The FORGE initiative of the US department of energy

FORGE = **F**rontier **O**bservatory for **R**esearch in **G**eothermal **E**nergy

SCCER SoE Annual Conference 2015

Markus Häring, 11. Sept. 2015

US DOE Geothermal Office (GTO) funded projects

- 4 DOE Geothermal Programs:
    1. Enhanced Geothermal Systems
    2. Hydrothermal
    3. Low-Temperature & Coproduced Resources
    4. System Analysis
- Approx **150 individual research projects**
- Annual Review by independent experts

PLUG INTO THE PLANET

FORGE
U.S. Department of Energy

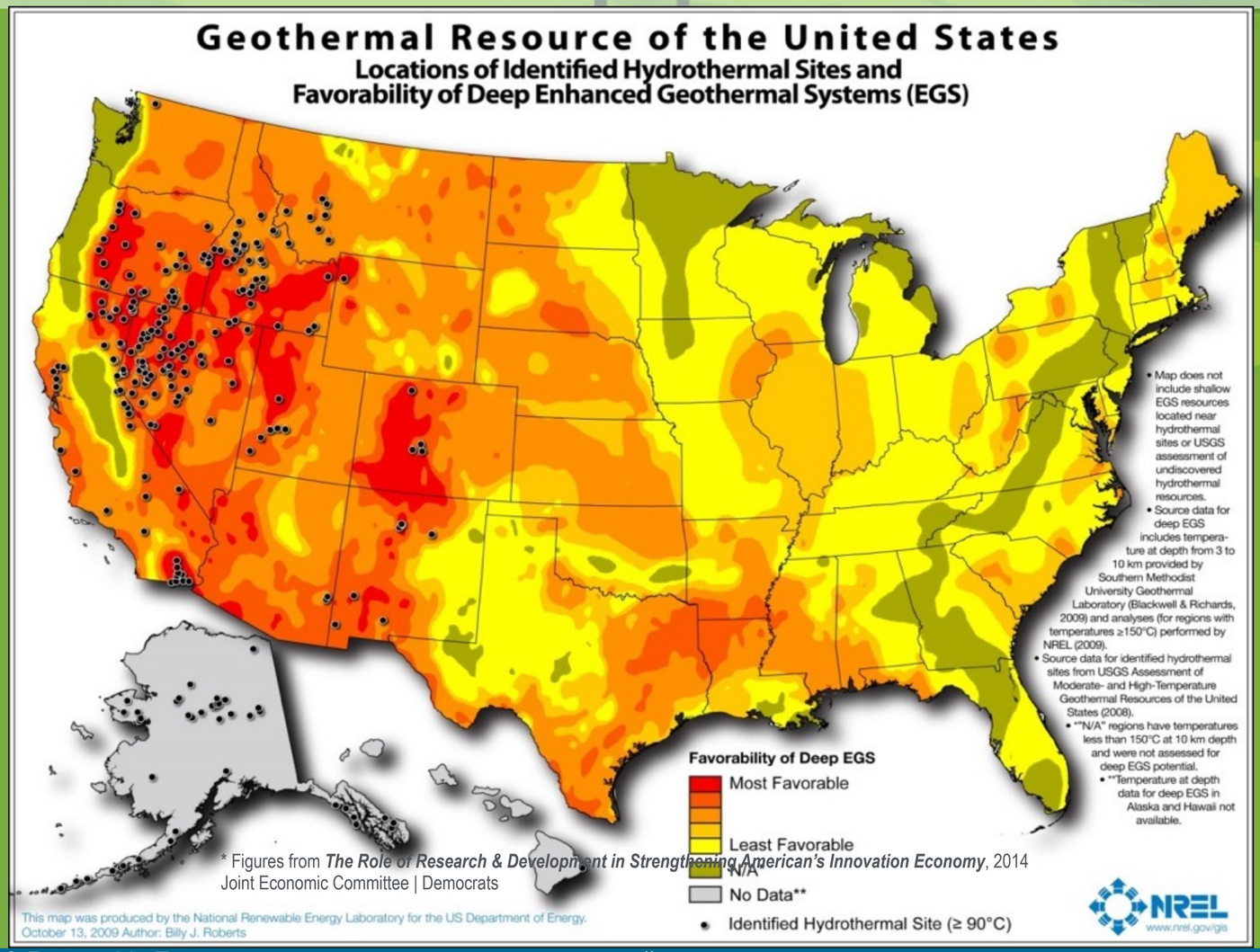
FRONTIER OBSERVATORY FOR RESEARCH IN GEOTHERMAL ENERGY

EGS Program Manager: Lauren Boyd

Why FORGE?

Opportunity Space

- Heat is present almost ***everywhere at depth***
- Potential resource is estimated to be on the order of ***100+ GWe*** (USGS)



* Figures from ***The Role of Research & Development in Strengthening American's Innovation Economy***, 2014 Joint Economic Committee | Democrats

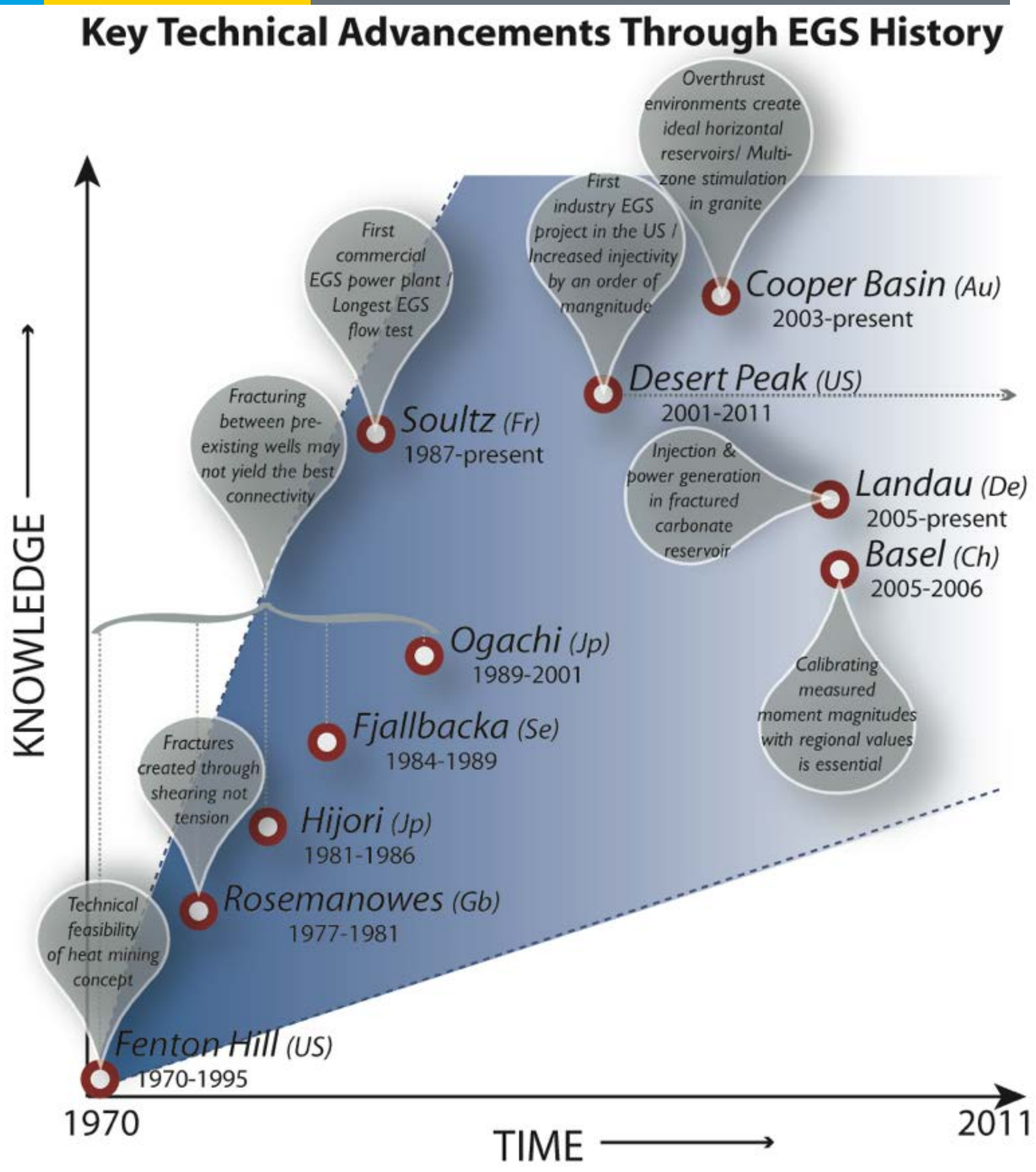
Foundational EGS Projects

Critical Needs:

- ***Characterization*** of ***local stress***, ***chemical potential***, and ***thermal pathways***
- Achieving ***sufficient productivity*** (and stimulated volume) for commercial EGS power generation

Path Forward:

- Remaining gaps are the foundation of the EGS portfolio
- Most ***technology needs*** are ***evolutionary-not revolutionary!***



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

EGS Demonstration Portfolio

Core Area Results

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The Geysers, CA


Desert Peak, NV


Well head
Newberry, OR


Newberry, OR

Performer	Project Site	Site Information	Status	Funding
Ormat Technologies Inc.	*Desert Peak, NV*	*Adjacent to existing hydrothermal development*	*Successful stimulation completed - 1.7 MW additional capacity added*	*$ 4.3 M*
Geysers Power Company, LLC	The Geysers, CA	Reopen two existing wells to deepen for injection and stimulation in inactive part of field	*Successful stimulation completed - 5 MW equivalent created*	$ 6.2 M
University of Utah	*Raft River, ID*	*Improve the performance of the existing Raft River geothermal field*	*Successful Stimulation underway - injectivity increasing daily*	*$ 8.9 M*
AltaRock Energy Inc.	Newberry Volcano, OR	High potential in an area without existing geothermal development	*Successful stimulation completed - multiple zones stimulated*	$ 21.4 M
Ormat Technologies Inc.	*Bradys Hot Springs, NV*	*Improve the performance of the existing Brady's geothermal field*	*Initial stimulation complete & long term strategy under development*	*$ 3.4 M*

FOA Structure

Multi-phased Approach

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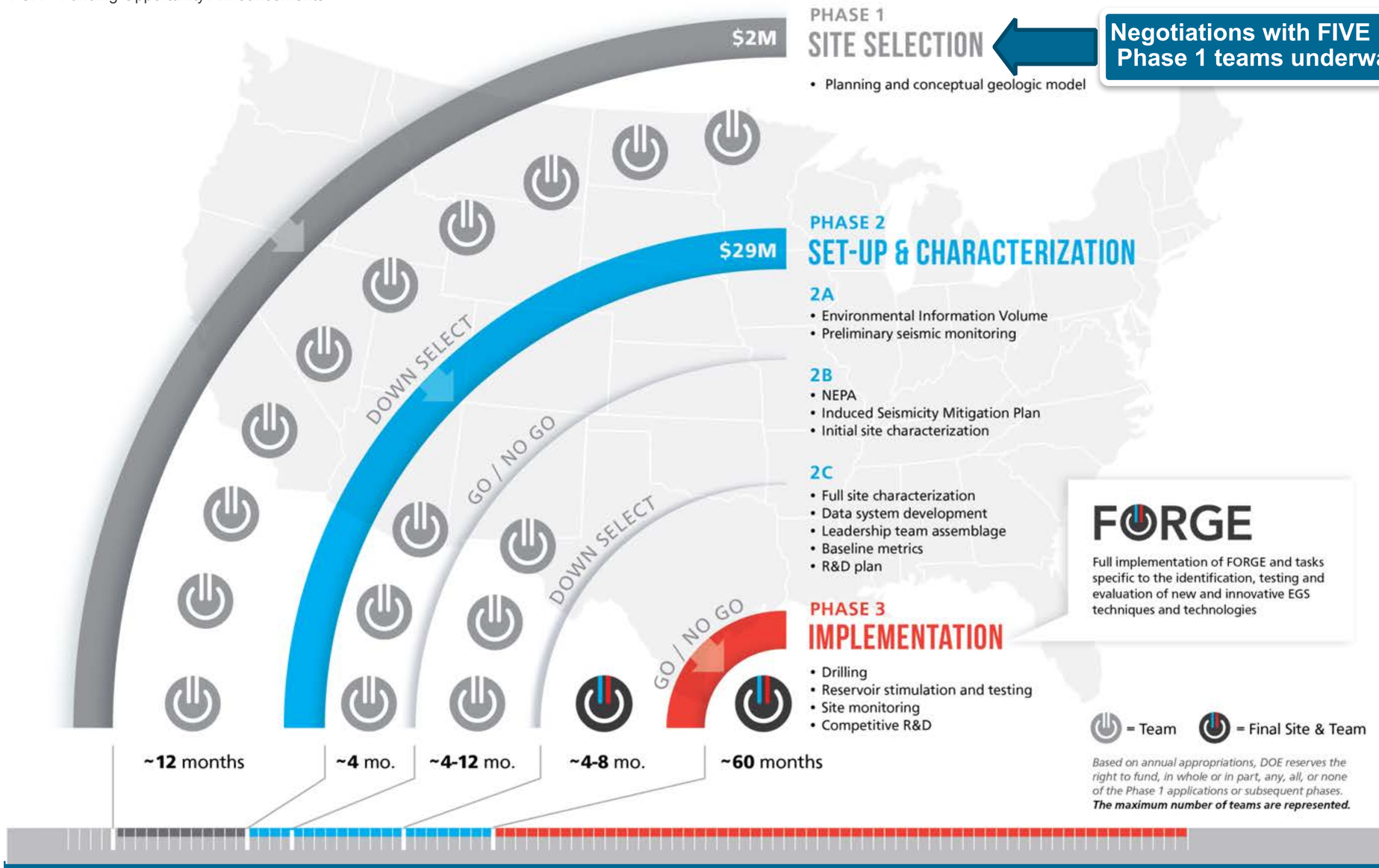
FOA = Funding Opportunity Announcements



PHASE 1

SITE SELECTION

- Planning and conceptual geologic model

Negotiations with FIVE Phase 1 teams underway

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.

Selected Teams

Broad Collaboration & Data Rich Sites

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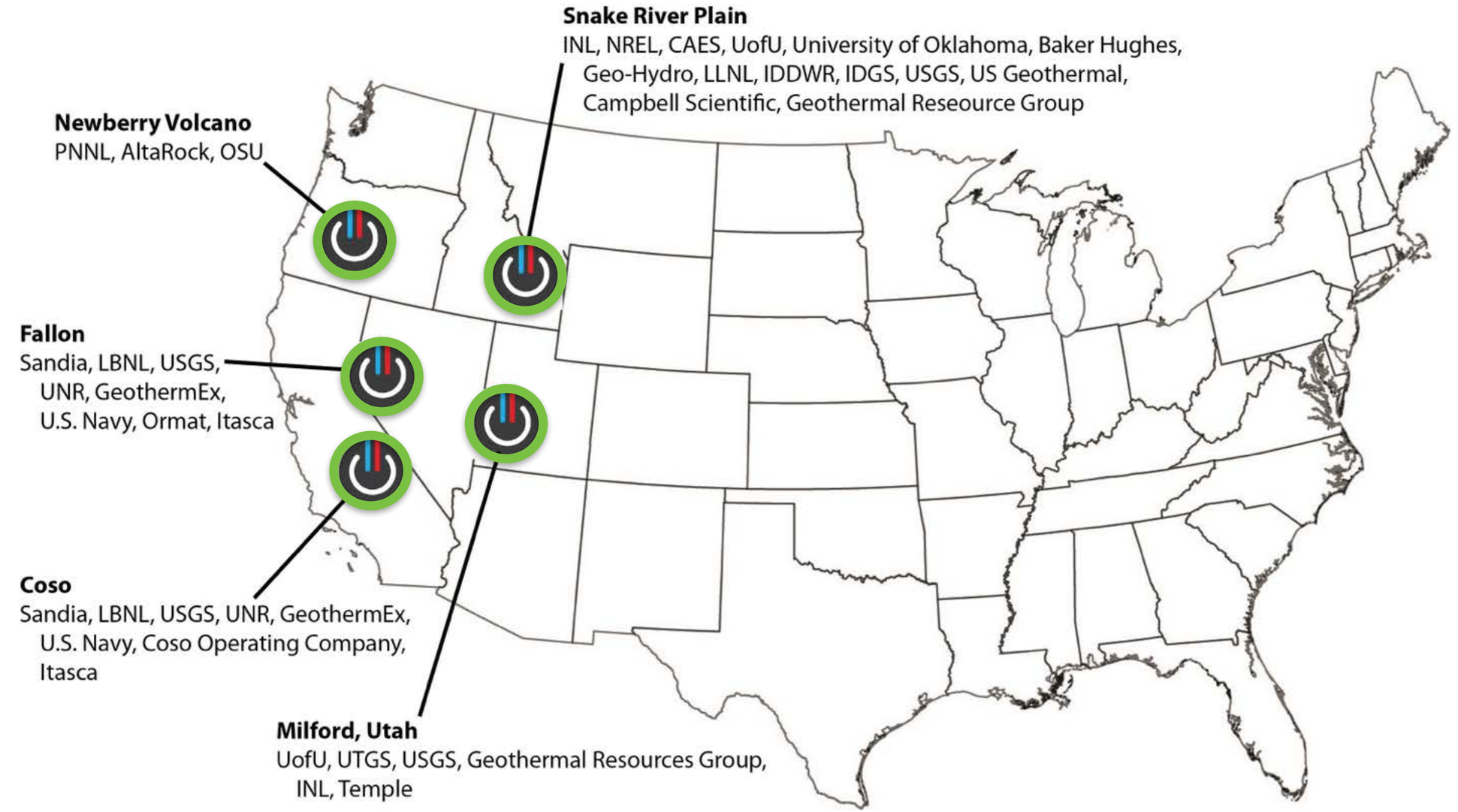
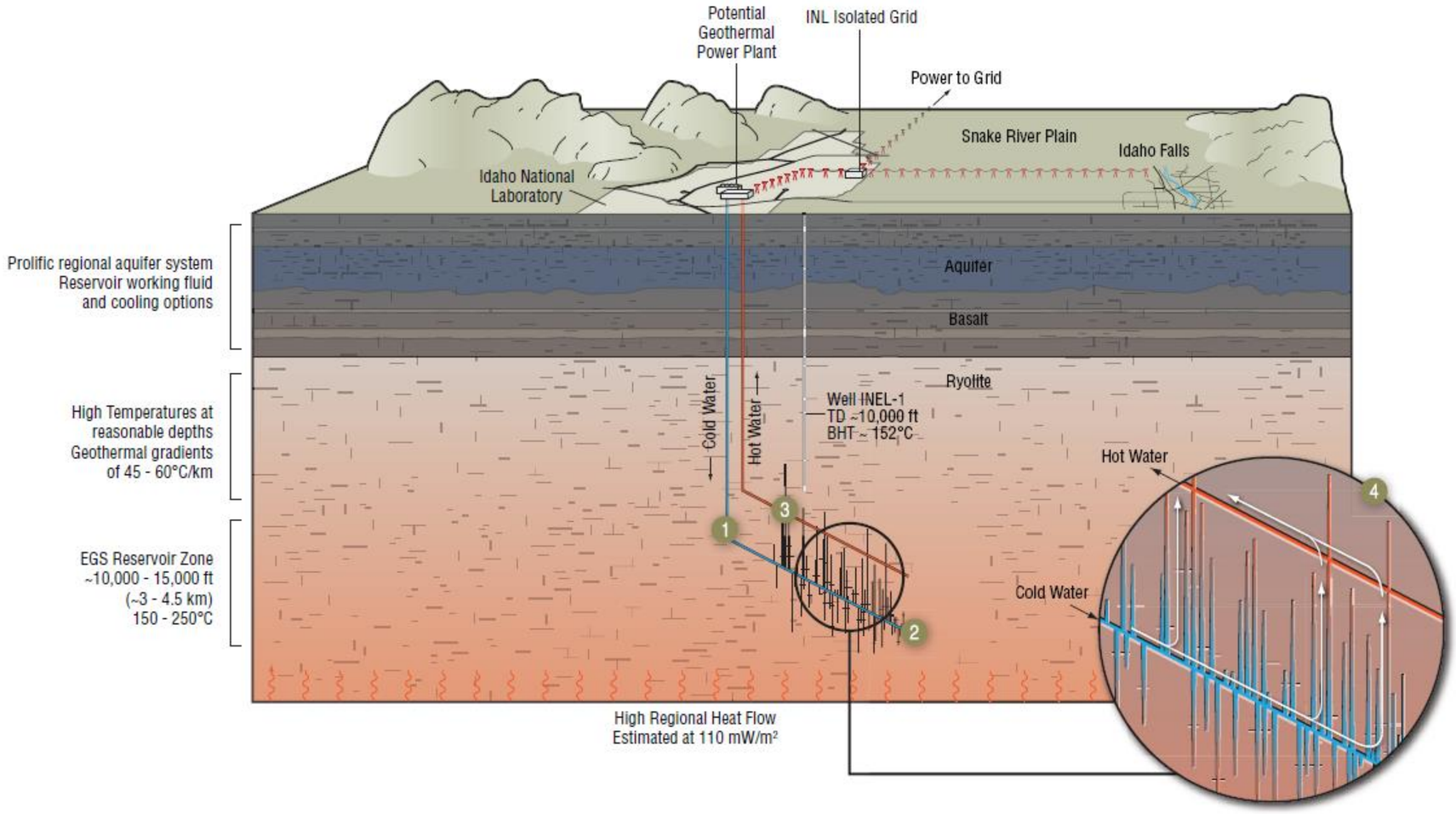


EGS Snake River Plain, Idaho

Lead: Idaho National Laboratory

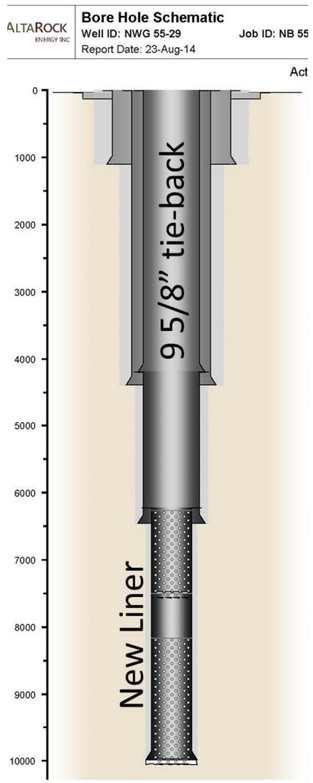


Snake River Geothermal Consortium:

National Renewable Energy Laboratory,
Lawrence Livermore National Laboratory,
Universities of Idaho, Oklahoma, and Wyoming,
Idaho State University,
Boise State University,
Energy & Geoscience Institute at the University of Utah,
Geothermal Resources Group Inc.,
Baker Hughes,
U.S. Geothermal Inc.,
Mink GeoHydro Inc.,
Campbell Scientific,
U.S. Geological Survey,
Idaho Geological Survey
Idaho Department of Water Resources.

EGS Newberry Volcano, Oregon

Lead: Pacific Northwest National Laboratories



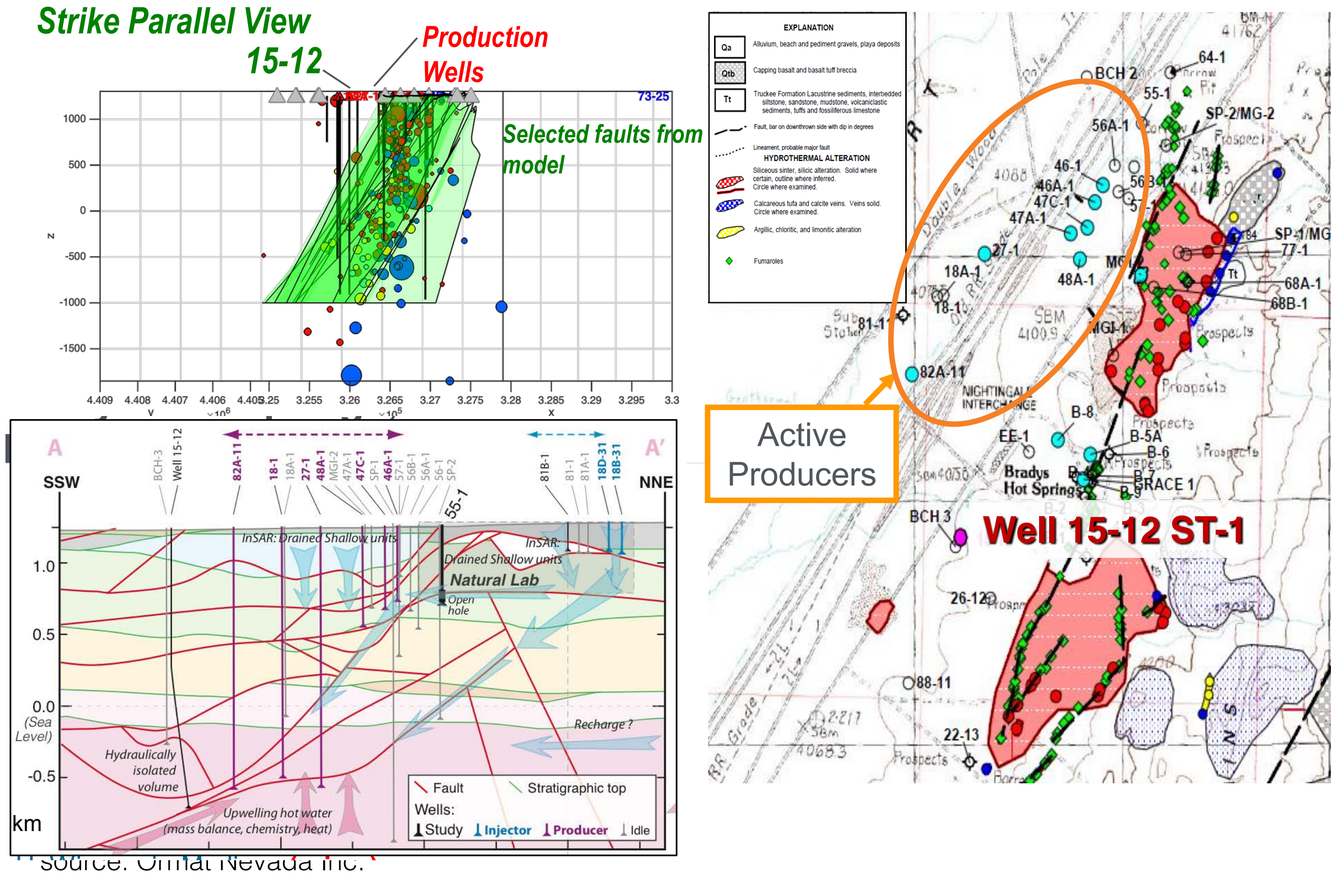
Key Partners:

Oregon State University
AltaRock Energy, Inc.

EGS Fallon, Nevada

Lead: Sandia National Laboratories

40 km SW of Brady Hots Springs



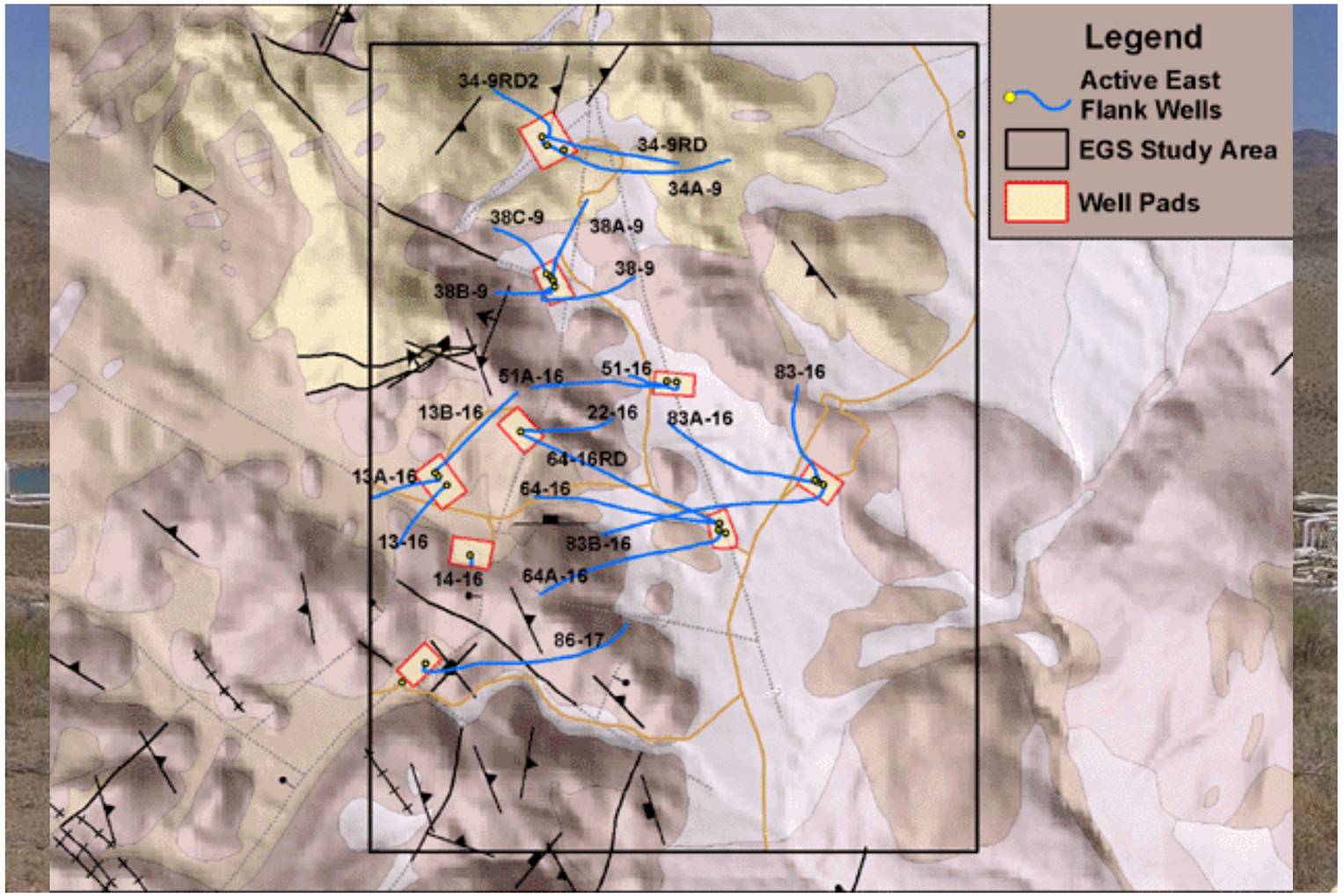
source: Ormat Nevada Inc.

Key Partners:

Lawrence Berkeley National Laboratory,
U.S. Geological Survey,
University of Nevada-Reno,
GeothermEx/Schlumberger,
U.S. Navy,
Ormat Technologies Inc.,
Itasca Consulting Group

EGS Coso, California

Lead: Sandia National Laboratories



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U.S. Navy,
Coso Operating Company LLC,
Itasca Consulting Group

EGS Milford, Utah

Thermo No. 1 at Milford: 10 MW Binary geothermal power plan

Key Partners:

Utah Geological Survey,
Murphy-Brown LLC,
Idaho National Laboratory,
Temple University,
Geothermal Resources Group Inc.,
U.S. Geological Survey

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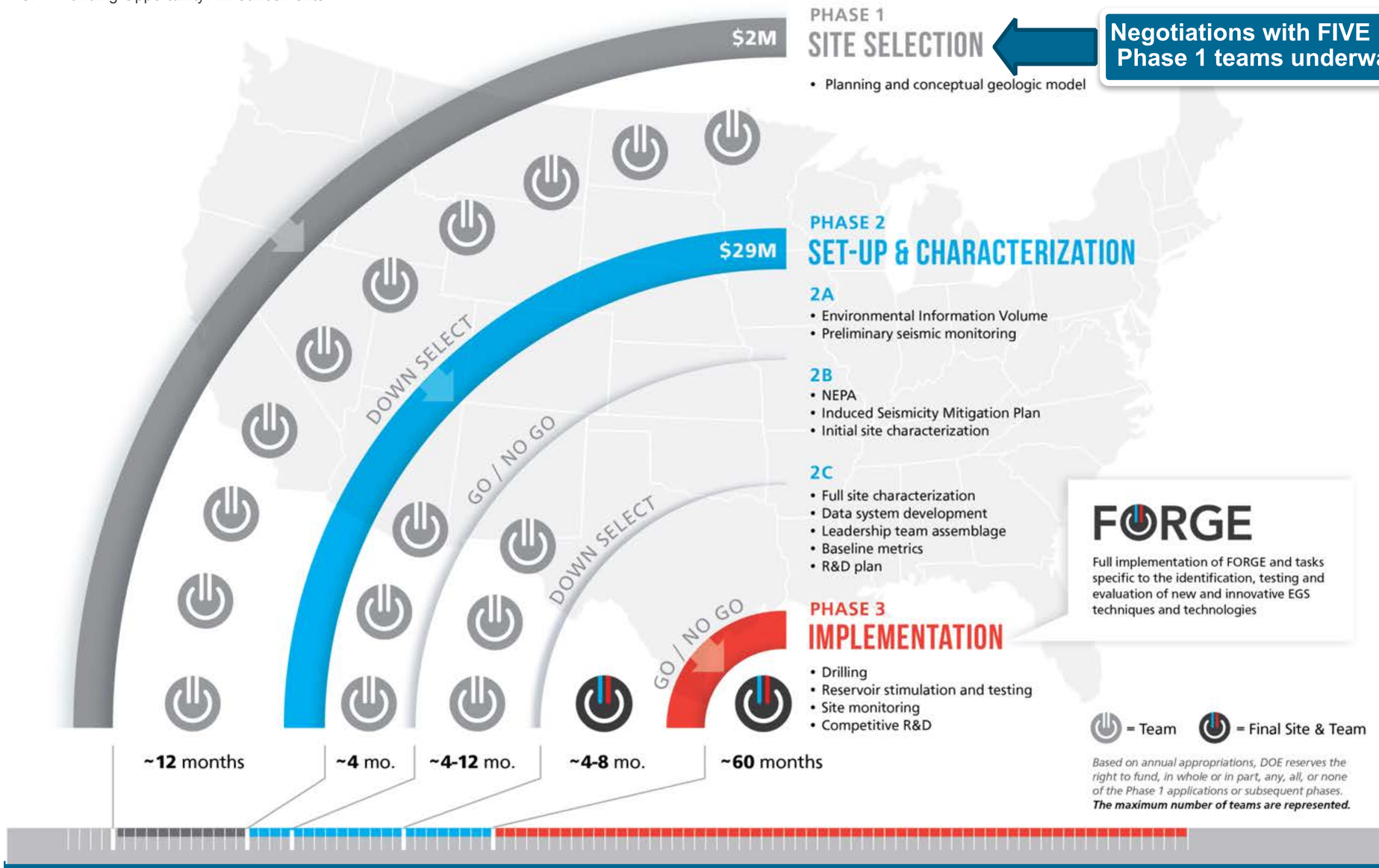

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EGS Technology Pathway Metrics

Measuring R&D Progress

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Topic	Metric	Technology Pathway	Metric	Description
Characterize	*Risk Reduction*	*Identify Natural Fractures and Flow Paths*	*Spatial resolution and ability to predict a priori reservoir performance*	*Develop precision geophysical methods, validated play books, and improved tools for subsurface.*
Create	*Reservoir Performance*	*Create New Fractures and Flow Paths*	*Fractured rock volume ability to predict a priori reservoir performance*	*Develop techniques to maximize heat extraction from a given volume of reservoir rock with a minimum of boreholes.*
Create/Operate	*Reservoir Performance*	*Monitor Flow Paths*	*Enthalpy and/or fractured rock volume*	*Develop ability to more accurately monitor and control flow paths in the reservoir.*
Create/Operate	*Reservoir Performance*	*Zonal Isolation*	*Enthalpy and/or fractured rock volume*	*Demonstrate the ability to isolate sections of the wellbore and reservoir.*
Operate	*Reservoir Performance*	*Manage Fractures and Flow Paths*	*Thermal drawdown and reservoir sustainability*	*Develop the ability to manage EGS reservoirs improving reservoir lifetime and productivity.*
All	*RR and RP*	*Drilling*	*ROP/Costs*	*Develop next generation rock reduction, drilling and well completion technologies.*
All	*RR and RP*	*Modeling*	*Ability to predict a priori and manage in real time reservoir performance*	*Develop robust, capable, and validated models of the subsurface.*
All	*RR and RP*	*Tools*	*T/P limits, sensitivity and durability*	*Develop tools that can withstand hostile EGS environments.*