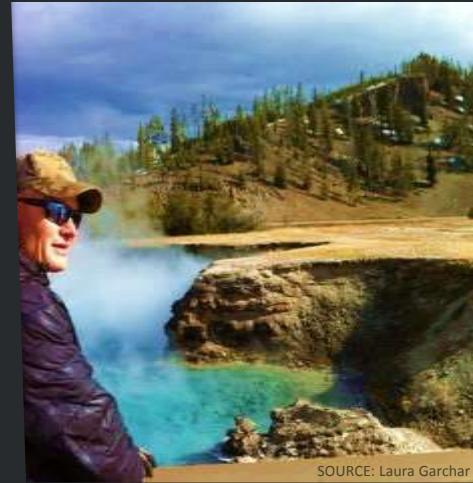


# Geothermal Technologies Office

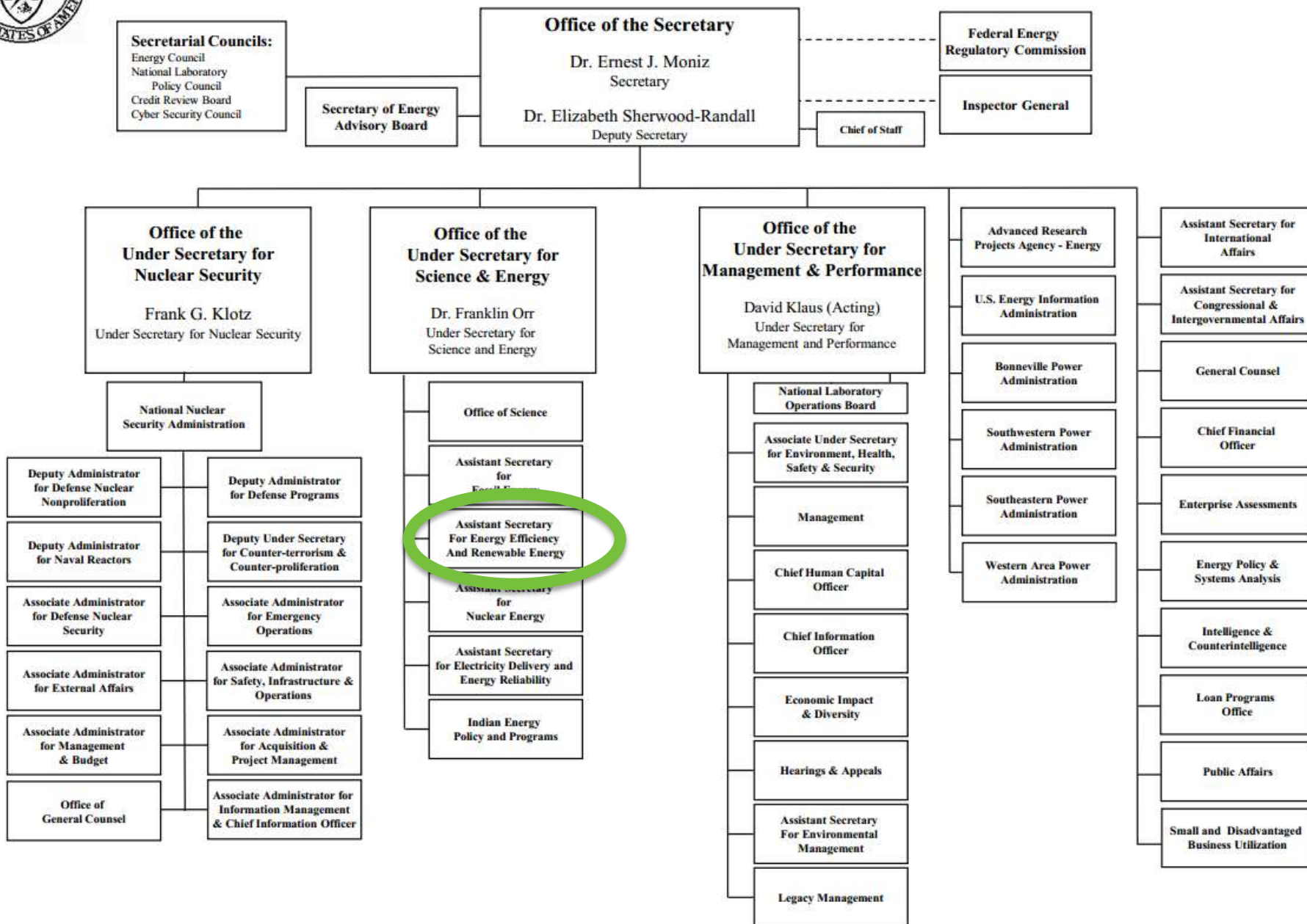
March 12, 2015



Laura Garchar, Fellow



# DEPARTMENT OF ENERGY





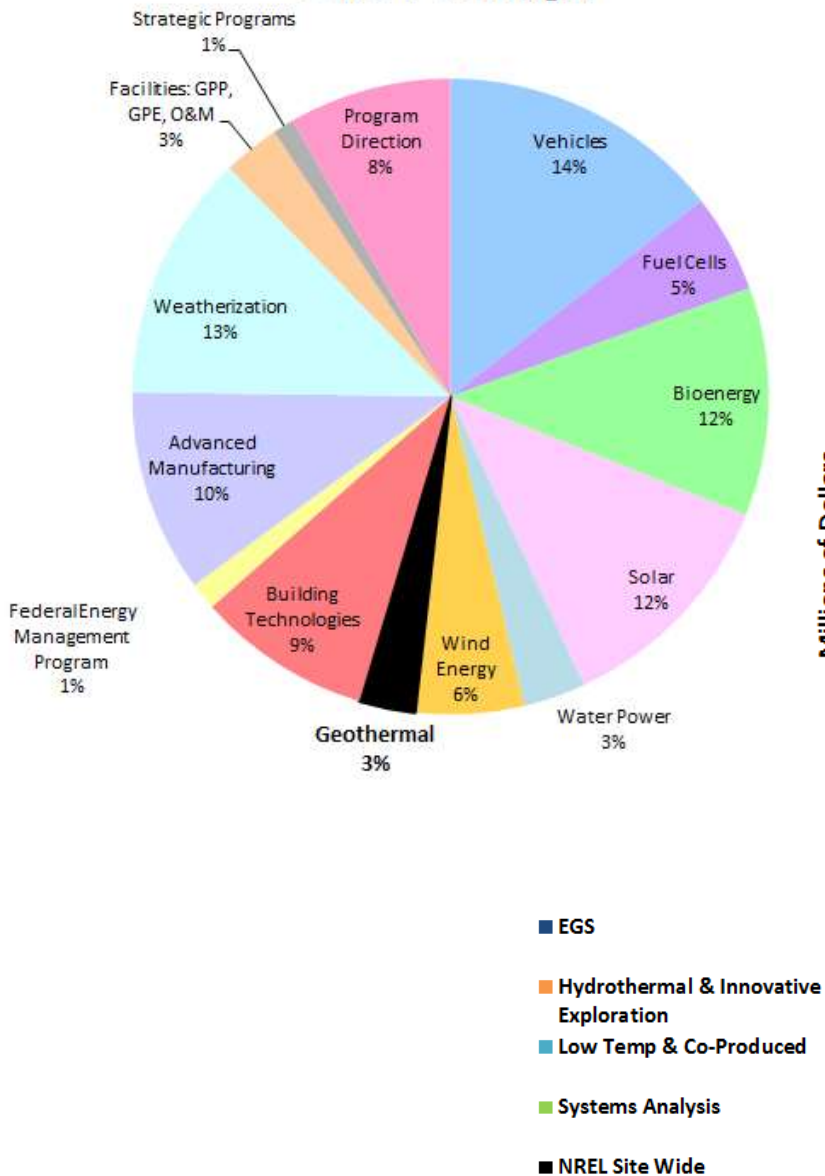
# Office Mission

To accelerate the development and deployment of clean, domestic geothermal power that will promote a stronger, more productive economy; support a cleaner environment; and improve energy security.

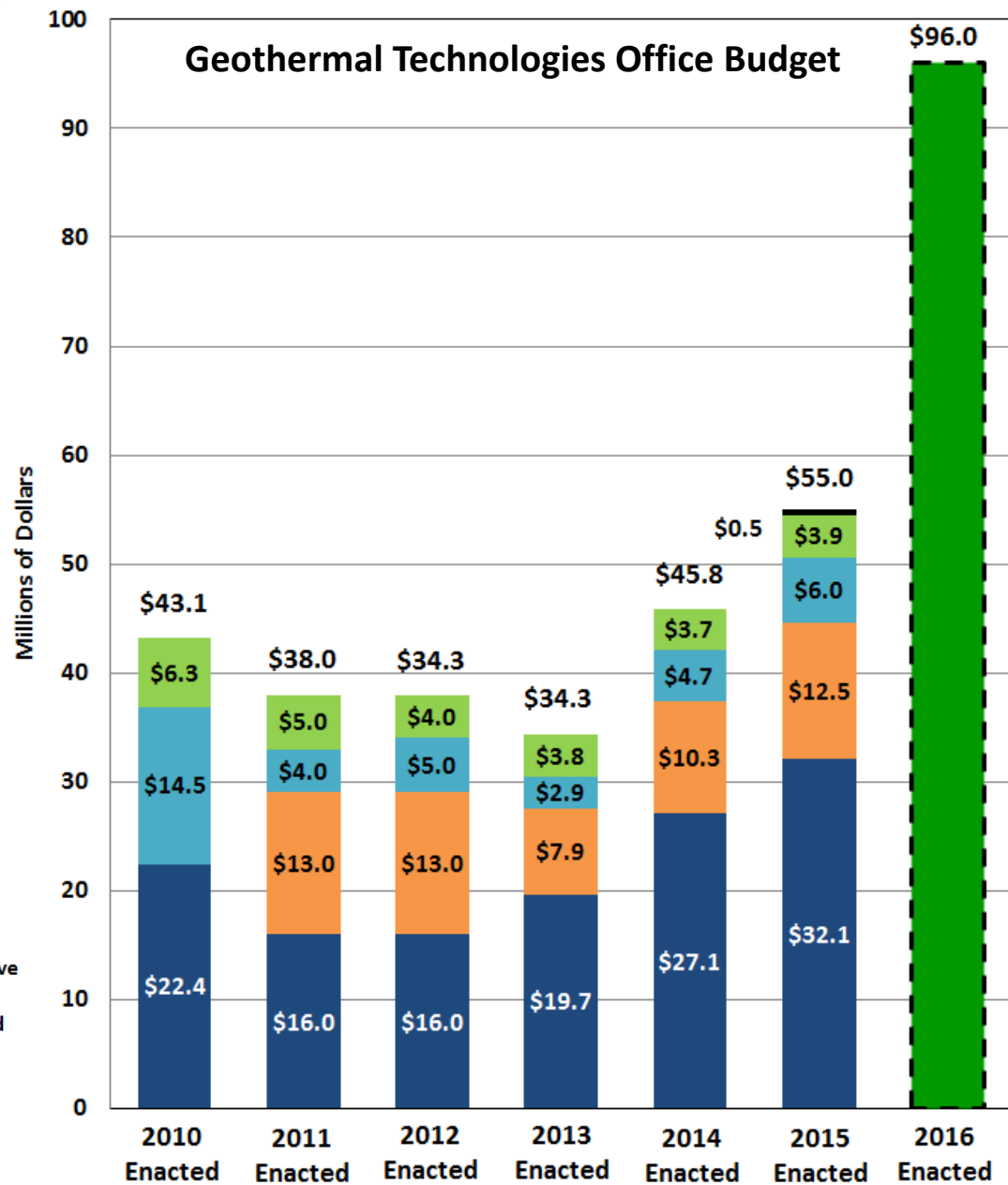


# DOE Budget

**EERE FY '15 Budget**



**Geothermal Technologies Office Budget**

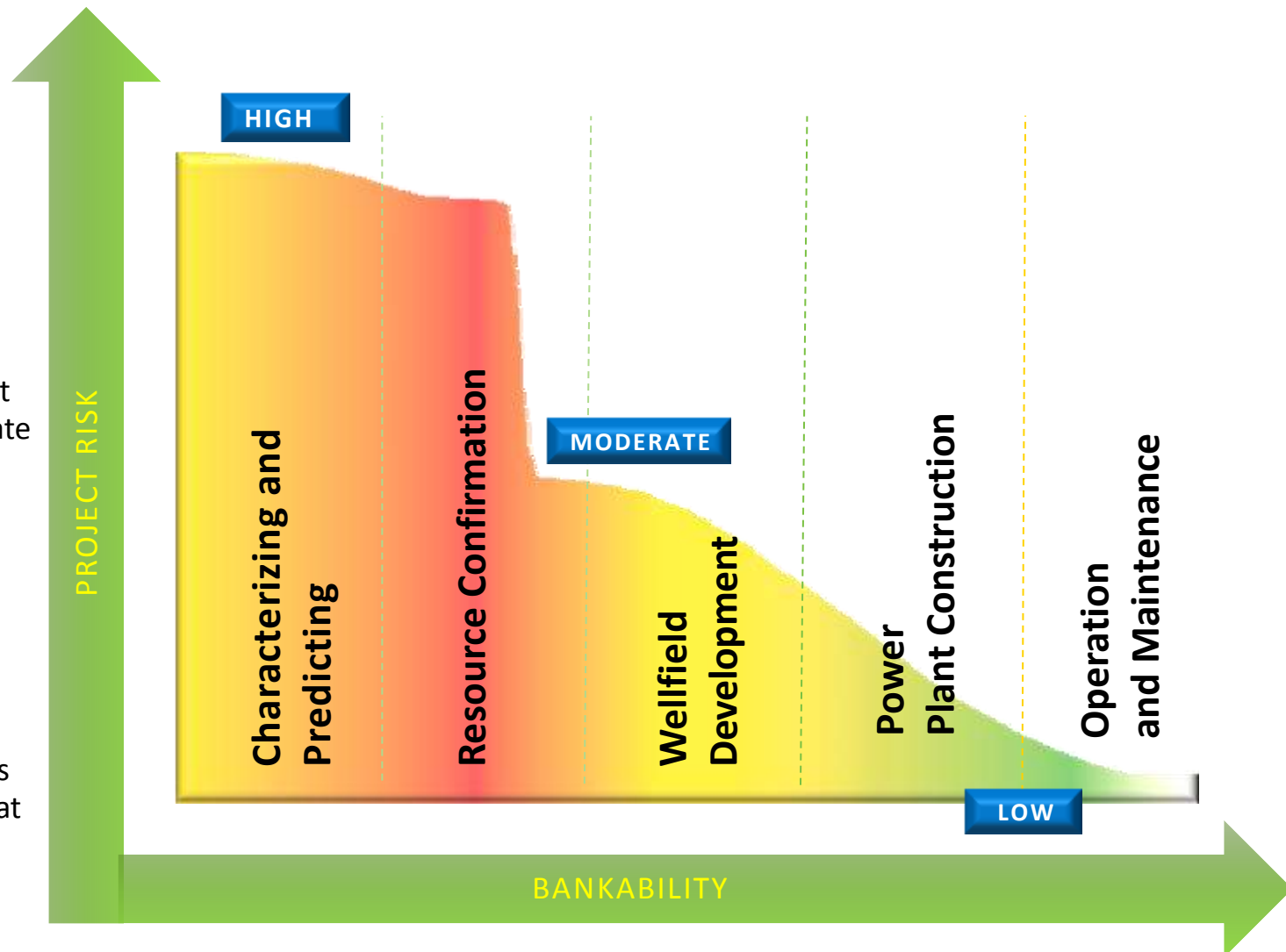


# Geothermal Lifecycle Costs and Risk: Stages to Deployment

## The Energy Department addresses geothermal challenges at every stage of development

with a full complement of projects to accelerate the adoption of geothermal energy:

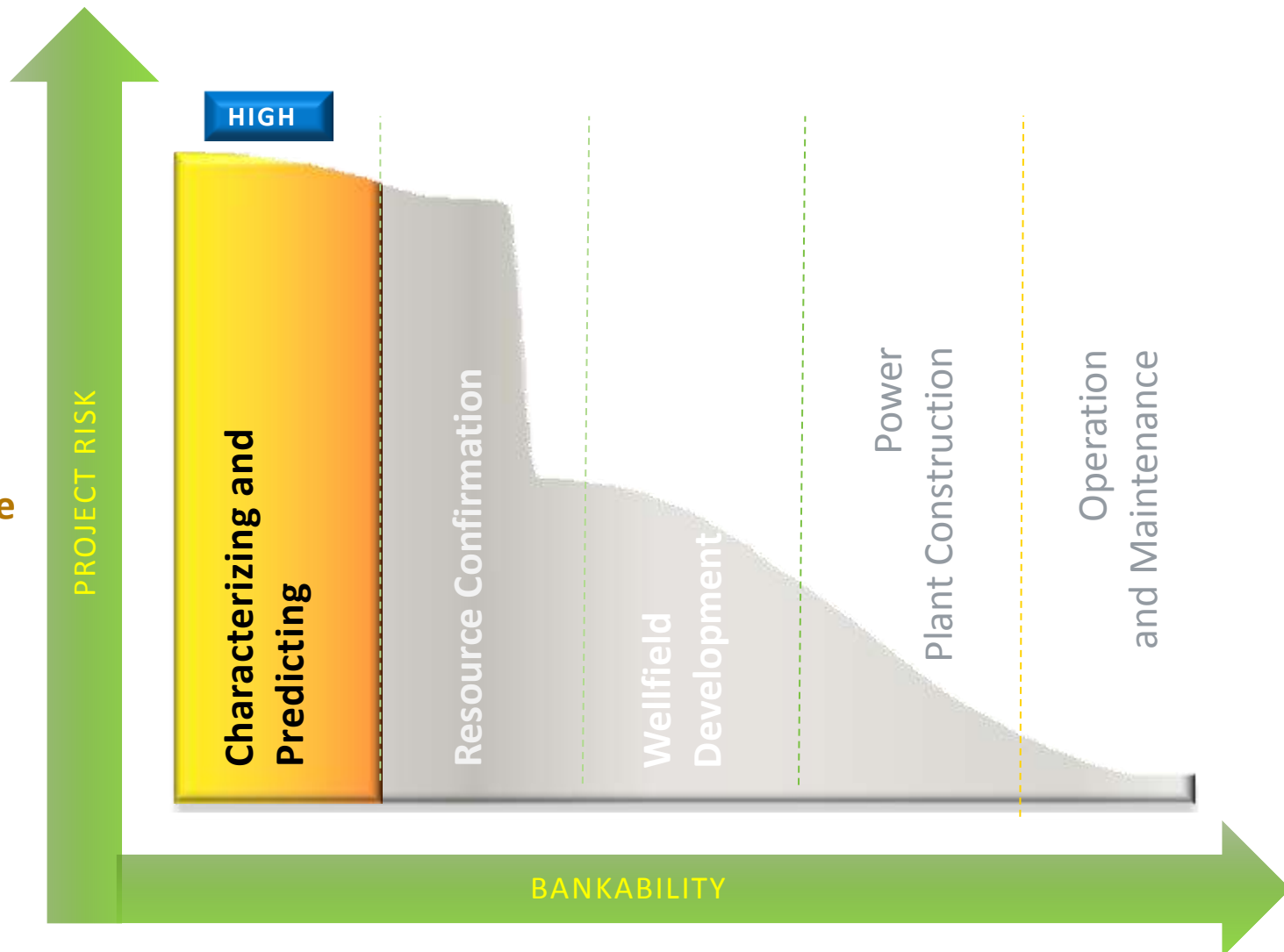
- Better targeted drilling
- Improved understanding of the subsurface
- Innovate new tools and techniques that improve the value equation
- Lower upfront costs



# Stage One: Characterize the Subsurface

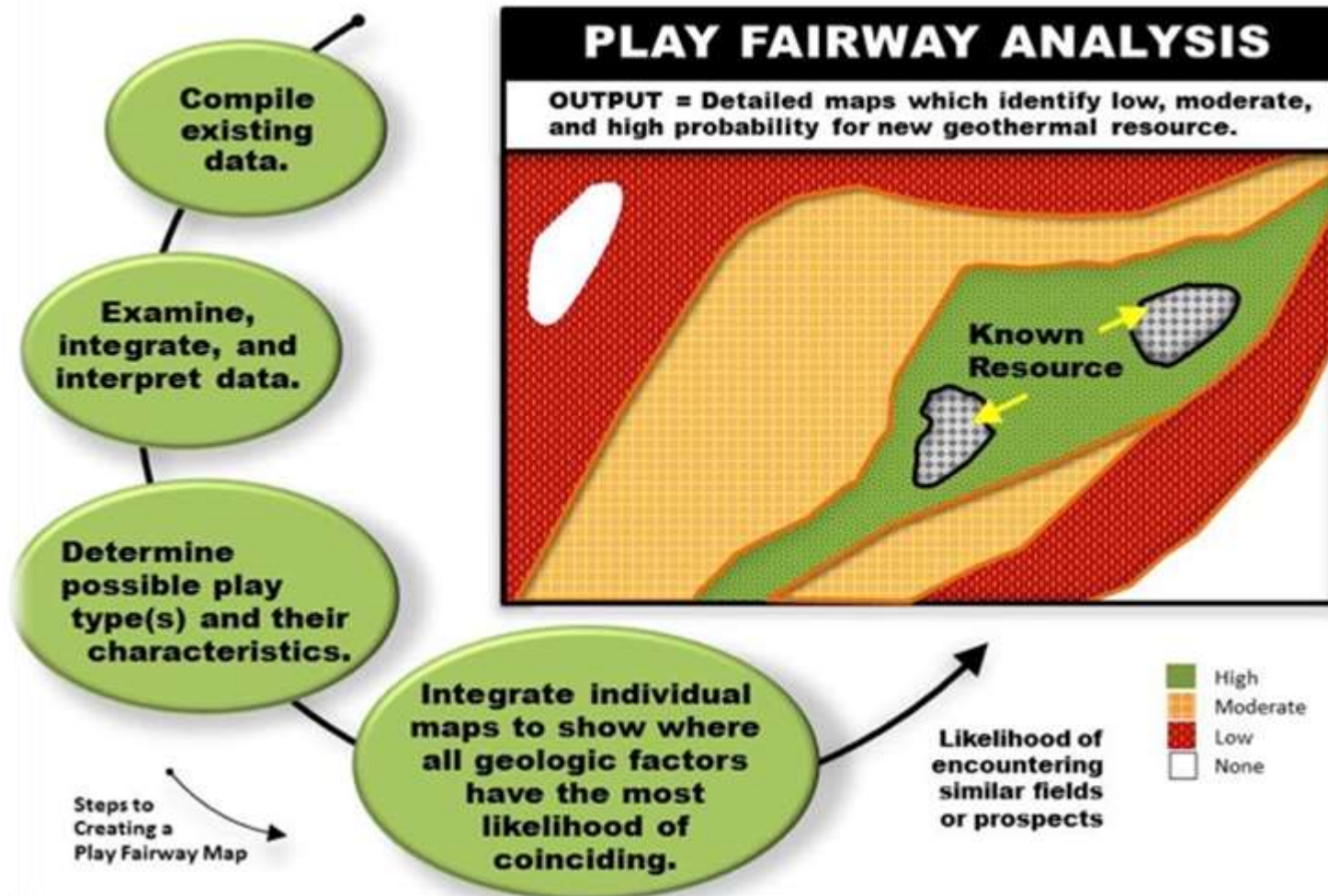
Mitigate the risks of geothermal exploration

- **National Geothermal Data System**
- **Play Fairway Analysis**
- **New Subsurface Signals**
- **Geochemical/Geo-physical Tools**
- **Exploration Decision Tree**





# Play Fairway Analysis (PFA)



# Play Fairway Analysis (PFA)

**Before disturbing the ground, PFA reduces uncertainty and grades levels of prospectivity**

- Focuses initially on unexplored and underexplored known geothermal regions
- Identifies locations that have the highest probability of success
- Phase II: new data collection & drilling

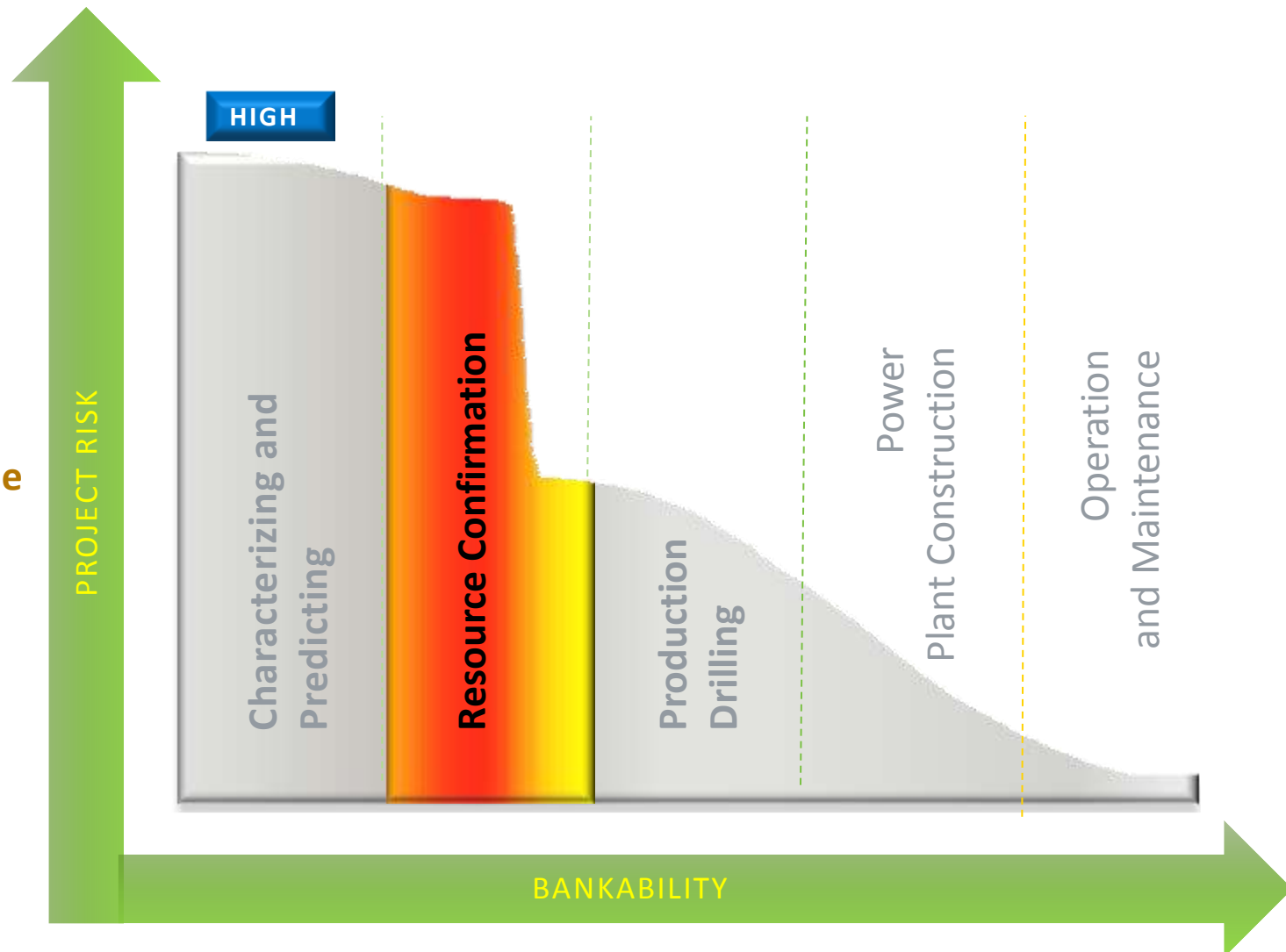




## Stage Two: Resource Confirmation

Validate and confirm the resource with:

- Innovative exploration drilling
- Micro-drilling
- Novel downhole tools
- Flow testing



# Innovative Exploration Drilling and Testing



## Validating prospective blind resources

- On-site active drilling projects
- Reduces risk through improvements in geothermal exploration
- USGS estimates 30 GW potential in blind hydrothermal systems in America
- Rigorous public-private collaboration
- Promotes economic viability of geothermal exploration technologies
- Identifies potential surface signals that can reveal deeper, hidden systems
- Play Fairway Validation Initiative - Phase II

# Innovative Exploration Drilling and Testing - Alaska

Courtesy of Mike Weathers



Courtesy of GRC



## Pilgrim Hot Springs:

To finish in March. 2MW PPA signed with the city of Nome.

## Akutan: Volcanic island in the Aleutian chain.

Recently passed phase 1 (field surveys), preparing to drill exploratory well in the summer.

\* Expected

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

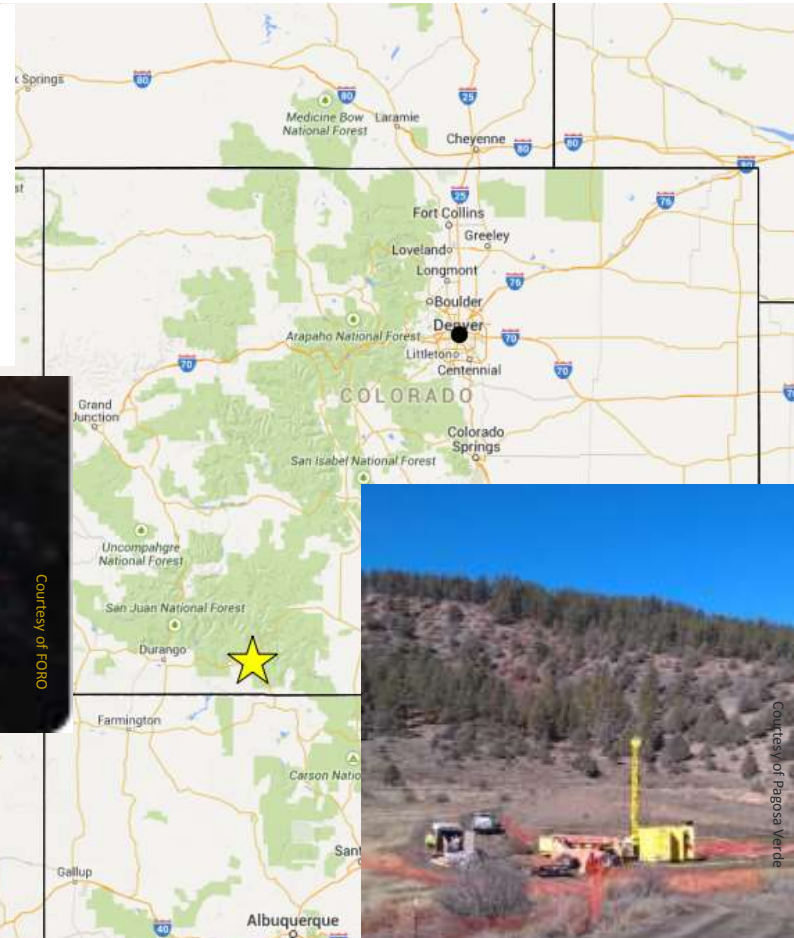
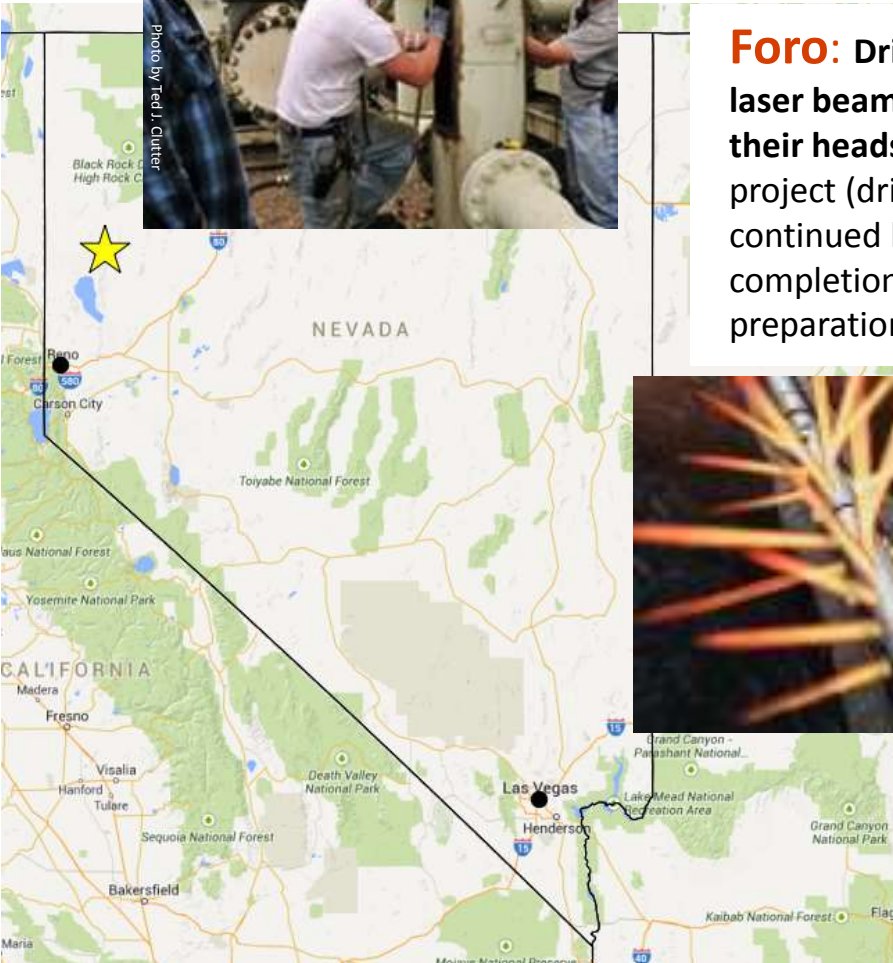


# Innovative Exploration Drilling and Testing



**US Geothermal:** using **seismic and radar** methods to image **large aperture fractures** to expand the San Emidio geothermal field.

**Foro:** Drill bits with **laser beams attached to their heads**. ARPA-E project (drilling) continued by GTO for completions. In preparation for field test.

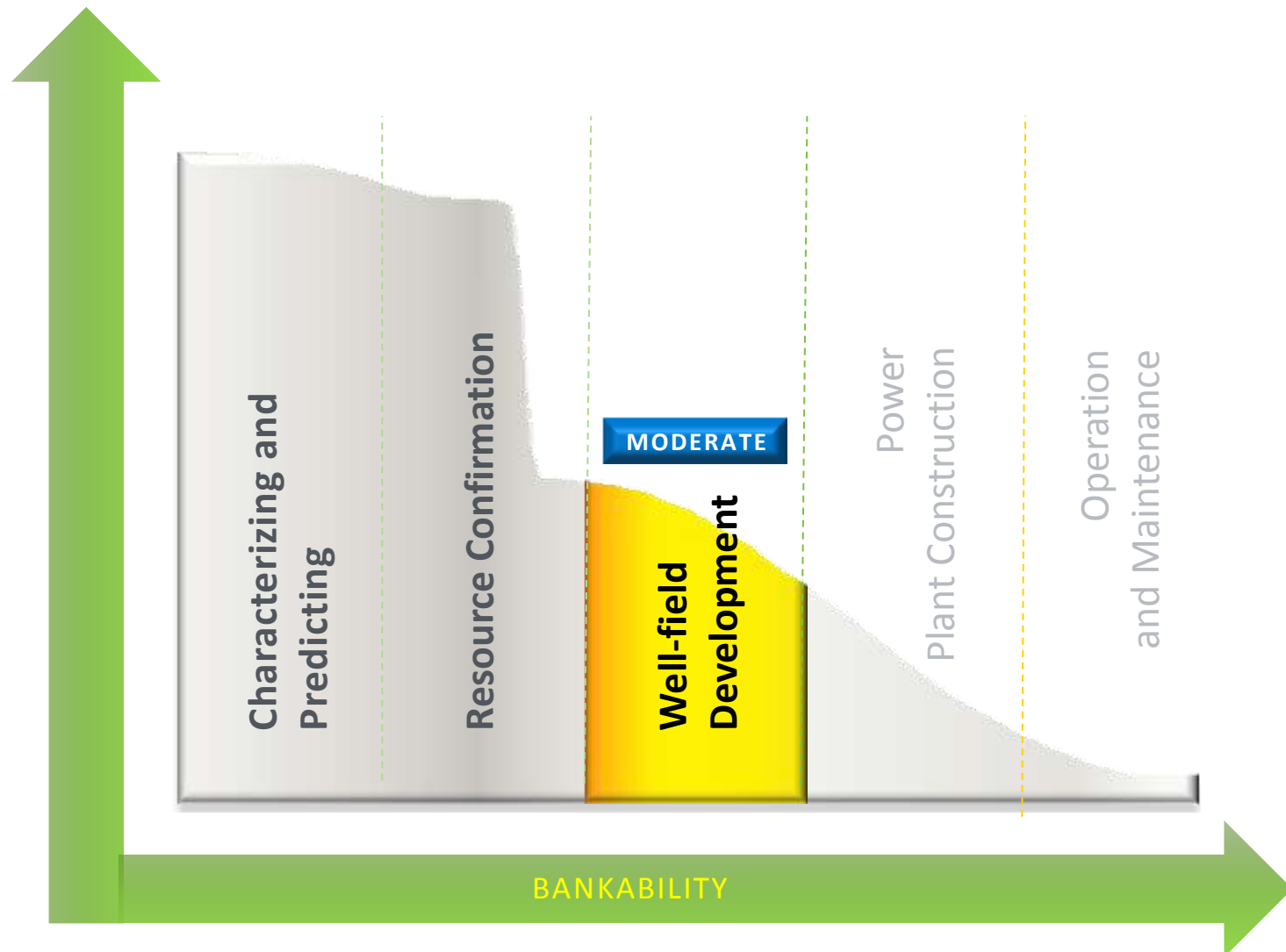


**Pagosa Verde:** GTO's \$3.9 million matched by \$1.98 million state bond, with a bill signed by Colorado Governor Hickenlooper in May 2014. Recently drilling.

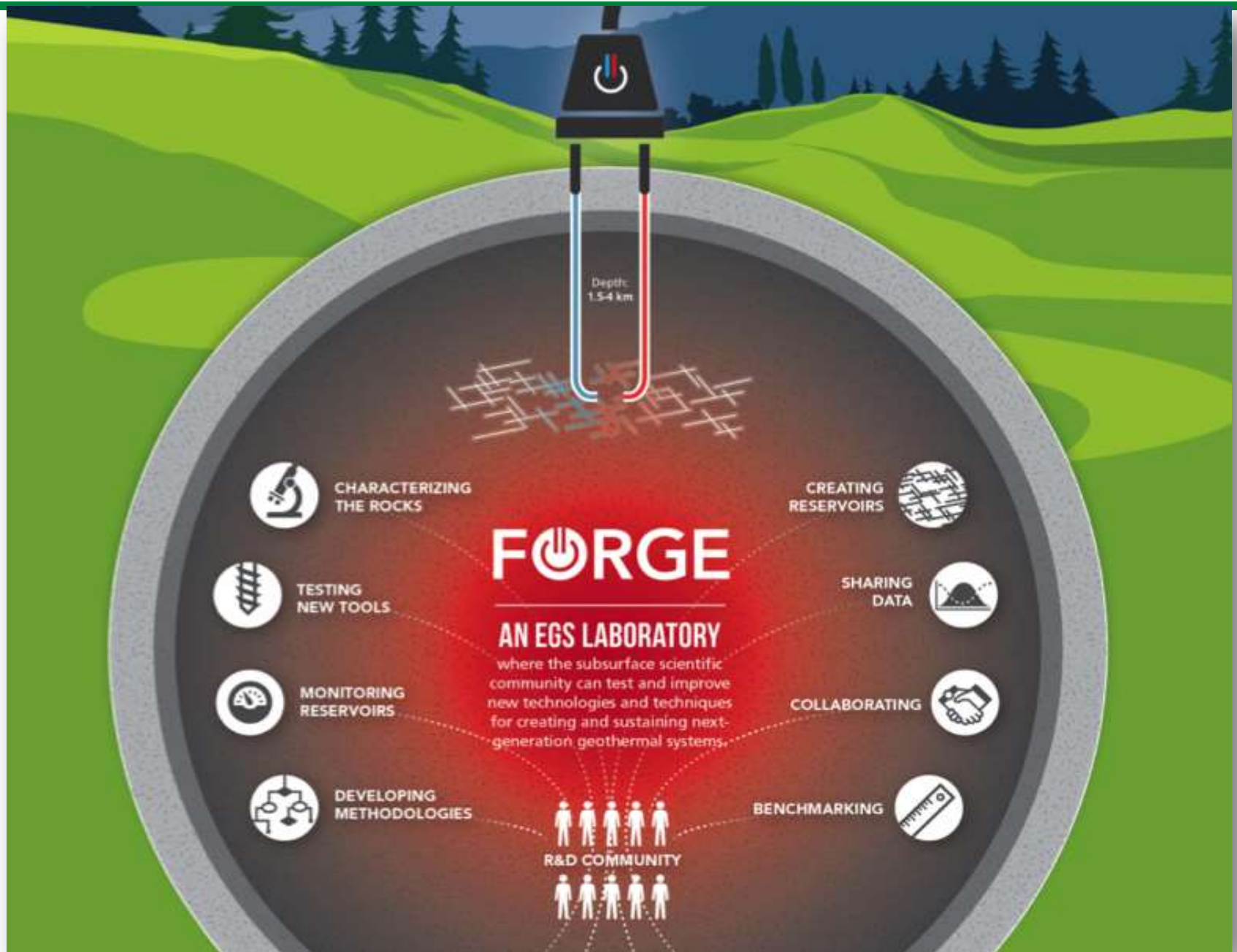
# Stage Three: Wellfield Development

## Reservoir engineering & optimization

- EGS R&D
- FORGE Laboratory
- EGS

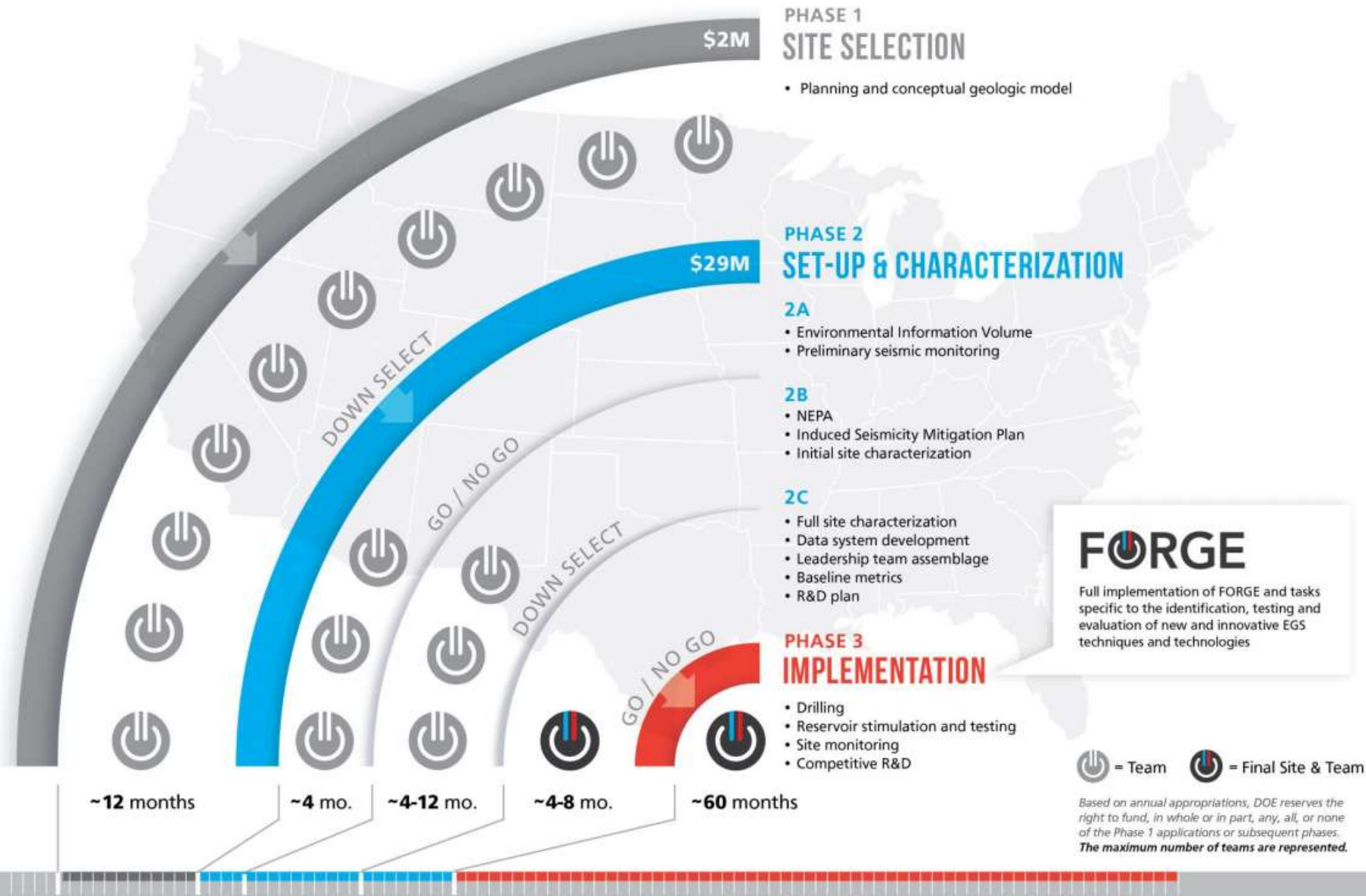


# FORGE Initiative





# FORGE Initiative

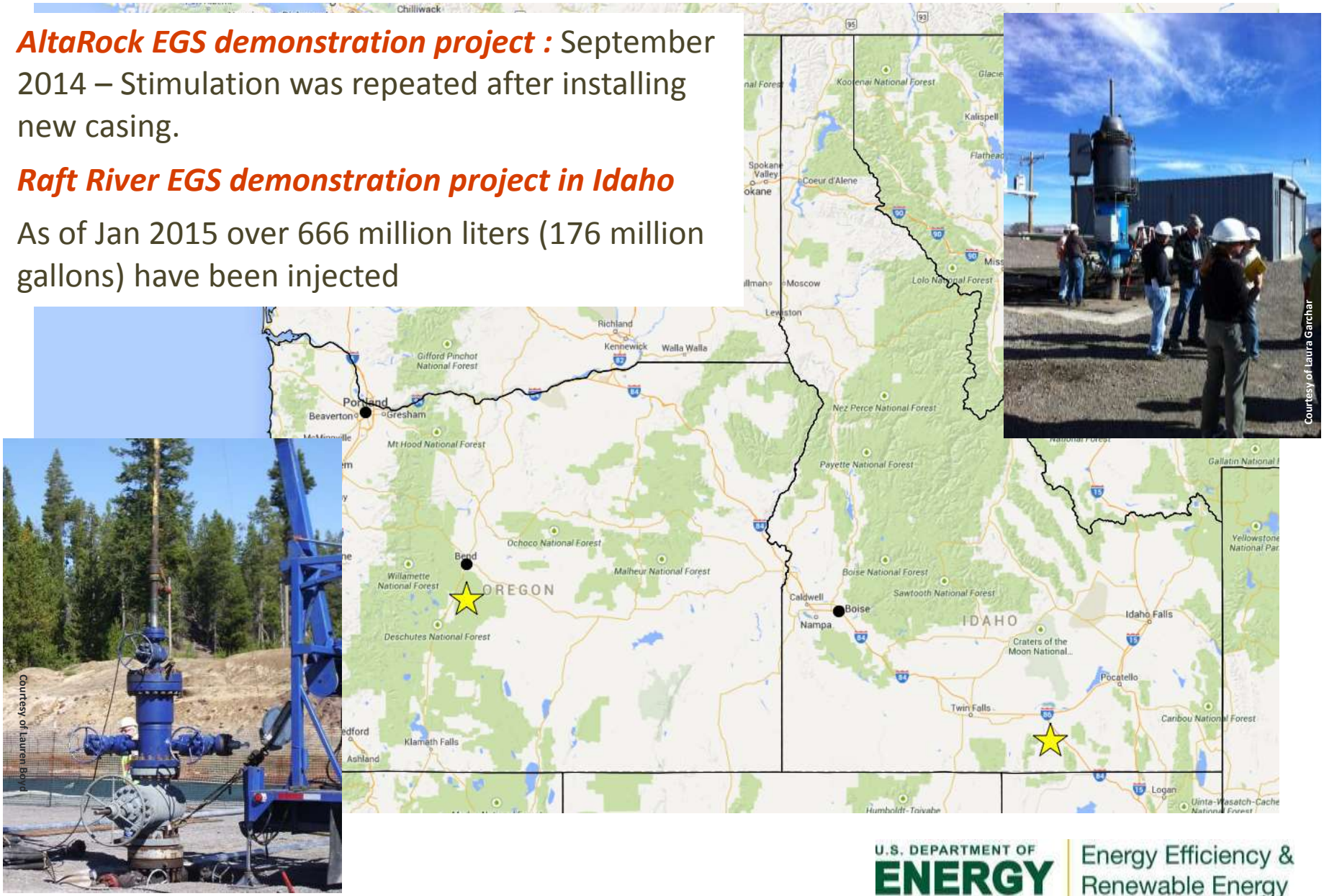


# EGS Demonstrations

**AltaRock EGS demonstration project** : September 2014 – Stimulation was repeated after installing new casing.

**Raft River EGS demonstration project in Idaho**

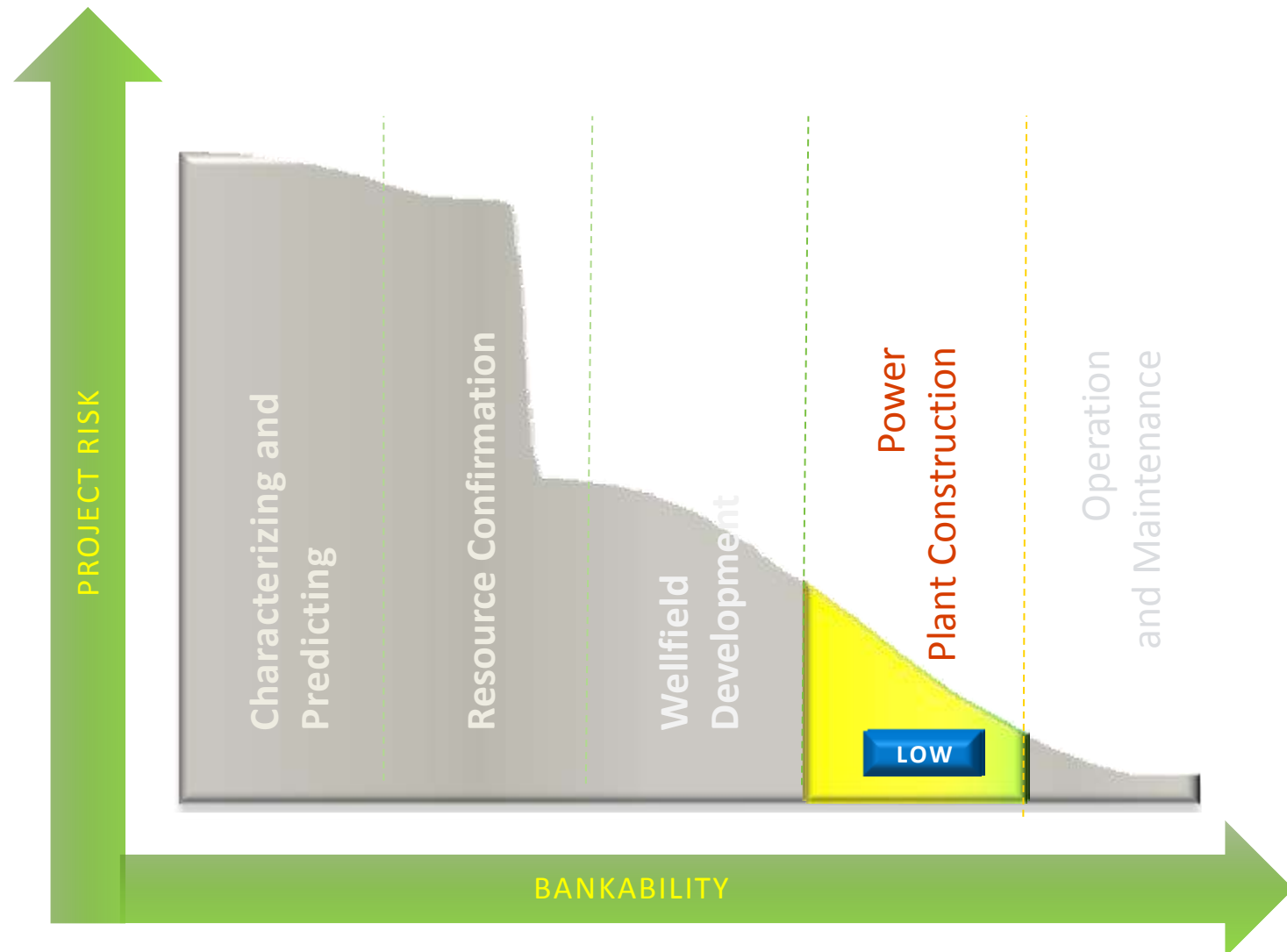
As of Jan 2015 over 666 million liters (176 million gallons) have been injected



# Stage Four: Power Plant Construction

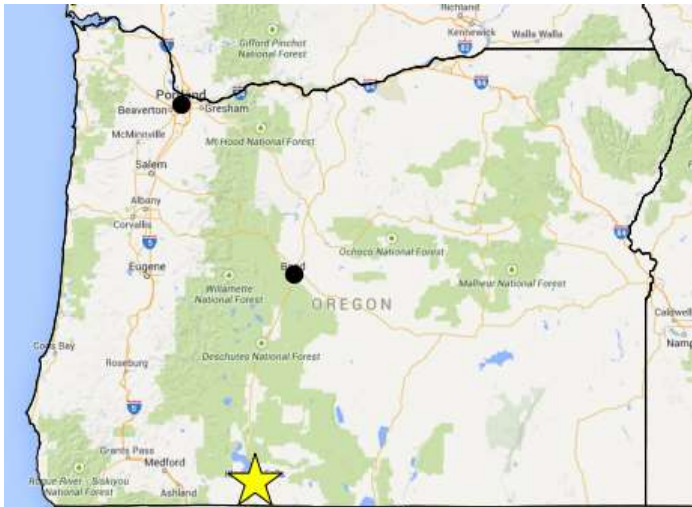
## Enhancing efficiencies

- Hybrid Power Systems
- Advanced heat transfer cycles
- Low-temperature applications
- Direct use & cascaded use

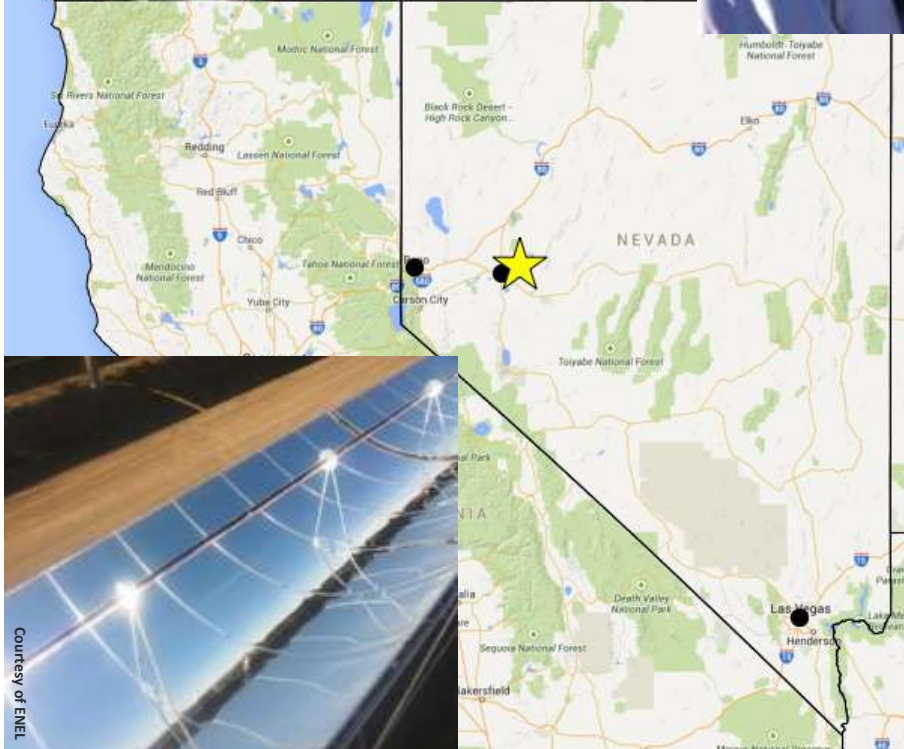




# Direct Use and Hybrid Systems



Thermal energy applied directly for heating/cooling, buildings, greenhouses, **aquaculture**, pools and spas at **Klamath Falls**. Resource 100 – 300°F.

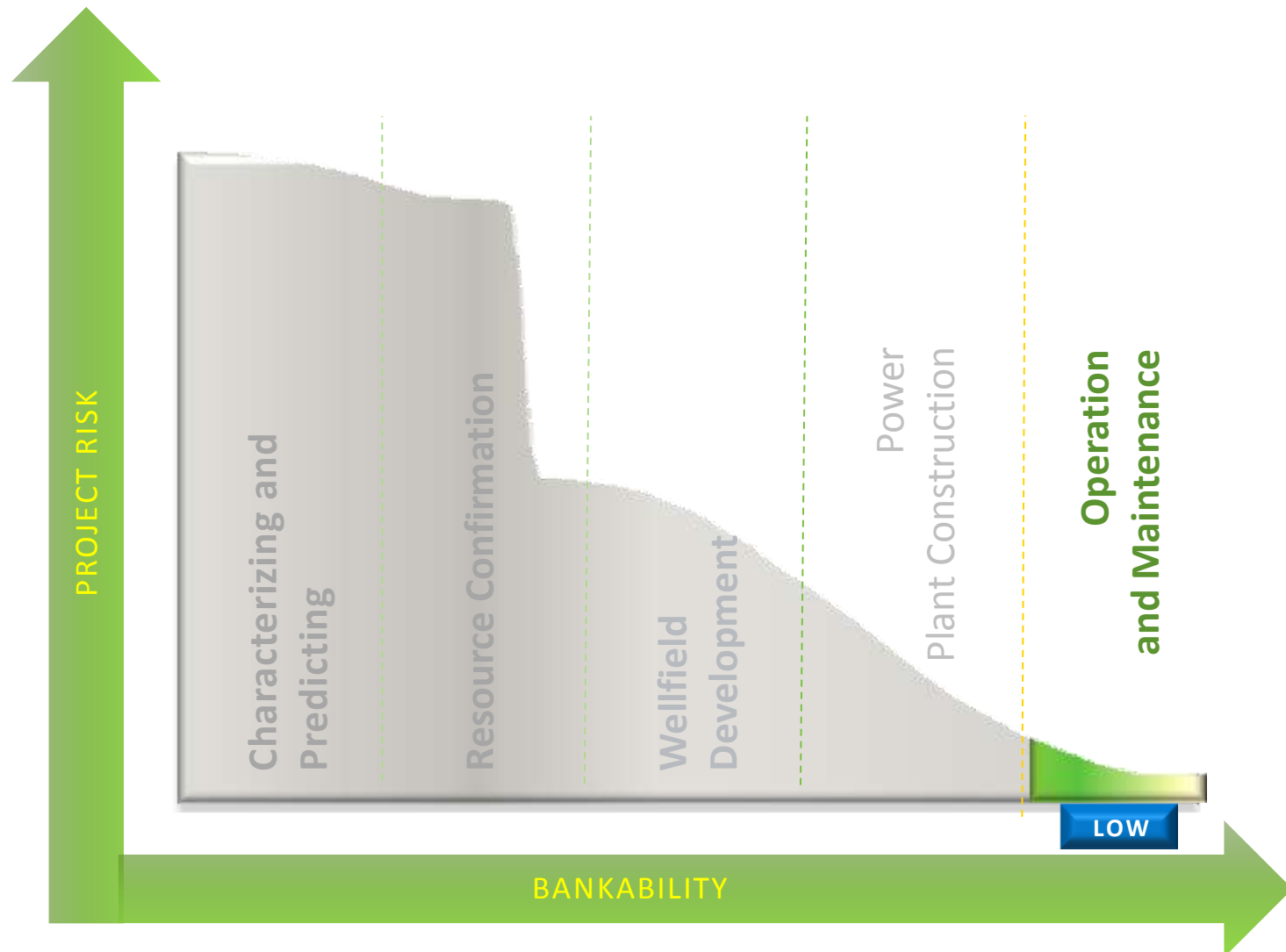


**Stillwater geothermal plant** (33 Mwe) will be integrated with a 17 MW **solar thermal facility** - the first hybrid plant in the world to combine the continuous generating capacity of binary-cycle, medium-enthalpy geothermal power with solar thermal technology.

# Stage Five: Operation & Maintenance and Additive Value

Increasing value propositions to make geothermal more economical

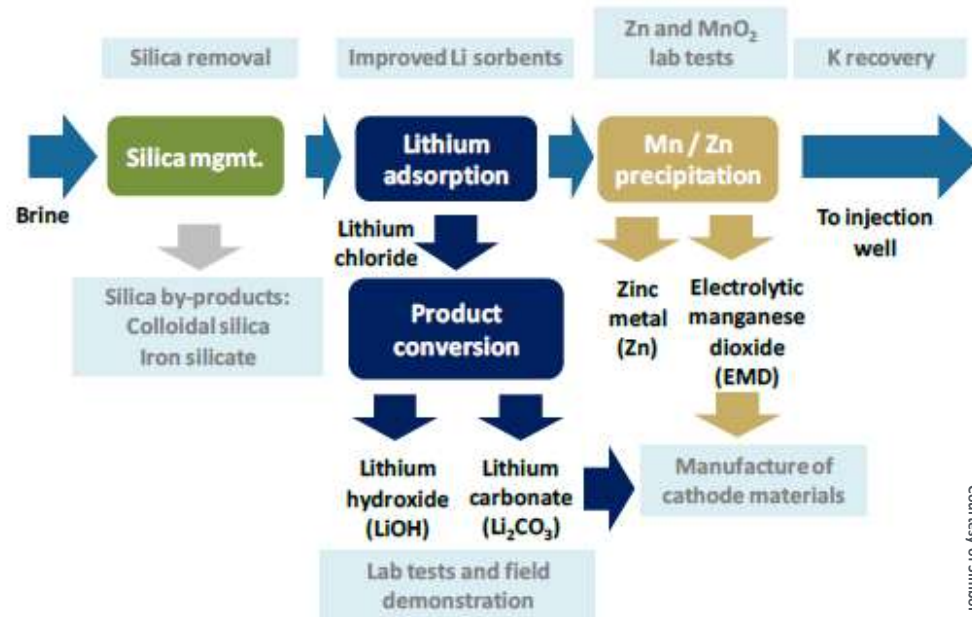
- Mineral recovery
- Innovative O&M Tools, Sensors, Methodology



# Strategic Materials

## Increasing the value stream of geothermal energy production

- Feasibility studies that include fully developed business plans laying out the **technical** feasibility and **economic** viability of mineral extraction technology(s) combined with geothermal power production at a new or existing geothermal resource.
- Assessments of the current rare earth and near-critical metal resource base, with potential extraction volumes/rates including coupled techno-economic analysis.
- Geochemical modeling and leaching experiments to optimize the composition of down-hole fluids and identify additives that selectively leach high value strategic elements.



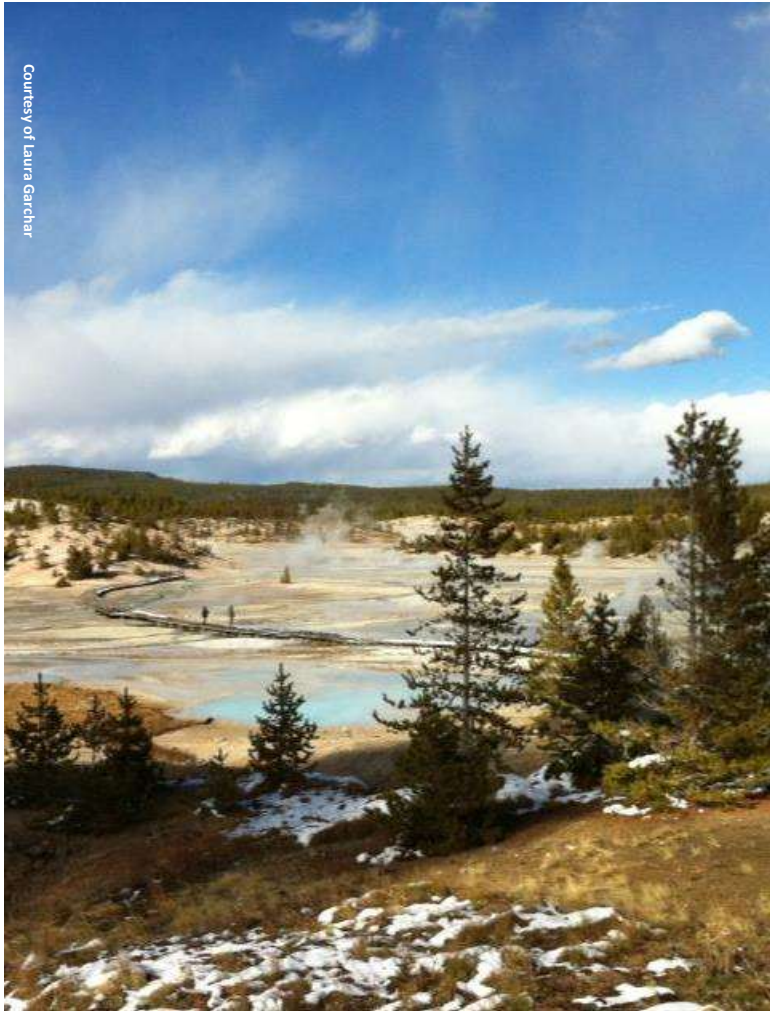
Courtesy of Simbol

Courtesy of Simbol



# GTO Vision Study

By 2016, DOE seeks to develop credible analysis jointly with GEA/GRC:



- I. Articulate clear **GTO investment strategies** across different sectors and a cohesive plan to attain the goals
- II. Discuss **geothermal growth scenarios** for 2020, 2030 and 2050 backed by robust data, modeling and analysis
- III. **Address all market segments** existing and potential hydrothermal, electrical and non-electrical usages, new EGS sector, and other value streams
- IV. Analysis will be supported by *objective and peer-reviewed industry data* and *available to decision-makers*
- V. Vision is **aspirational** and **inspirational**

## Adaptive Control of Subsurface Fractures and Fluid Flow

Intelligent Wellbore  
Systems

Subsurface Stress &  
Induced Seismicity

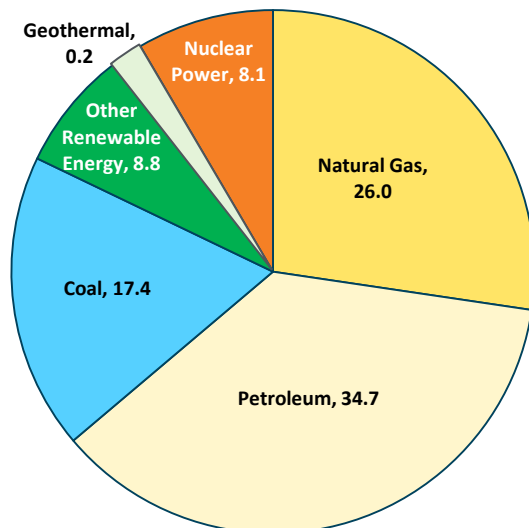
Permeability  
Manipulation

New Subsurface  
Signals

### Energy Field Observatories

Fit For Purpose Simulation Capabilities

Personnel Needs



**Primary Energy Use by Source, 2012**  
Quadrillion Btu [Total U.S. = 95.1 Quadrillion Btu]

### ENERGY PRODUCTION

- Increase U. S. electrical production from geothermal reservoirs
- Increase U.S. unconventional oil and natural gas for industrial and power applications and export
- Enhanced secure domestic supply

### ECONOMIC & SOCIAL BENEFITS

- Retain U. S. leadership
- Increased public confidence
- Increase revenues (taxes and royalty) to Federal, State, and local governments

### PROTECT THE ENVIRONMENT

- President's Climate Action Plan: Safely store CO<sub>2</sub> to meet GHG emissions reduction targets
- Safe storage/disposal of nuclear waste
- Reduced risk of induced seismicity
- Protect drinking water resources
- Alternatives for energy storage

### ENERGY SECURITY

- Hard target defeat
- NNSA core missions



## **New Prospecting Opportunities**

Play Fairway Analysis GO/NO GO decision  
Announcing play fairway drilling validation opportunity

## **Advancing Innovative Geothermal Tools & Techniques**

Build upon R&D and demonstration project successes  
Initiate Phase I, Frontier Observatory for Research in Geothermal Energy (FORGE)

## **Geothermal Vision Study**

Geothermal continuum  
Value proposition and its Impact on the President's Climate Action Plan

## **Additive Value**

Low-Temperature Mineral Recovery  
Hybrid systems

## **Subsurface Engineering Crosscut (SubTER)**

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



# Imperial Valley Potential

## GTO seeks to understand and grow the region's geothermal power generation



Courtesy of GRC

- GTO perceives a high level of interest in the Imperial Valley area by the US and international geothermal community. GTO would like to have adequate understanding to assist in framing tasks and needed R&D to grow the region in geothermal
- This volume of knowledge may then be used by the DOE as a resource to identify data gaps and potential future roles for DOE GTO involvement in the region as well as to develop National Lab projects or future FOA topics
- DOE is looking to team with ongoing NREL efforts, the geothermal industry, and other state and federal agencies in this effort

1976-2014

The Geothermal Technologies Program annual budget peaked in the late 1970s, helping to drive an increase in installed capacity that lasted about ten years.

