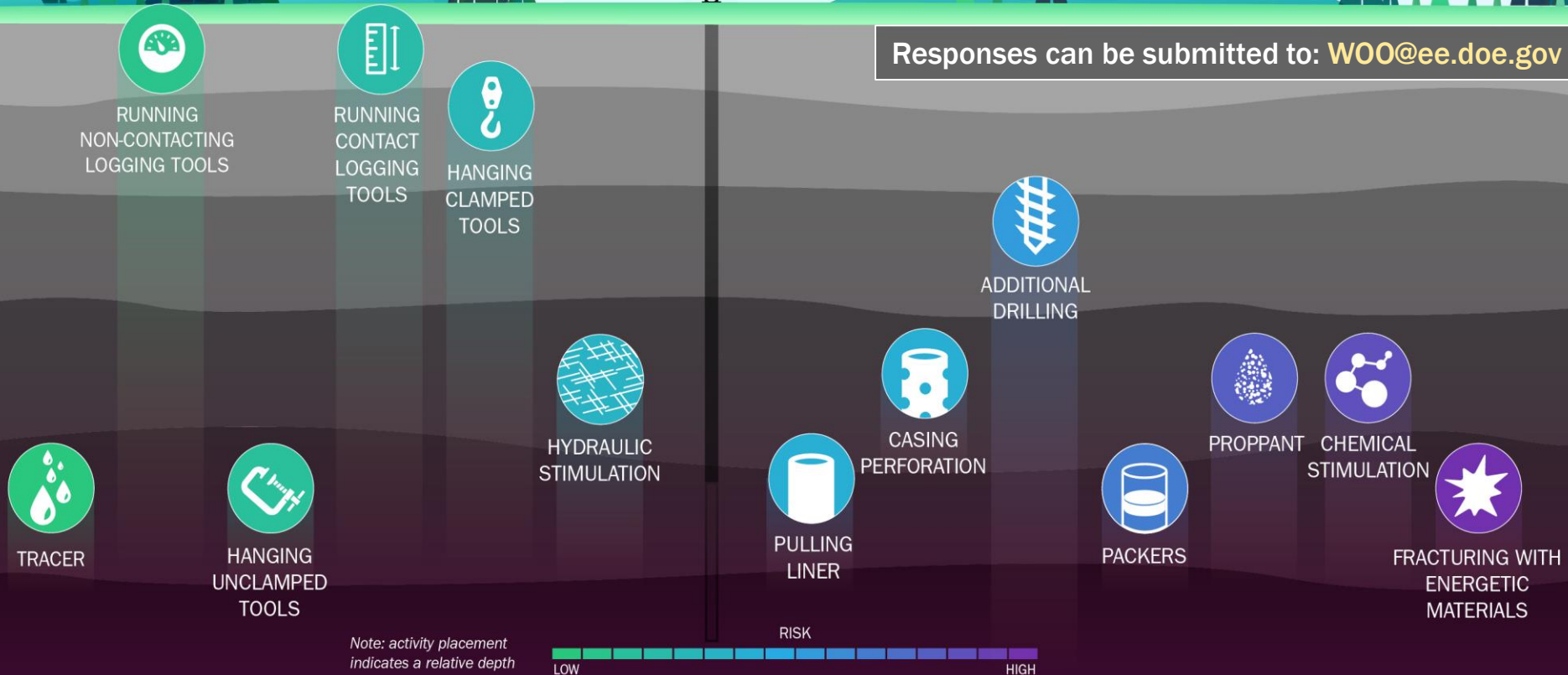Tuesday, September 17 / 2:00 & 3:50 PM / Catalina

Images: Joseph Moore

RFI: Wells of Opportunity

GTO is seeking input on wells/sites that could be put to use advancing innovative geothermal research. This input will help as we consider additional opportunities to test novel EGS-relevant technologies outside of the FORGE Utah site.

REQUEST FOR INFORMATION:
WELLS OF OPPORTUNITY

Responses can be submitted to: WOO@ee.doe.gov

RUNNING NON-CONTACTING LOGGING TOOLS

RUNNING CONTACT LOGGING TOOLS

HANGING CLAMPED TOOLS

ADDITIONAL DRILLING

HYDRAULIC STIMULATION

CASING PERFORATION

PROPPANT

CHEMICAL STIMULATION

TRACER

HANGING UNCLAMPED TOOLS

PULLING LINER

PACKERS

FRACTURING WITH ENERGETIC MATERIALS

Note: activity placement indicates a relative depth

RISK

LOW   HIGH

EGS Collab

- Insight into reservoir creation and sustainability gained from EGS Collab **directly supports FORGE research.**
- In the first phase, the team demonstrated creation of new hydraulic fractures and stimulation of natural fractures.
- Collab is in the process of receiving a conditional "go" for the project's second phase.

EGS Collab sessions
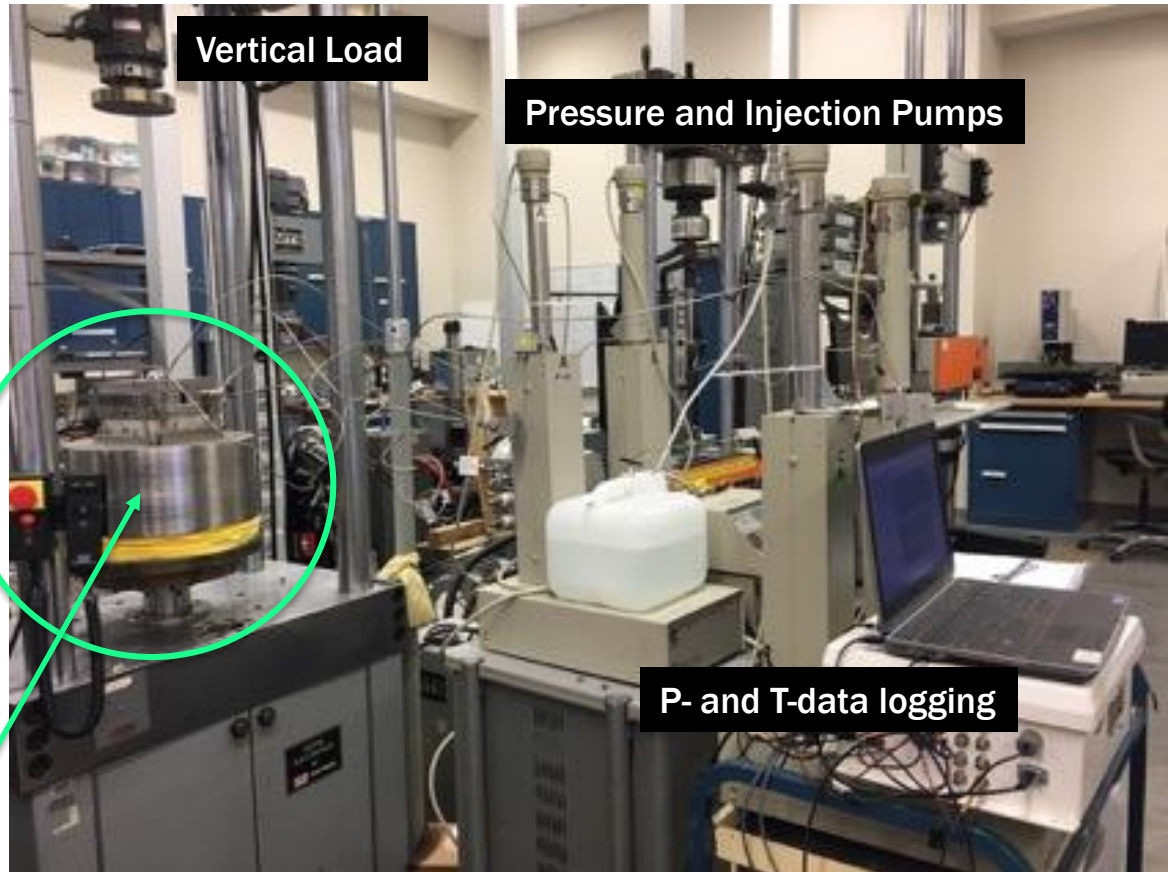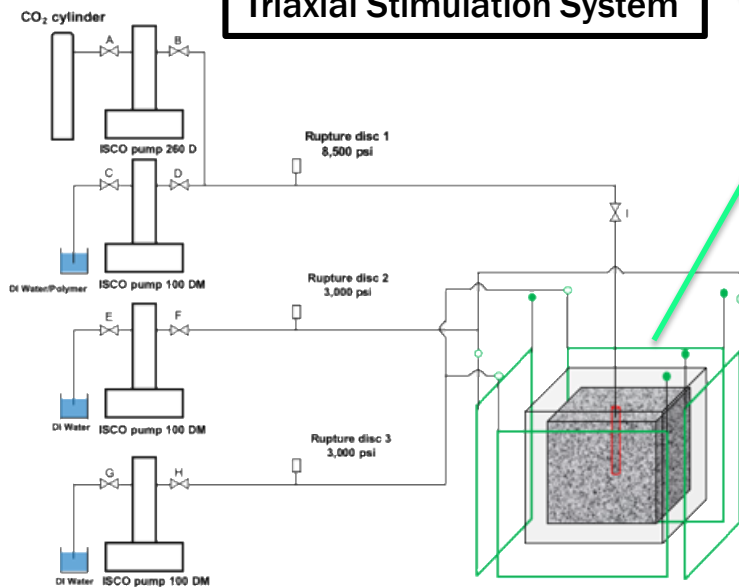Wednesday, September 18 / 8:00 & 10:10 AM / Catalina

Waterless Stimulation: PNNL

TOPIC: Responsive Fracturing Fluids for Enhanced Geothermal Systems

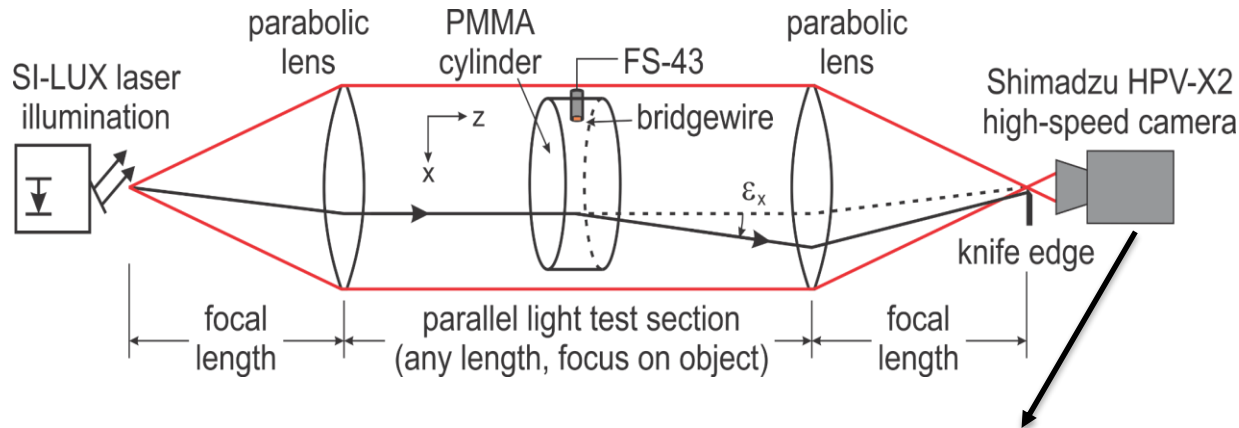**Triaxial Stimulation System**

Vertical Load

Pressure and Injection Pumps
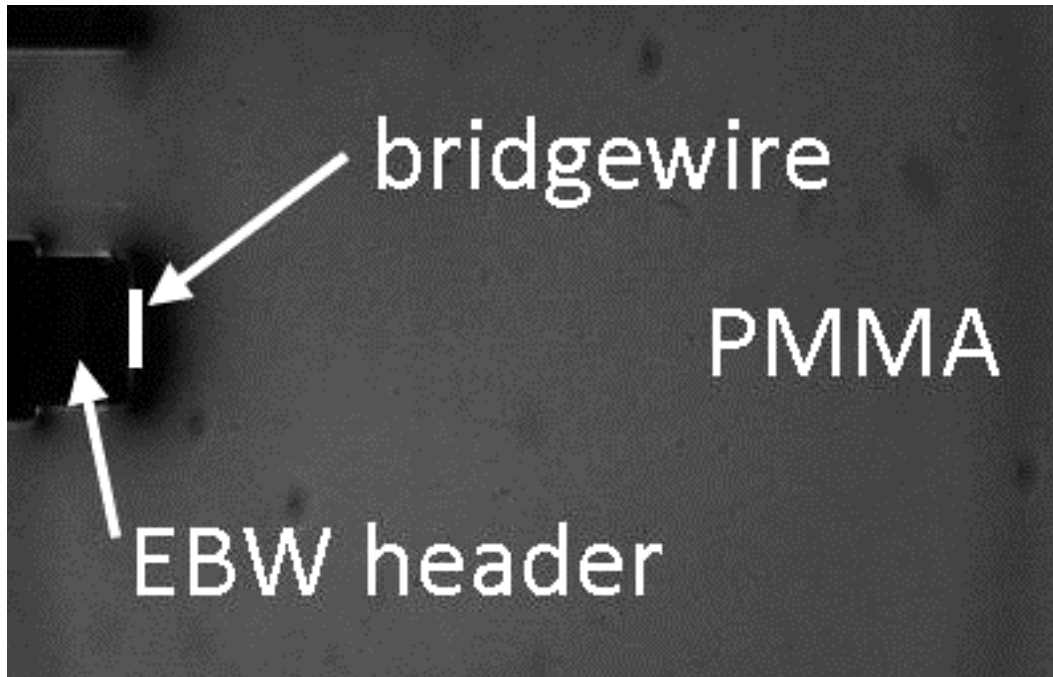
P- and T-data logging

What's next?
Evaluate StimuFrac™ co-injection with CO2.
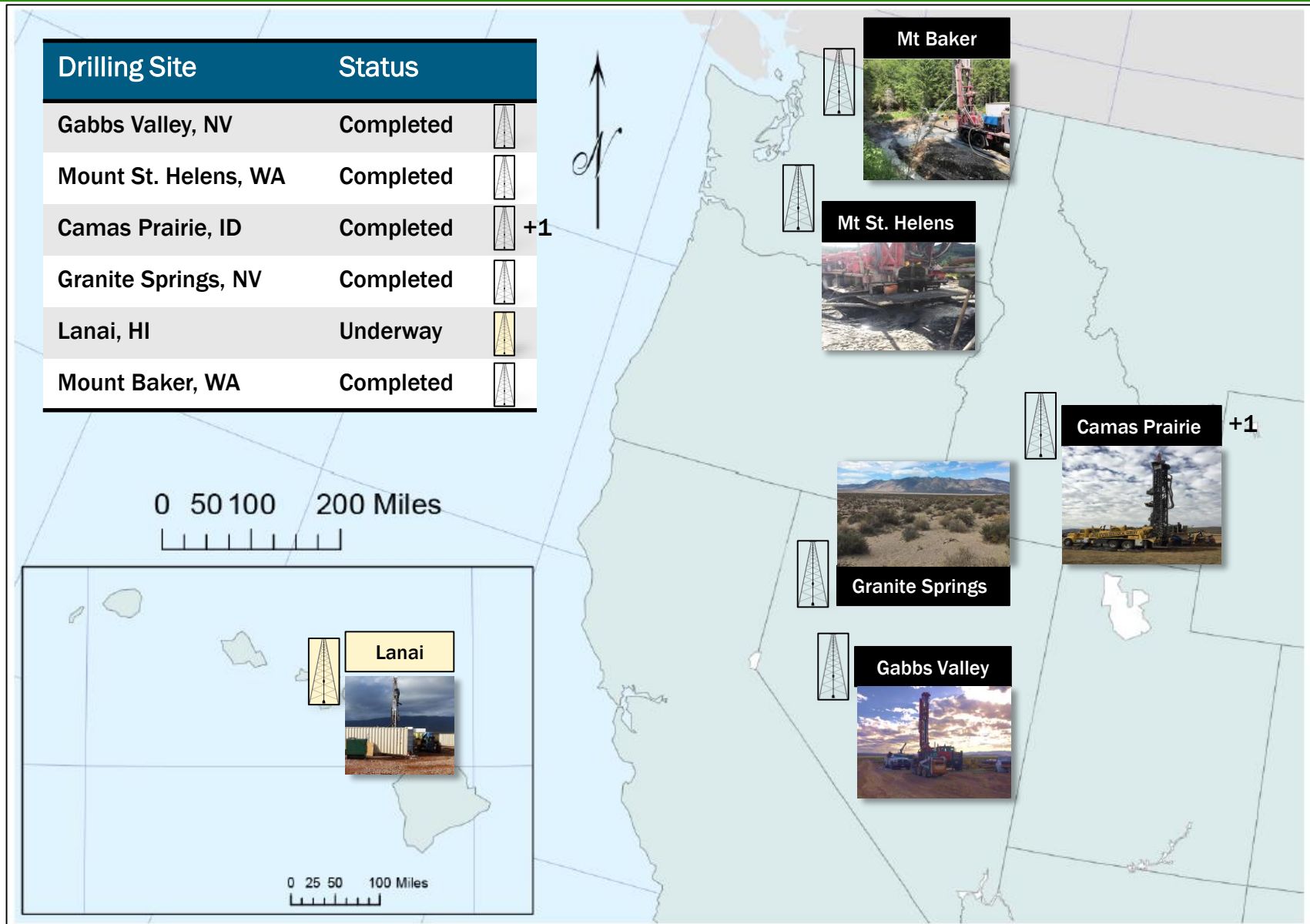
Waterless Stimulation: SNL

TOPIC: POT (Pressure, Orientation, Timing) for Anhydrous Energetic Stimulation
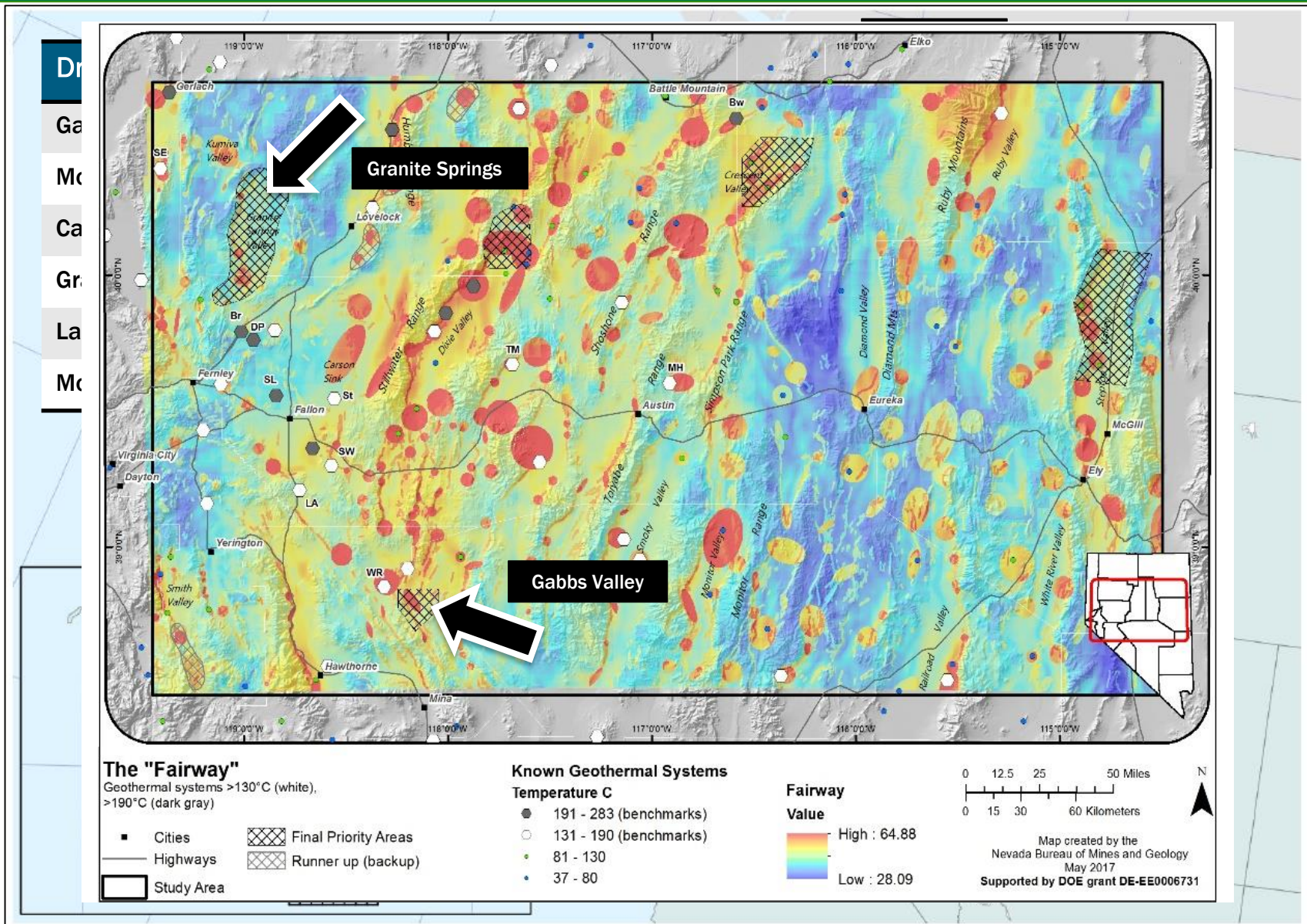

- Ultra-high speed digital camera capture at <u>10 million frames per second.</u>

- Bridgewire explosion produces an anhydrous shockwave that delivers local PMMA fractures.

- Shock motion and reflection are tracked for <u>comparison with computational simulations.</u>

Play Fairway Analysis

Drilling Site	Status	
Gabbs Valley, NV	Completed	
Mount St. Helens, WA	Completed	
Camas Prairie, ID	Completed	+1
Granite Springs, NV	Completed	
Lanai, HI	Underway	
Mount Baker, WA	Completed	

Mt Baker

Mt St. Helens

Camas Prairie +1

Granite Springs

Gabbs Valley

Lanai

0 50 100 200 Miles

0 25 50 100 Miles

Play Fairway Analysis

Deep Direct-Use

WV ENERGY INSTITUTE

- WVU Facilities Management
- West Virginia Geological & Economic Survey
- Lawrence Berkeley National Laboratory
- Cornell University

Portland State UNIVERSITY

- AltaRock Energy
- City of Portland
- Oregon Health & Science University
- U.S. Geological Survey

Cornell University

Seven research teams are currently assessing DDU feasibility in diverse regions across the U.S.

Appalachian Basin – WV, NY, PA sites

Wassuk Range – Hawthorne, NV

Columbia River Basalt – Portland, OR

Cotton Valley – East Texas

Illinois Basin – Champaign-Urbana, IL

Studies are underway to determine whether low-temperature geothermal resources can be used directly to heat and cool large-scale installations or districts. Cascaded heating and cooling (heat pumps and hybrid systems) may be included.

Sandia National Laboratories

- U.S. Navy Geothermal Program
- Power Engineers, Inc.
- University of Nevada-Reno

ILLINOIS

- University of Wisconsin-Madison
- Loudon Technical Services
- U.S. Army CER Laboratory
- MEP Associates
- Illinois Geothermal Engineering
- Trimeric

NREL — NATIONAL RENEWABLE ENERGY LABORATORY

- Southern Methodist University
- Eastman Chemical
- TAS Energy
- Electric Power Research Institute

**NETL — NATIONAL ENERGY TECHNOLOGY LABORATORY**

Advanced Energy Storage Initiative (AESI)

AESI supports objectives of the DOE's Grid Modernization Initiative (GMI).

Subsurface research is critical to achieving integrated and reliable underground thermal energy storage.

Summary of AESI "seedling" projects presented in **Beyond Batteries** technical session – Wednesday / 8:00 AM / Mojave

Image: Idaho National Lab
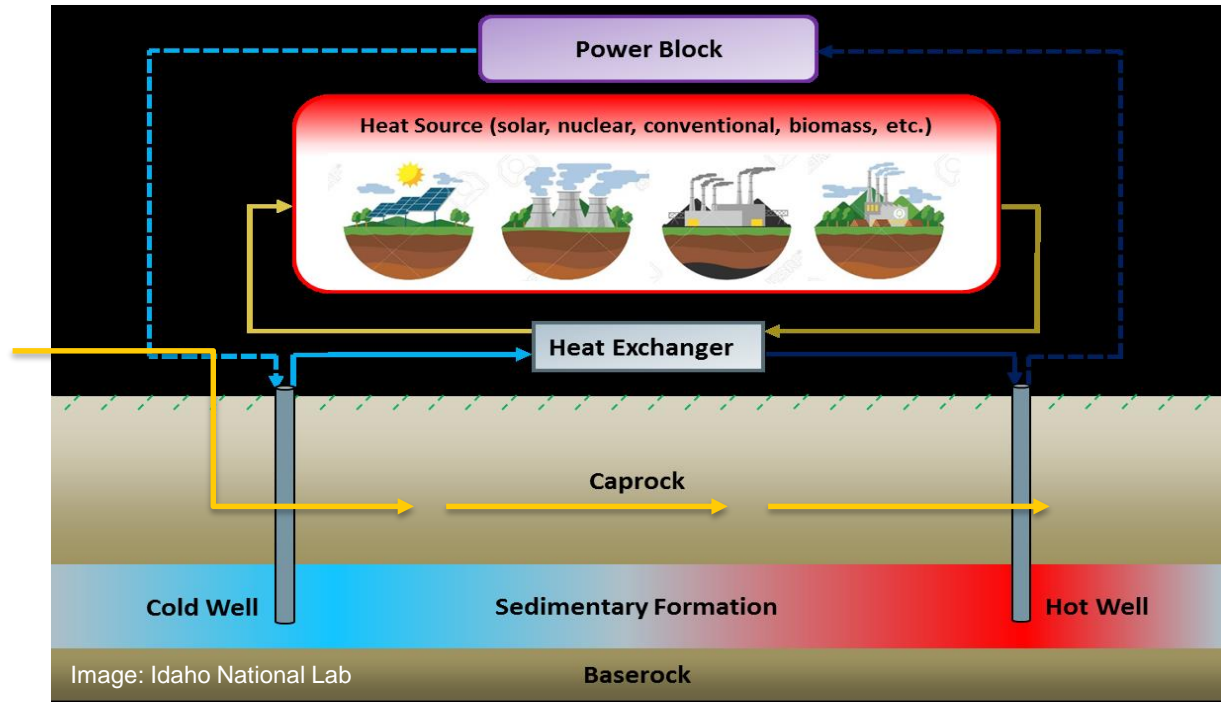
| Topic	Research Lead(s)
Novel heat pump-integrated underground thermal energy storage; **integrate subsurface thermal energy storage.**	Oak Ridge National Laboratory
Advanced insulating lightweight **thermal shock-resistant cement** suitable to withstand frequent thermal cycling.	Brookhaven National Laboratory Sandia National Laboratories
Dynamic storage: Terawatt-year, grid-scale energy storage using **Earth as a thermal battery.**	Idaho National Laboratory Berkeley Lab

Lithium Recovery: Salton Sea Region

Li 3 Lithium 6.941
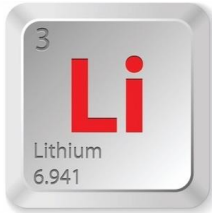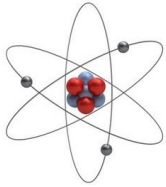
EERE seeks to demonstrate added value in regions where geothermal brines can deliver critical elements such as lithium.
Uniting GTO, AMO, and VTO creates clear-path integration from supply to manufacturing to end-market, with improved efficiencies and economics.

Geothermal Technologies
SUPPLY

Advanced Manufacturing
PROCESS

Vehicle Technologies
MARKET
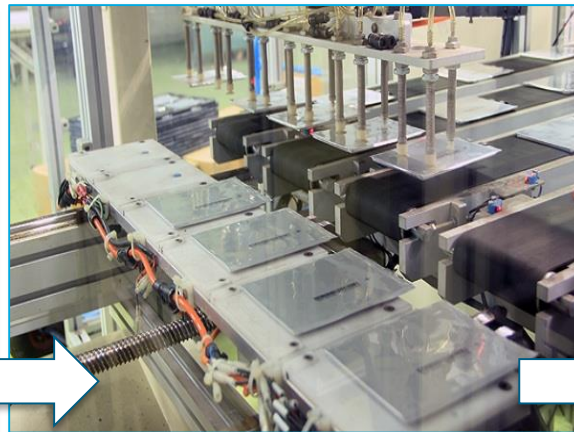
State of Stress & Lost Circulation

<u>Up to $7 million in funding</u> available for research and development of innovative technologies that...

- ...improve subsurface understanding of stress fracture networks, helping geothermal operators reduce risk and achieve optimal well placement.
- ...minimize the impact of lost circulation events (LCEs) during drilling, thus reducing drilling cost while improving efficiency.

(Proposals currently under review)

Images: Ormat [Tungsten Mountain, NV]

Topic Area 1	Development of technologies for characterizing, monitoring, and predicting state of stress for geothermal drilling.
Topic Area 2	Development of new technologies for predicting and mitigating lost circulation events in geothermal drilling.

Efficient Drilling for Geothermal Energy (EDGE)

Efficient Drilling for Geothermal Energy

- Drilling operations can account for up to 50% of the cost of geothermal development.
- GTO is funding 10 projects for a total of $14.5 million in funding.
- Research into new drilling techniques and technologies that can reduce cost for geothermal developers and operators.

- Argonne Laboratory
- Sandia National Laboratories
- General Electric
- Oklahoma State University
- Texas A&M University
- University of Oklahoma
- University of Texas
- Oregon State University

|	
Topic Area 1	**3 awardees** / Projects will focus on early-stage R&D to **reduce common delays in drilling operations.**
Topic Area 2	**5 awardees** / Projects will focus on early-stage R&D in **innovative drilling technologies.**
Topic Area 3	**2 awardees** / Projects will explore innovative approaches and models to **accelerate the transfer of geothermal drilling and related technologies** from the laboratory to the real world.

Machine Learning for Geothermal Energy

Machine Learning offers substantial opportunities for technology advancement and cost reduction throughout the geothermal project lifecycle.

Objectives:
- Identifying data acquisition targets (+drilling) with high scientific value for future work
- Identifying new signatures for detecting hidden geothermal systems
- Optimizing power production through plant/reservoir monitoring and analytics
- Improving prediction and detection of trouble events

Awardees:
- Colorado School of Mines
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Renewable Energy Laboratory
- Pennsylvania State University
- University of Arizona
- University of Houston
- University of Nevada-Reno
- University of Southern California
- Upflow Limited (New Zealand)
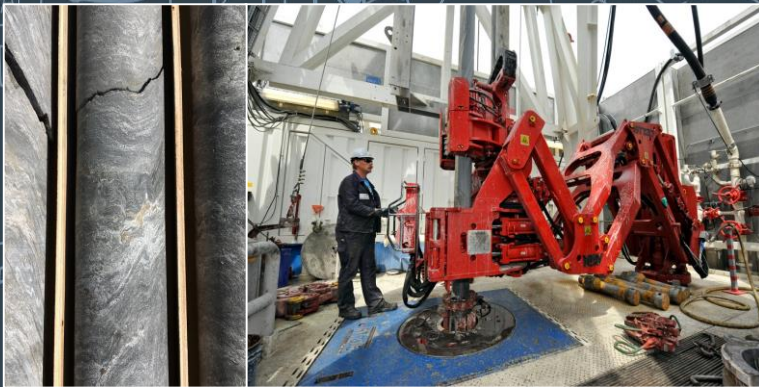
10 awards / $5.5 million in funding

Thanks, and have a wonderful conference!

Visit us at Booth 121/123

The **Geothermal Technologies Office (GTO)** works to reduce the cost and risk associated with geothermal development by supporting innovative technologies that address key exploration and operational challenges.

By advancing the value stream for grid (electricity) production and deep direct-use, GTO aims to make geothermal energy a cost-competitive, widely available, geographically diverse component of the national energy mix.

Visit us at **www.energy.gov/eere/geothermal**