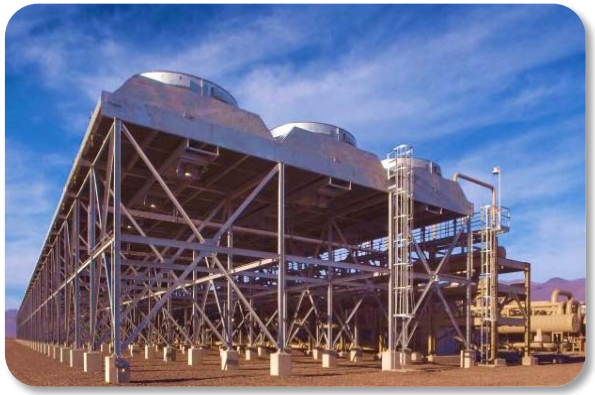
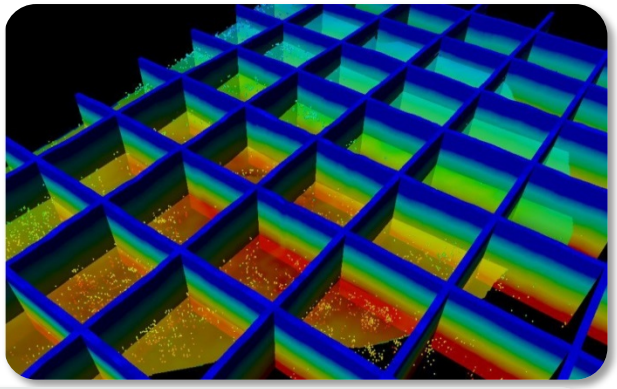
Enhanced Geothermal Systems & Frontier Observatory for Research in Geothermal Energy (FORGE) Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy





Robert Vagnetti
National Energy Technology Laboratory

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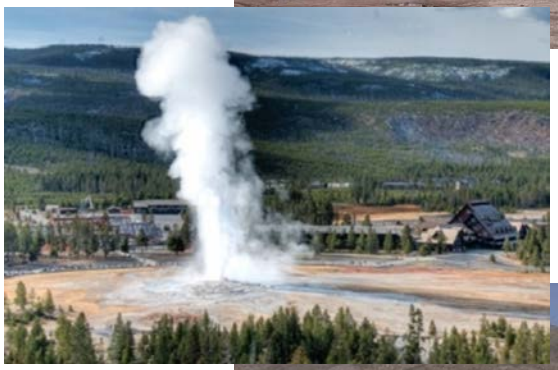
Types of Geothermal

Geothermal Heat Pumps/ Ground Source Heat Pumps	Use relatively constant temperature of the earth as heat source for commercial and residential heating and cooling	• Near ambient temperatures (40-80°F) • Shallow depths - trenches to wells hundreds of feet deep
Direct Use Geothermal	Use thermal energy (heat) from the earth directly for heating/cooling buildings, greenhouses, aquaculture, pools, spas, etc.	• Moderate temperatures (100-300°F) • Wells hundreds to thousands of feet deep
Geothermal Power (Electricity Generation)	Use thermal energy (heat) from the earth to generate electricity	• High temperatures (>300°F) as well as low temperatures (<300°F) • Wells up to many thousands of feet deep • Baseload generation value proposition

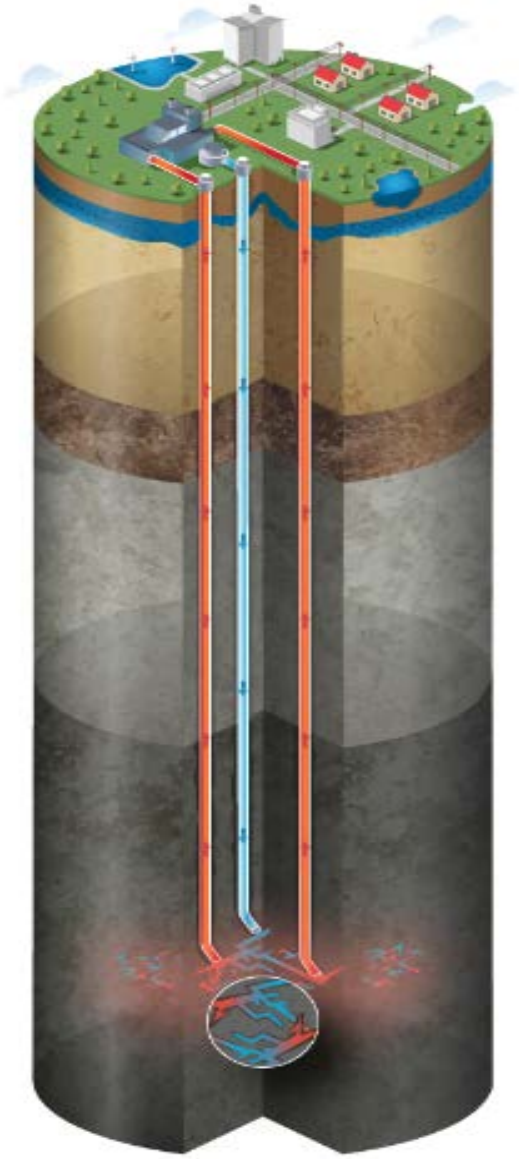
Why Does Geothermal Matter?

Geothermal…

- An always-on energy source that harnesses the earth's natural heat
- Provides flexible, baseload (24-hr) power
- Creates thousands of valuable energy sector jobs and strengthens local economies
- Plants with 40-60 year lifespans
- Supports domestic technology innovation
- Improves domestic energy security and energy independence
- No greenhouse gas emissions
- With enhanced geothermal systems and deep direct use, becomes a widely available renewable energy source…an "everywhere" solution

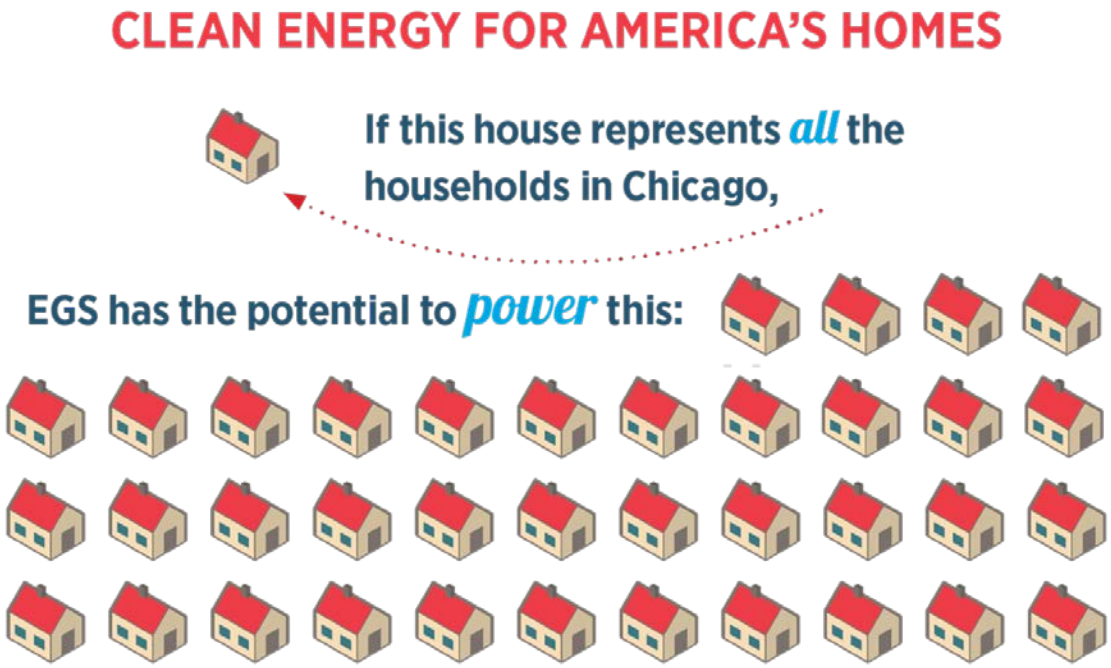


Enhanced Geothermal Energy



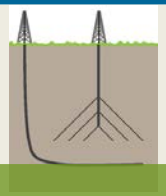
EGS Technology would allow Americans to install a geothermal reservoir and produce baseload, flexible power anywhere.

The resource potential of this is huge:

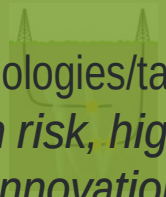


But Technology Challenges Remain

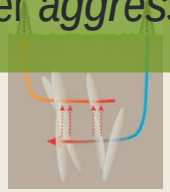
Targeted technology breakthroughs and field validation needed to demonstrate commercial replicability



Reservoir Access
New well geometries and concepts, optimized drilling



Reservoir Creation
Controlled fracturing, stimulation, and fracturing methods; increase fractured volume per well



Productivity
Increase flow rates without excessive pressure needs or flow localization

Sustainability
Maintain productivity with minimal thermal drawdown and water losses

Federal Role:

- Test technologies/take *technical risks* not possible in private sector
  - *High risk, high pay-off research and development*
- Advance *innovation – domestic & international*
- Work under *aggressive timeframe*

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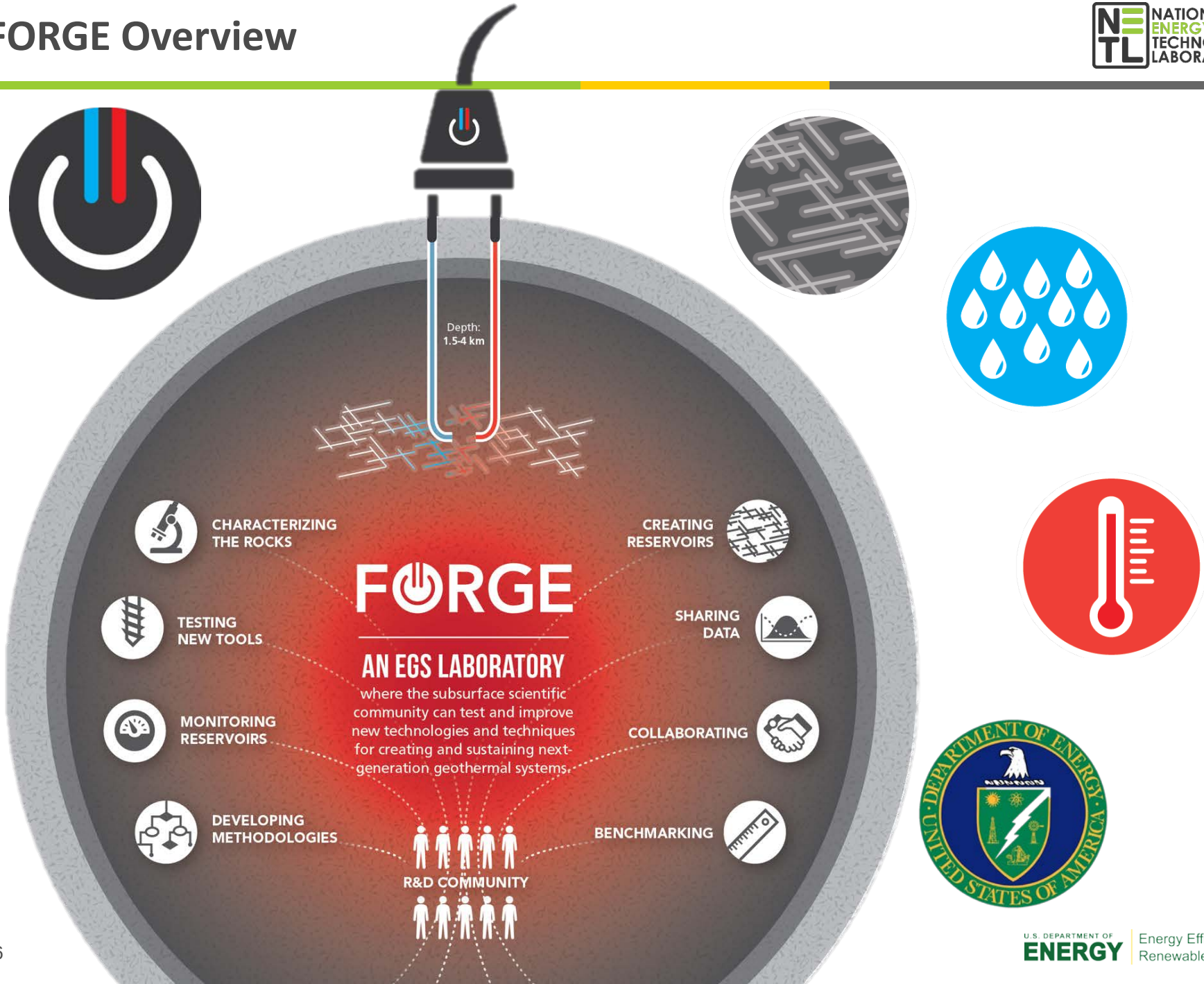
FORGE Overview



FORGE Principles

- Gain fundamental understanding of the **key mechanisms controlling Enhanced Geothermal System (EGS) success**.
- Develop, test, and improve new **technologies and techniques** in an ideal EGS environment.
- Make integrated **comparison of technologies and tools** in a controlled environment.
- Rapidly **disseminate technical data and communicate** to the research community, developers, and other interested parties

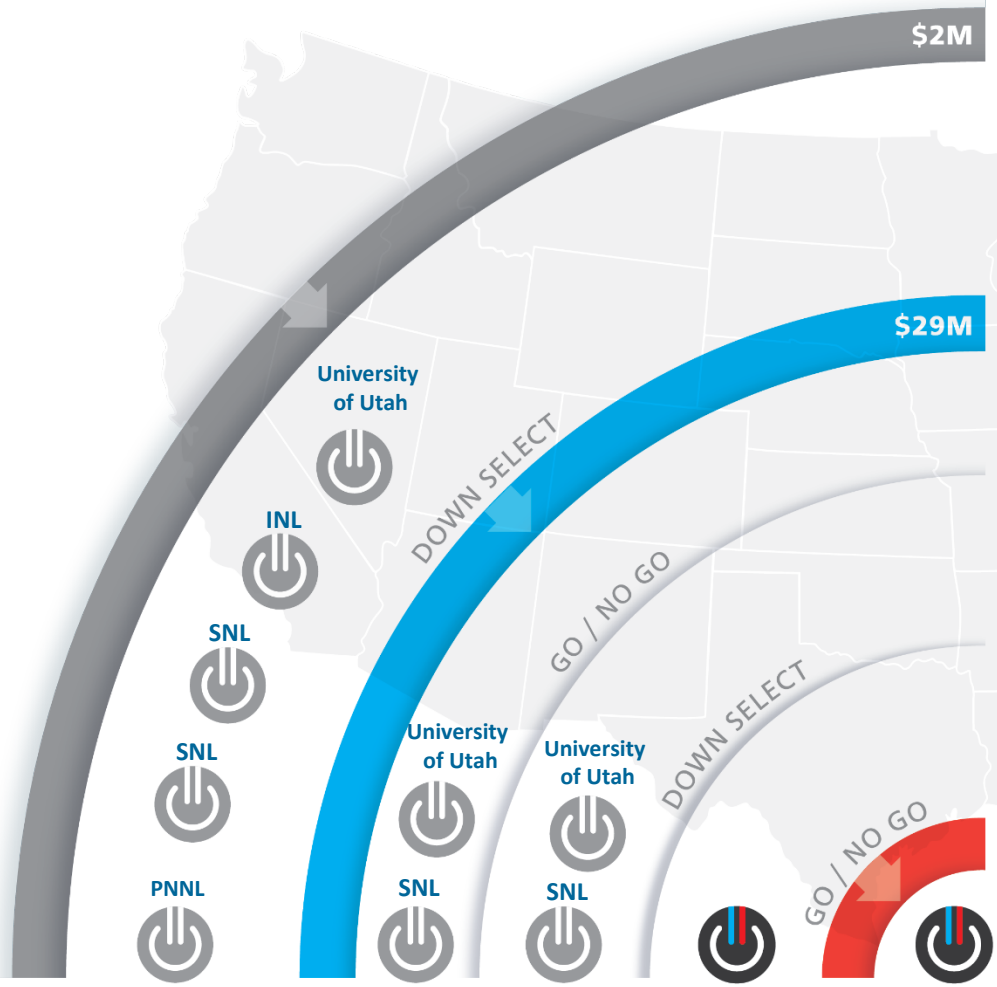
FORGE Site Criteria

- Well characterized, with high temperatures in the target formation in the range of **175-225 °C**
- Moderate permeability of order **10^{-16} m^2**, below the limit that typically supports natural hydrothermal systems
- Target formation between **1.5-4 km depth**, to avoid excessive costs associated with the drilling of new wells while attaining stress and temperature characteristics that are suitable to EGS and advancement of new technologies
- Must **not be within an operational hydrothermal field**
- Does **not stimulate** or **circulate fluids through overlying sedimentary units**, if applicable

Other site selection considerations included:

- **Owner/lease holder commitment** to the project
- **Environmental review** and **regulatory permitting**
- Available **infrastructure** necessary for carrying out the operation of FORGE

FORGE Structure, Tasks, & Funding



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.

FORGE Status

NATIONAL ENERGY TECHNOLOGY LABORATORY

Phase 1 **Phase 2** ***Phase 3***

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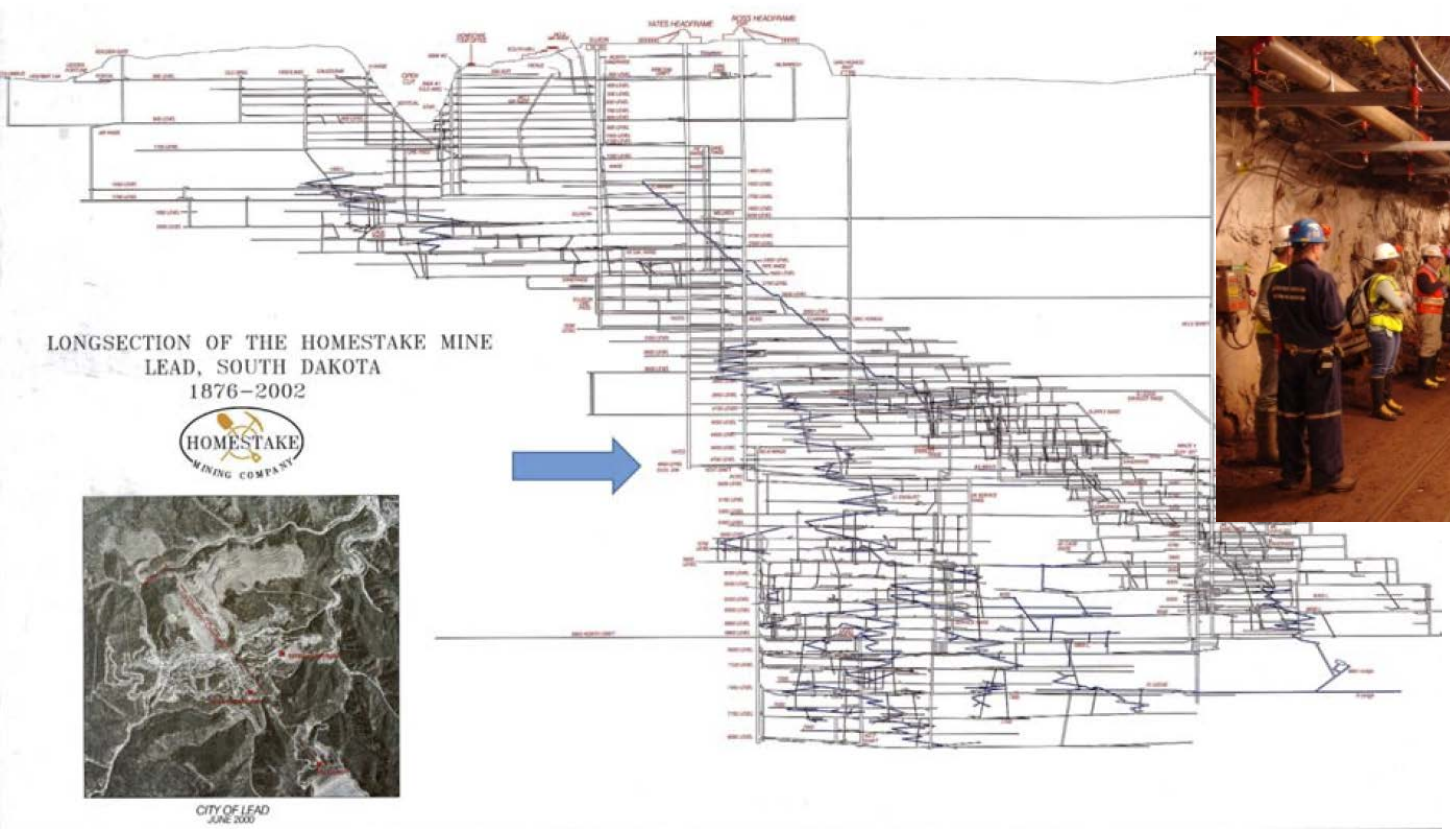
FORGE Phase 2: Full Site Readiness

FORGE Phase 3: Technology Testing & Evaluation

- Full implementation of FORGE
- Drilling of two or more full-sized wells, reservoir stimulation, connectivity and flow testing, dynamic reservoir modeling, and continuous monitoring
- Annual R&D solicitations with 10-20 subcontracts awarded for research and technology testing per competition (subject to annual appropriations) in the following categories:
    - Reservoir characterization (coupled imaging, drilling for interrogation and monitoring, high-temperature tools and sensors)
    - Reservoir creation (formation access, fracture characterization, zonal isolation, stimulation technologies)
    - Reservoir sustainability (long-term testing, monitoring, and operational feedback)

- **At least 50% of annual Phase 3 FORGE funding** will be directed towards competitive R&D solicitations, exclusive of funds dedicated to innovative drilling and flow testing.

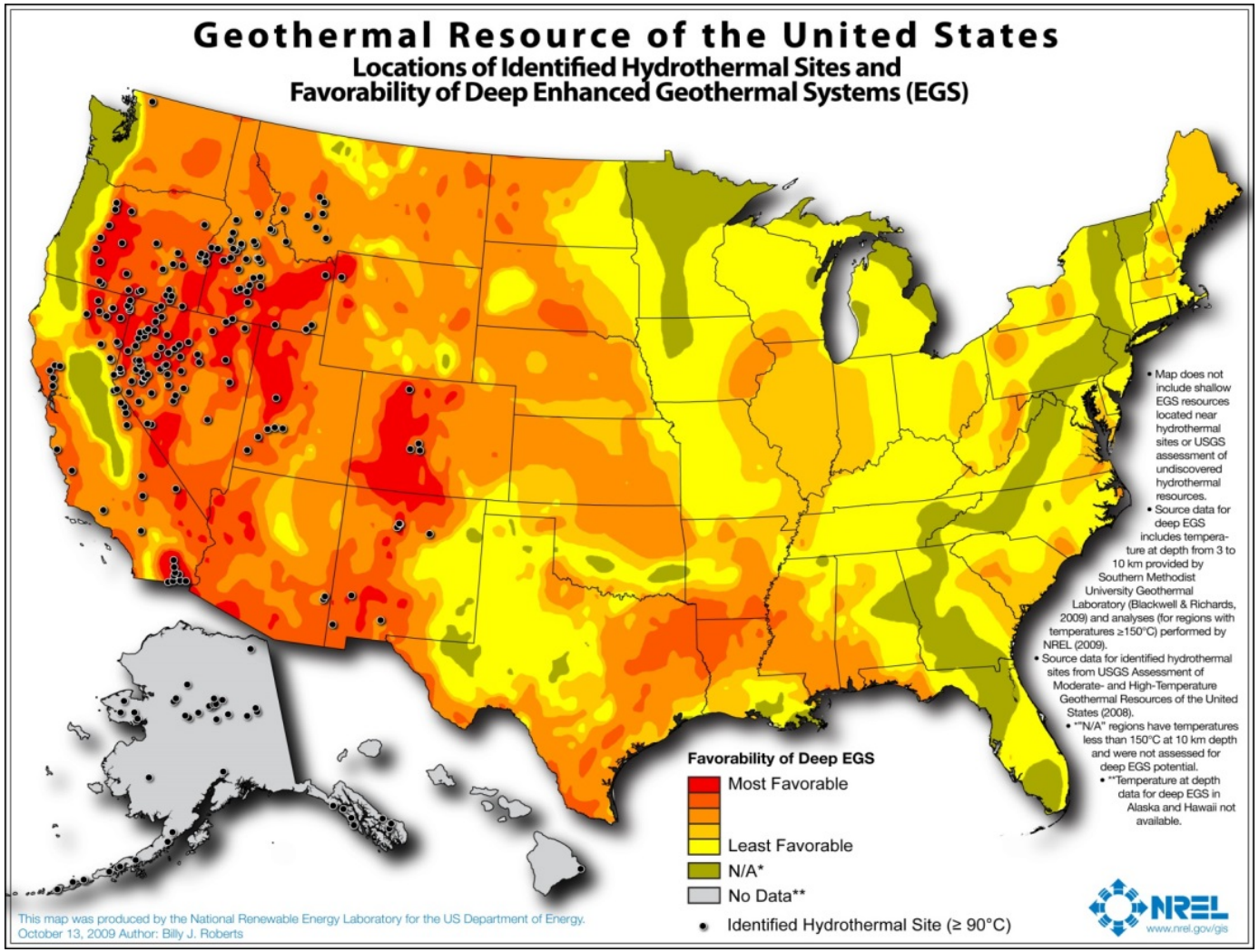
Integration of EGS Collab Project



The EGS Collab will aid in the acceleration of near-term FORGE R&D activities and testing via research conducted at readily accessible underground facilities at intermediate (on the order of 10 m) scales.

This National Lab collaboration will refine our understanding of rock mass response to stimulation and provide a test bed for the validation of thermal-hydrological-mechanical-chemical (THMC) modeling approaches as well as novel monitoring tools.

FORGE Summary



EGS Information

https://energy.gov/eere/geothermal/geothermal-energy-us-department-energy

https://energy.gov/eere/geothermal/enhanced-geothermal-systems-0

https://energy.gov/eere/forge/forge-home

https://energy.gov/eere/forge/sandia-national-laboratories-fallon

https://egi.utah.edu/forge/

https://energy.gov/eere/geothermal/egs-collab

Lauren W.E. Boyd
Enhanced Geothermal Systems Program Manager
Geothermal Technologies Office
Energy Efficiency and Renewable Energy
Department of Energy
202.287.1854
Lauren.Boyd@ee.doe.gov