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.
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

**Geothermal Lifecycle Costs and Risk: Stages to Deployment**
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)

1. Compile existing data.
2. Examine, integrate, and interpret data.
3. Determine possible play type(s) and their characteristics.
4. Integrate individual maps to show where all geologic factors have the most likelihood of coinciding.

OUTPUT = Detailed maps which identify low, moderate, and high probability for new geothermal resource.
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
**Akutan:** Volcanic island in the Aleutian chain. Recently passed phase 1 (field surveys), preparing to drill exploratory well in the summer.

**Pilgrim Hot Springs:** To finish in March. 2MW PPA signed with the city of Nome.
**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

Characterizing and Predicting

Resource Confirmation

Well-field Development

BANKABILITY

Power

Plant Construction

Operation and Maintenance

U.S. Department of Energy
Energy Efficiency & Renewable Energy
FORGE Initiative

An EGS Laboratory

where the subsurface scientific community can test and improve new technologies and techniques for creating and sustaining next-generation geothermal systems.

- Characterizing the Rocks
- Testing New Tools
- Monitoring Reservoirs
- Developing Methodologies
- Creating Reservoirs
- Sharing Data
- Collaborating
- Benchmarking
- R&D Community
FORGE Initiative

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

~12 months
~4 mo.
~4-12 mo.
~4-8 mo.
~60 months

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

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.
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
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.
Increasing value propositions to make geothermal more economical

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

Stage Five: Operation & Maintenance and Additive Value
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.
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**
**SubTER Crosscut**

**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**

**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 CO₂ 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

---

**Primary Energy Use by Source, 2012**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Quadrillion Btu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>26.0</td>
</tr>
<tr>
<td>Petroleum</td>
<td>34.7</td>
</tr>
<tr>
<td>Coal</td>
<td>17.4</td>
</tr>
<tr>
<td>Other Renewable Energy</td>
<td>8.8</td>
</tr>
<tr>
<td>Nuclear Power</td>
<td>8.1</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*Total U.S. = 95.1 Quadrillion Btu*
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
GTO seeks to understand and grow the region’s geothermal power generation

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

**Annual Budget for the Geothermal Technologies Office and Installed Capacity 1976 - 2014**

- **1978:** The *Public Utility Regulatory Policies Act* forces utilities to buy renewable sources at a higher price and drives geothermal development until 1990.
- **1990:** After a spike in the mid-1980s, natural gas prices are low.
- **1997:** With the help of the DOE, a wastewater injection program begins at the Geysers, restoring production and prolonging the life of the field.
- **2000:** Growth attributed to GRED program.
- **2008:** Economic crisis slows development across all sectors and is addressed with the Recovery Act.

**Summary Points:**
- **1976:** Peak in annual budget.
- **1978:** PURPA.
- **1979:** Drop in budget.
- **1980:** Recovery in budget.
- **1981:** Drop in budget.
- **1982:** Recovery in budget.
- **1983:** Drop in budget.
- **1984:** Rise in budget.
- **1985:** Drop in budget.
- **1986:** Rise in budget.
- **1987:** Drop in budget.
- **1988:** Rise in budget.
- **1989:** Drop in budget.
- **1990:** Rise in budget.
- **1991:** Drop in budget.
- **1992:** Rise in budget.
- **1993:** Drop in budget.
- **1994:** Rise in budget.
- **1995:** Drop in budget.
- **1996:** Rise in budget.
- **1997:** Drop in budget.
- **1998:** Rise in budget.
- **1999:** Drop in budget.
- **2000:** Rise in budget.
- **2001:** Drop in budget.
- **2002:** Rise in budget.
- **2003:** Drop in budget.
- **2004:** Rise in budget.
- **2005:** Drop in budget.
- **2006:** Rise in budget.
- **2007:** Drop in budget.
- **2008:** Rise in budget.
- **2009:** Drop in budget.
- **2010:** Rise in budget.
- **2011:** Drop in budget.
- **2012:** Rise in budget.
- **2013:** Drop in budget.
- **2014:** Rise in budget.