



Artesy Ben Phillips

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Systems Analysis and Low-Temperature and Coproduced
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Motivation/Focus

The Geothermal Technologies Program accelerates the deployment of domestic energy generation from geothermal resources by investing in transformative research, development, analysis and demonstration-scale projects that will catalyze commercial adoption. Successful efforts will promote a stronger, more productive economy; provide valuable, stable, and secure renewable energy to power the U.S.; and support a cleaner environment.

(Dollars in Thousands)	FY 2015 Enacted	FY 2016 Enacted	FY 2017 Request	FY 2017 vs. FY 2016
Enhanced Geothermal Systems	32,100	45,000	45,000	0
Hydrothermal	12,500	13,800	40,500	+26,700
Low Temperature and Coproduced Resources	6,000	8,000	10,000	+2,000
Systems Analysis	3,900	3,700	4,000	+300
NREL Site-Wide Facility Support	500	500	0	-500
Total, Geothermal Technologies	55,000	71,000	99,500	+28,500

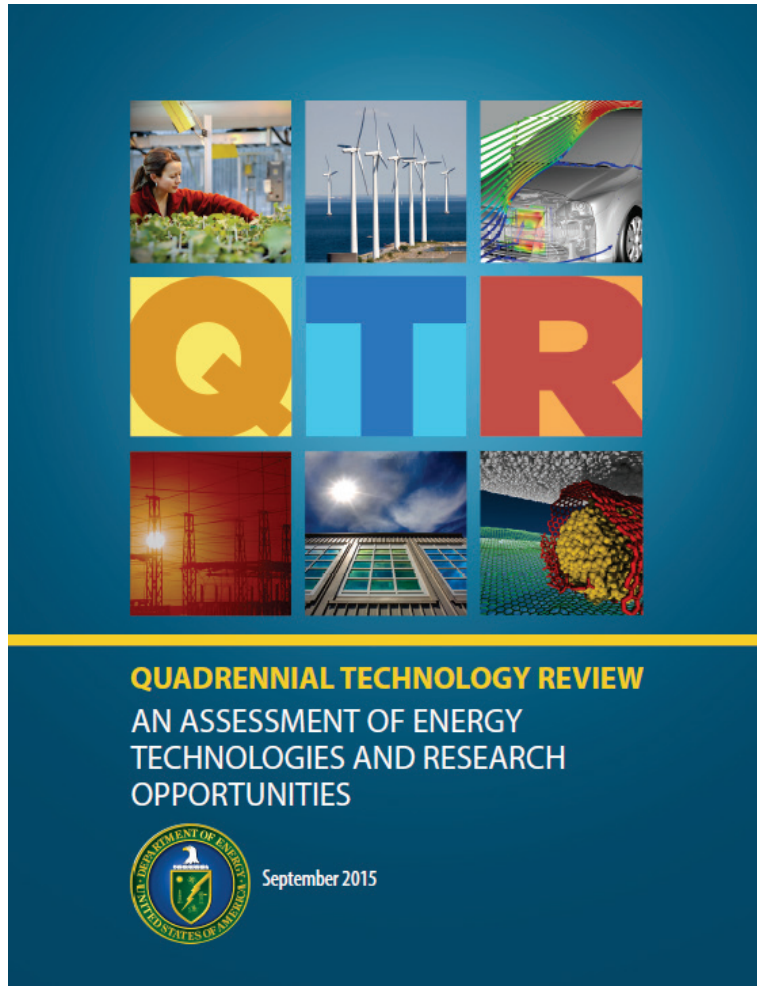
GTO Performance Metrics Overview

<i>Opportunities for Technology Development</i>		Sub-Program	Sub-Program Goal	Baseline Metric (year)	Target Metric (year)
1 <i>Improve and lower \$/MW subsurface access technologies</i>	2 <i>Achieve purposeful control of subsurface fracturing and flow</i>	Enhanced Geothermal Systems	Demonstrate stimulation of at least 5 reservoir zones via a single wellbore and correlate to increased reservoir performance.	2 zone stimulation achieved at existing EGS demonstration site (2014) ¹	At least 5 reservoir zones created within a single wellbore (2017)
	3 <i>Develop advanced remote resource characterization tools to identify geothermal opportunities without surface expression</i>	Hydrothermal	Demonstrate the effectiveness of Play Fairway Analysis for exploration risk reduction by delineating prospects within five sub-basins through temperature gradient well drilling .	5-10 resource play fairways identified under PFA Phase II (2016) ²	2 - 5 drilling geothermal prospects identified from play fairway analysis (2017)
4 <i>Develop mineral recovery and hybrid systems to provide second stream of value</i>		Low Temperature	Demonstration of thermal desalination technology that is cost-competitive with current produced water treatment methods.	\$6/m ³ for disposal by injection (2014) ³	\$1.70-\$2.60/m ³ for product (by 2018)

¹Modeled performance improvement over non-engineered well stimulation.

²Identifying 2 - 5 prospects for subsurface characterization utilizing validated PFA methodologies derived from the 11 PFA awards

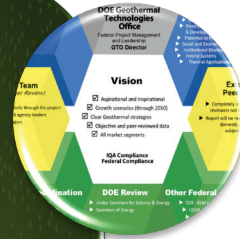
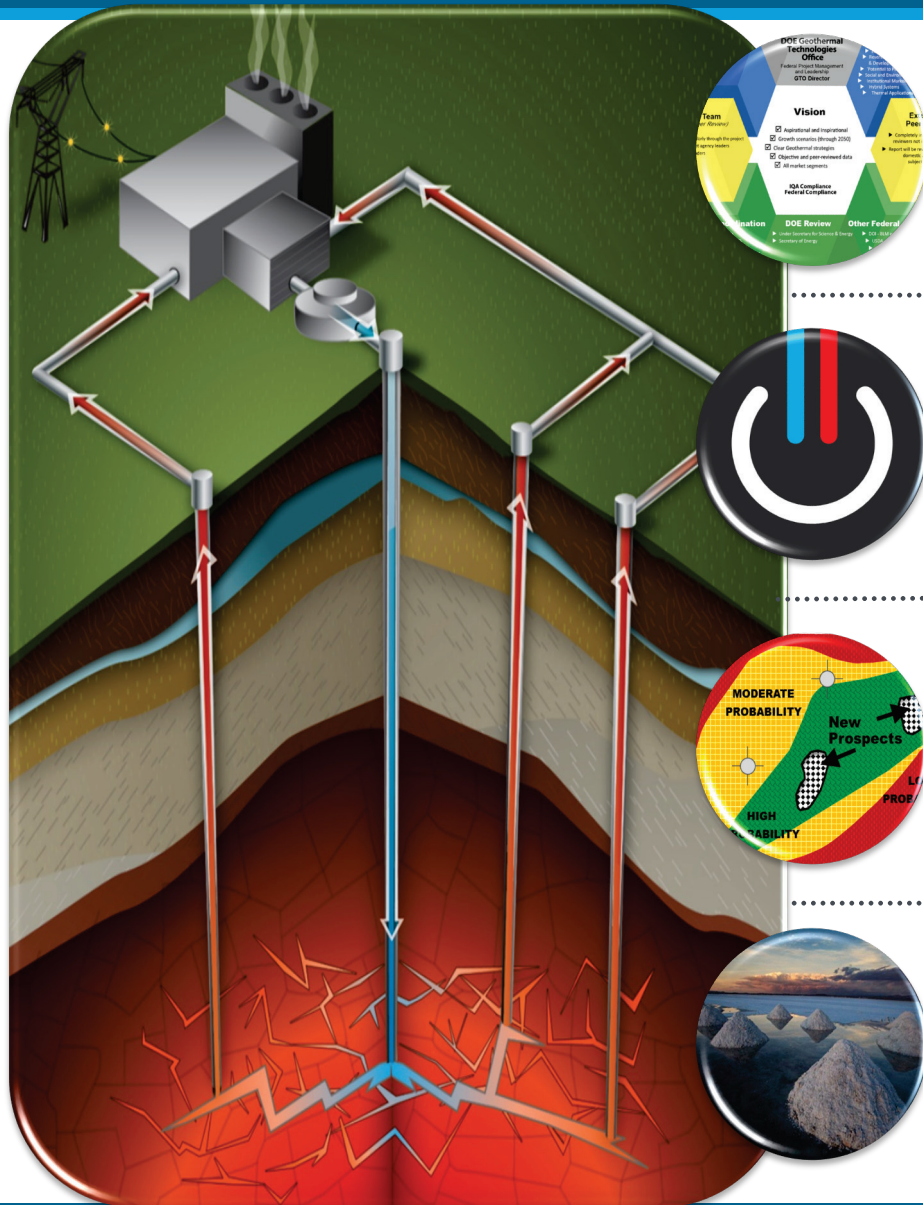
³Demonstrated pilot-scale performance at or over the cost-effective baseline.



- Develop advanced remote resource characterization tools to identify geothermal opportunities without surface expression
- Purposeful control of subsurface fracturing and flow
- Improve and lower \$/MW subsurface access technologies
- Develop mineral recovery and hybrid systems to provide second stream of value

<http://www.energy.gov/qtr>

Geothermal Technologies – FY16 & FY17 Major Initiatives

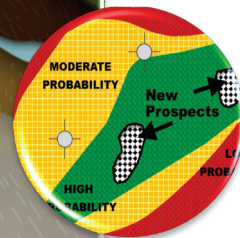


Systems Analysis • GeoVision Study



Enhanced Geothermal Systems

- Frontier Observatory for Research in Geothermal Energy (FORGE)



Hydrothermal

- Play-Fairway Analysis
- Subsurface Engineering Crosscut (SubTER)



Low Temperature

- Mineral Recovery
- Hybrid Systems
- Desalination



- **Low-Temperature Mineral Extraction** - Resource assessment and feasibility (ongoing)
- Large-scale **Direct Use**: where does it make technical and commercial sense?
- Use geothermal hot fluids for heating and cooling
- Potential displacement of traditional baseload generation on site-by-site basis
- Targeted RD&D on innovative energy conversion, additional **revenue-stream creation (e.g., hybrid systems & thermal desalination)**, and further development of power generation cycles



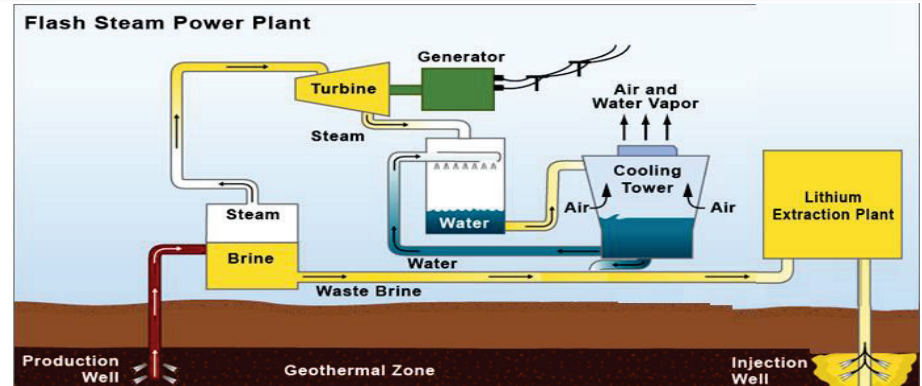
DOE is interested in:

- Determining the **technical** feasibility and **economic** viability of mineral extraction technology(s)
- Assessments of the **current rare earth** and **near-critical metal resource** base
- Geochemical **modeling** and **leaching**

A periodic table of elements with several elements circled in red. The Lanthanides series (La to Lu) is highlighted in blue. Other circled elements include Li, Mn, Cu, Zn, Ag, Cd, Au, and Hg. The source 'USGS' is noted at the bottom.

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La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu					
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71					
Lanthanides																			
H	He											B	C	N	O	F	Ne		
Li	Be											Al	Si	P	S	Cl	Ar		
Na	Mg	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
K	Ca	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
Rb	Sr		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
Cs	Ba	Lu																	
Fr	Ra	An	Lr																

USGS



Current Activities

Phase I (Initiated FY2014)

- Technical feasibility and economic viability of proposed mineral extraction technology(s) combined with geothermal power production at a new or existing geothermal resource
- Assess current Rare Earth Element (REE) and near-critical metal resource base; potential extraction volumes with techno-economic analysis

Phase II (Initiated FY2016)

- Competitive Funding Opportunity Announcement released.
- Up to \$4M to be awarded under select Topic Areas
 - Topic Area 1, Subtopic 1A: Leveraging Methods from Other Extractive Industries for Surface Operations
 - Topic Area 1, Subtopic 1B: Leveraging Methods From Other Extractive Industries to Enhance Subsurface Materials Recovery
 - Topic Area 2: U.S. Regional or Nationwide Assessment of High Value Materials in U.S. Geothermal Fluids and Produced Fluids.
- Public, quantified analysis of rare earths and possible high value minerals in geothermal (both high and low temperature) fluids
- Work anticipated to run through FY18



Objective

- Determine the feasibility of developing and deploying low-temperature, deep-well geothermal systems for heating and cooling, as well as other thermal applications throughout the U.S.

Why it Matters

- DDU for campuses, military installations, hospital complexes, offices, hotels, and other large energy end-uses offers great opportunities to significantly expand the impact and reach of geothermal energy applications across the United States.

Planned FY17 Activities (\$4M Requested)

- DDU applications would be systemically engineered to optimize the use of the heat entrained in geothermal brines to provide the energy needed for large-scale residential and commercial thermal applications.
- GTO plans to run a competitive FOA (Up to \$4M) for a DDU site selection, assessment, and feasibility study.

Objective

- Continue to dedicate targeted RD&D to innovative energy conversion and additional revenue-stream creation with the goal of steadily increasing the value of geothermal resources.

Why it Matters

- Geothermal resources can be utilized in hybrid systems when they may not be economic to develop on their own, by increasing efficiencies while utilizing lower temperature resources.
- Thermal desalination can utilize geothermal energy to create fresh water presenting an opportunity to clean produced waters reducing environmental impact and disposal costs.

Planned FY17 Activities

- Continue funding projects that validate the feasibility of hybrid geothermal systems, including engineering of other renewable energy or fossil energy with geothermal power; as well as combinations of different power generation cycles in geothermal systems.
- Support the Energy-Water Nexus Crosscut with continued testing of geothermal desalination technologies including forward osmosis (FO) using switchable polarity solvents (SPS).

First commercial coproduced generation
Williston Sedimentary Basin.



Source: Kirby Baier of Continental Resources

- **Use hot fluid—a by-product of oil, gas, and other material harvesting processes—to generate electricity**
- **Has the potential to extend the economic life of oil and gas fields**

Value Proposition

The GTO is exploring opportunities to partner with Industry to deploy binary systems in operating commercial oil and gas (O&G) fields.

GTO Provides:

- Units at low/nominal cost (subject to final contract)
- Funds for minimally invasive and fast installation
- Necessary O&M of the unit

Industry Partner Provides:

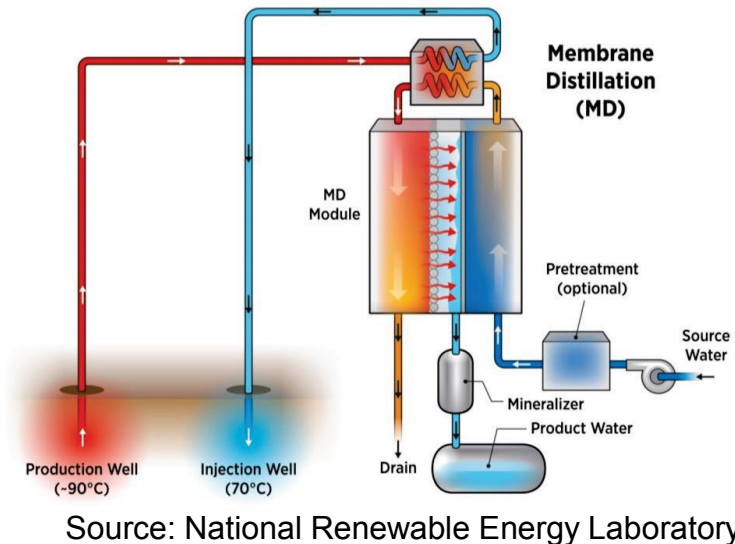
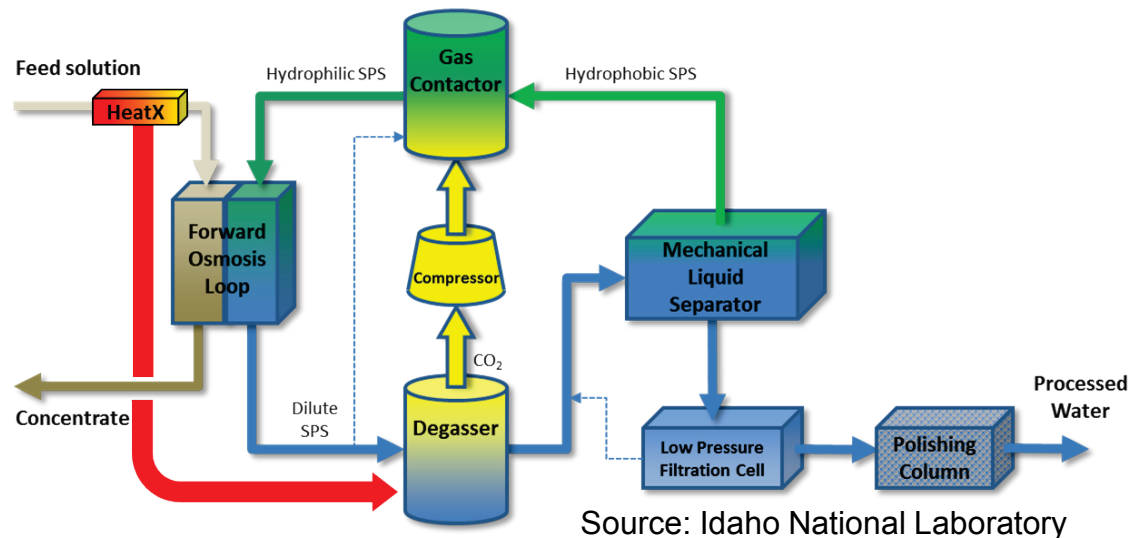
- Site access for installation and contingency operations
- Shared information on coproduced water volumes, temperature, flow rate, fluid chemistry, and power production and operability
- Design and engineering of the field (for cost estimate)
- Clearly defined site ownership/control

- **Utilize geothermal alongside another energy source, with innovative power cycles, or through cascaded uses of the resource**
- **Can expand the geographic range of geothermal use, decrease production costs and increase the resource base**
- **First-its-of-kind plants:**
 - **Triple hybrid power plant commissioned in March 2016**

Stillwater triple hybrid power plant combines Geothermal, CSP, and PV.



- Opportunity to use co-produced geothermal resources to treat produced waters
- Offset disposal costs and adverse environmental effects – induced seismicity
- Two thermal desalination projects:
 - Switchable Polarity Solvent – Forward Osmosis at INL
 - Membrane Distillation at NREL



QUESTIONS?

CONTACT INFORMATION

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