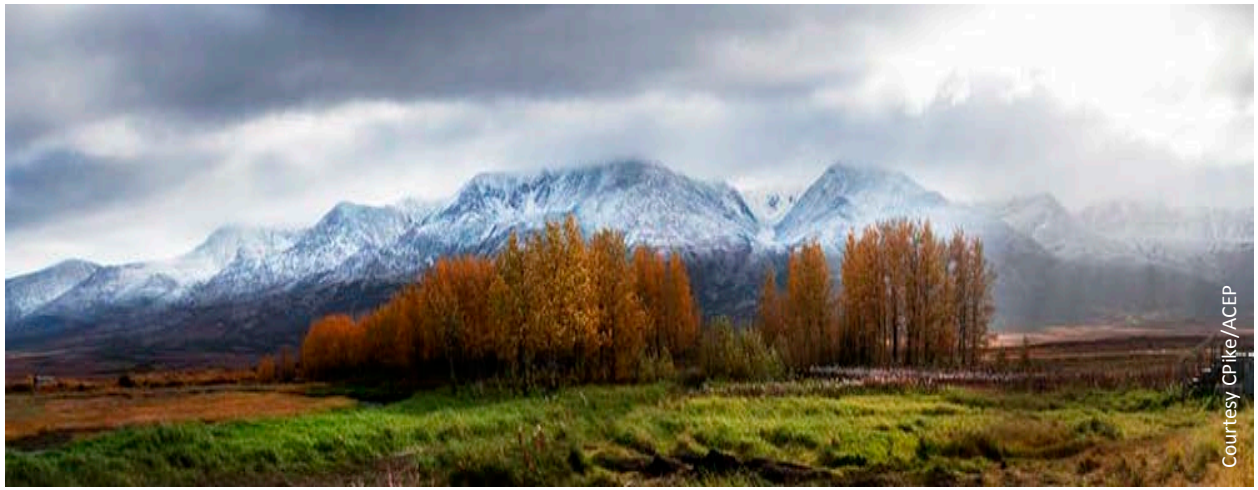
Geothermal Technologies Office



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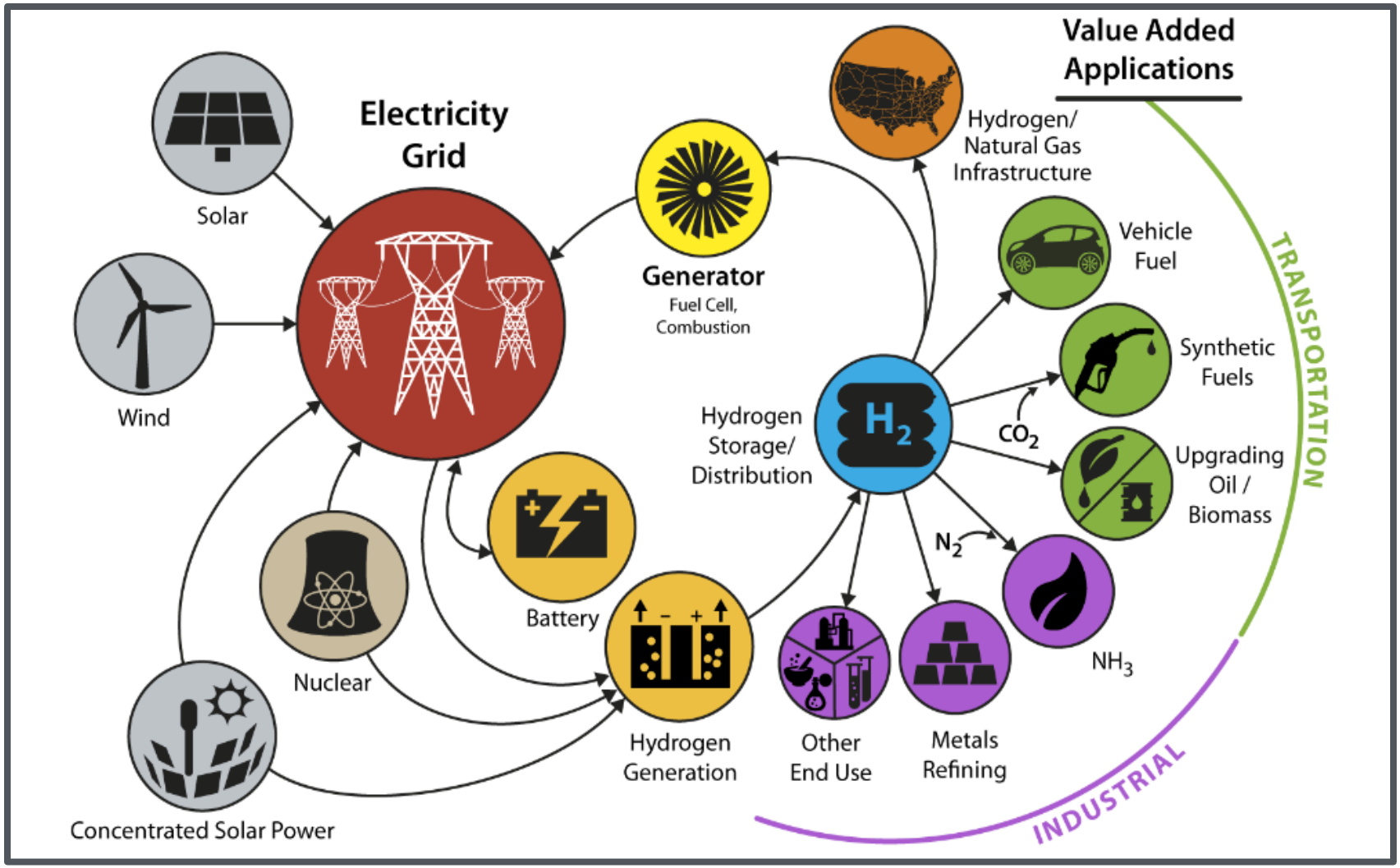
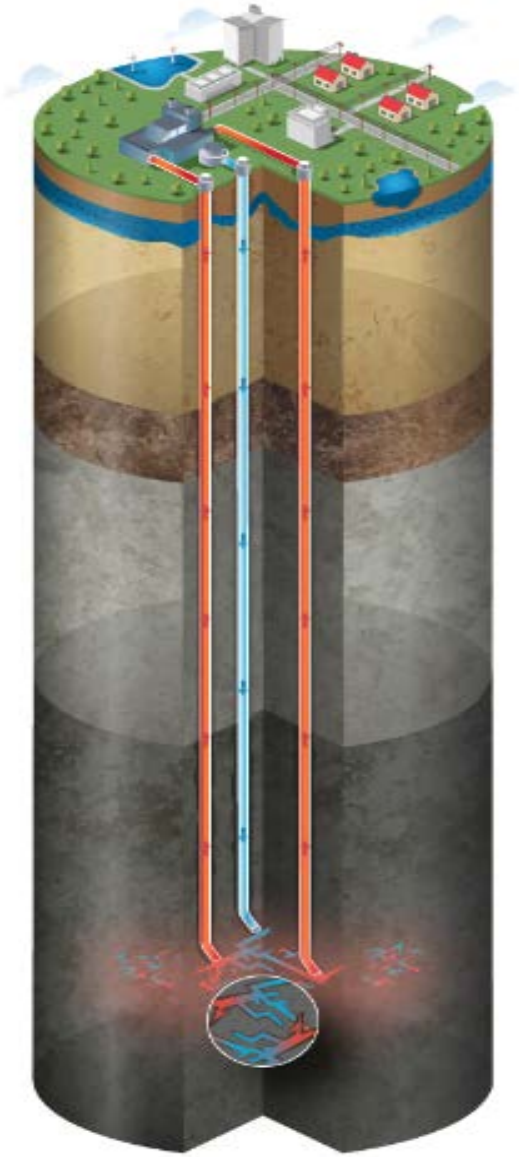
Geothermal Energy - ‘Plugging Into The Planet’



From the RFI: The key challenges are clean, low cost hydrogen production and efficient utilization/systems integration.

Typical Geothermal Electric Power System



To generate electric power from natural geothermal systems, you need:

Fluid to carry heat from the rocks

+

Small pathways to conduct fluid through the hot rocks

+

Abundant heat found in rocks at depth

With these conditions naturally in place, hot fluids are pumped to the surface, where they drive turbines and generate electricity in a power plant.

Those fluids are typically reinjected into the subsurface for later power production.

Why spend money on geothermal technology development?

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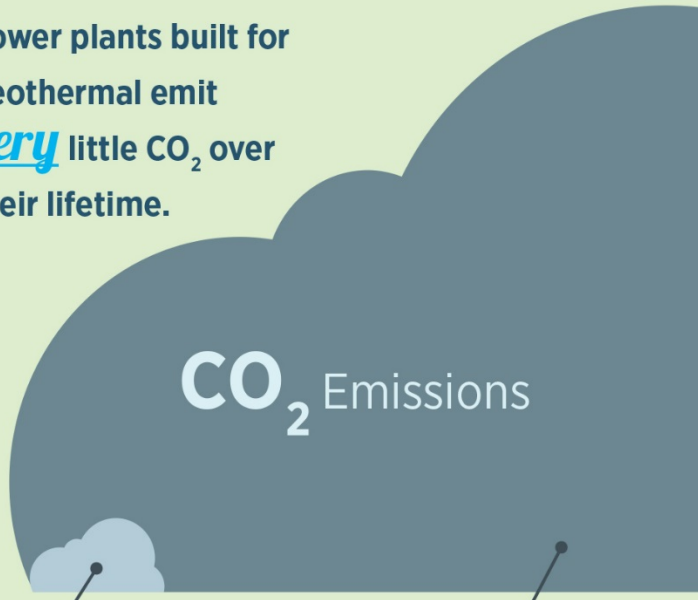
ENERGY THAT *Works* AROUND THE CLOCK

Geothermal is a reliable, baseload energy source. It can provide power *24* hours a day, *365* days a year, independent of weather conditions and with the flexibility to meet consumer demand.

GREEN TECHNOLOGY FOR A *Greener* WORLD

Power plants built for geothermal emit *very* little CO_2 over their lifetime.



[1&2] For more information about the refereces visit: energy.gov/FORGE/Information-resources

* A plant using moderately heated geothermal and secondary fluid that pass through a heat exchanger. The geothermal fluid causes the secondary fluid to flash to vapor driving turbines to power generators.

What is Geothermal?

Geothermal Heat Pumps/ Ground Source Heat Pumps	Use relatively constant temperature of the earth as heat sink 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

Geothermal Energy – U.S. Overview

The U.S. is the world leader in installed geothermal electric power production with 3.7GW of operating nameplate capacity

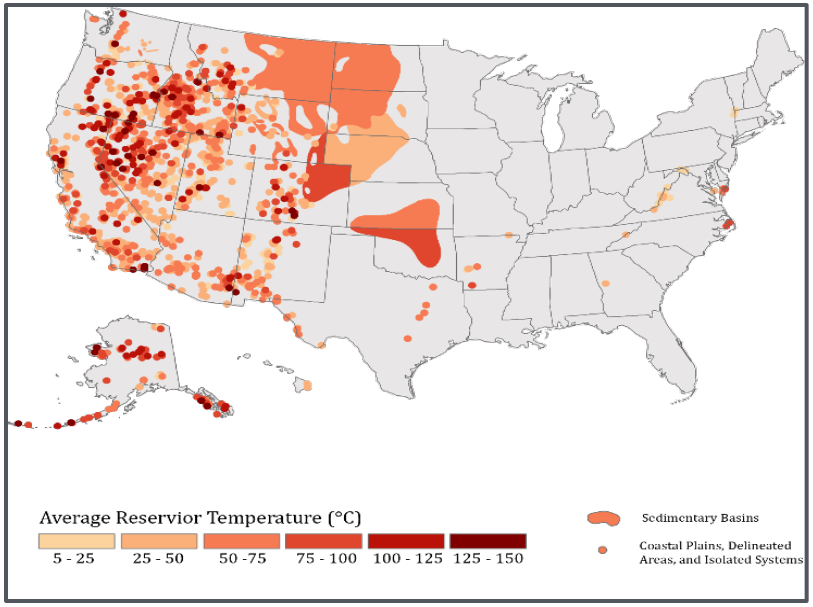
Since 2015 the U.S. has brought online an additional 70 MW of electric power production

The U.S. has 1,250 MW of geothermal electric power under development among 80 projects nationwide

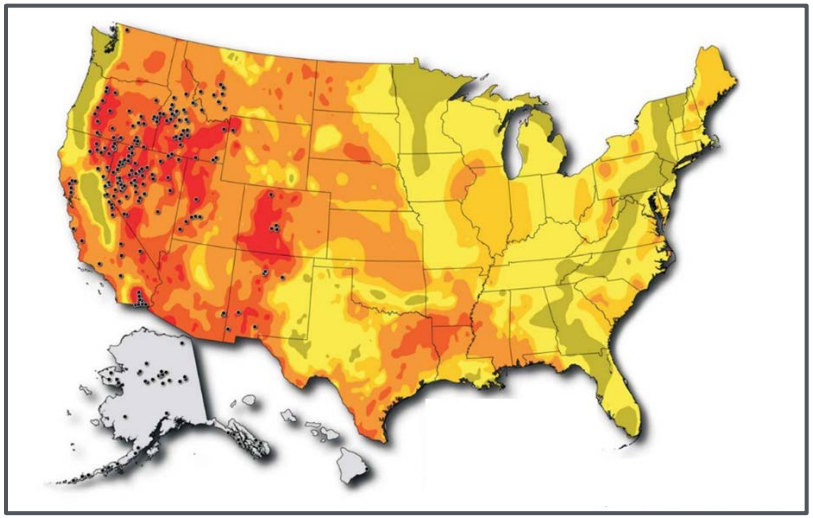
GTO invests in activities to facilitate growth of installed electrical capacity and utilization of thermal energy along a spectrum of technology readiness

US - the world's largest for geothermal power production and geothermal reserves

U.S. Resources



- Hydrothermal (high temperature) Resources in the US



- Enhanced Geothermal and Deep Direct Use US Resources

GTO Major Initiatives

EGS

- **Accelerate EGS**
  - Build upon R&D and demonstration project successes
  - EGS Integrated R&D FOA
  - Frontier Observatory for Research in Geothermal Energy (FORGE) FOA kicked off

Hydrothermal

- **New Geothermal Opportunities**
  - Play Fairway Analysis
  - Pathway to next-step drilling validation
- **Subsurface Engineering Crosscut**
  - Intra-DOE efforts to address common subsurface challenges and better leverage RD&D

SALT

- **Additive Value**
  - Low Temperature Mineral Recovery
  - Hybrid systems and Desalination
- **Looking Forward**
  - GeoVision Study

FORGE Overview

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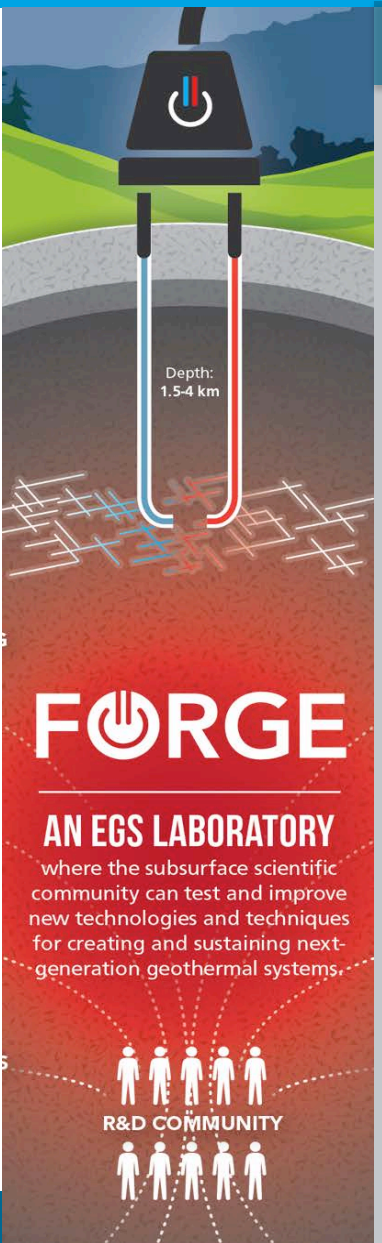


FORGE GOALS

Promote DIVERSE & TRANSFORMATIONAL research to:

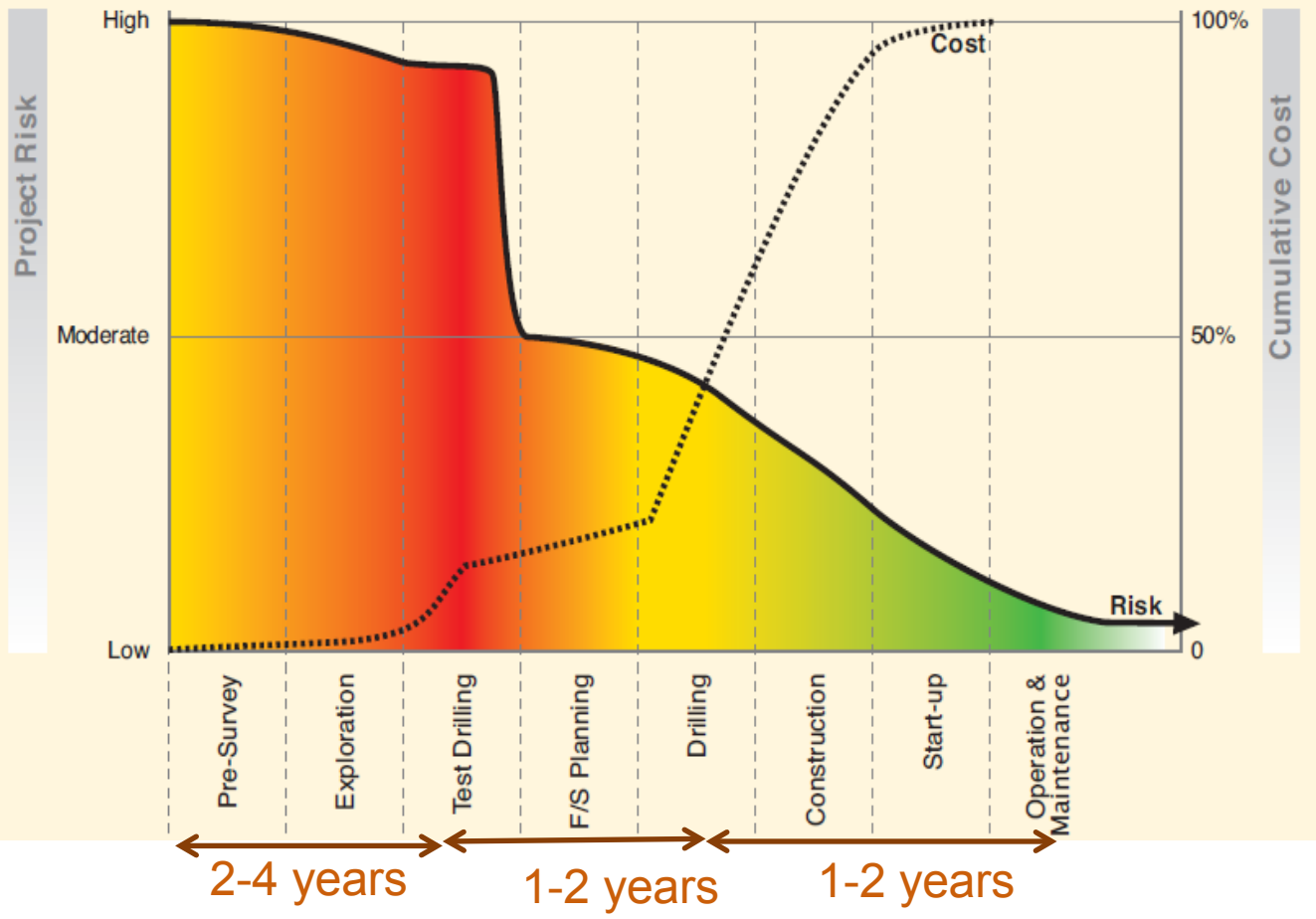
- ***Validate*** and ***optimize*** enhanced geothermal systems (EGS) technology
- Perfect access to and creation of ***productive and sustainable reservoirs***
- ***Develop***, ***test*** and ***improve*** new fundamental and techniques in an ideal EGS environment.
- ***Capture*** and ***disseminate*** high fidelity *data* in real-time to the community
- Ensure ***reproducibility for commercial scale-up***

Federal Role:

- Test technologies/take technical risks not possible in private sector
- Work under aggressive timeframe
- Enable access to enormous renewable resource

Fairway Evaluation

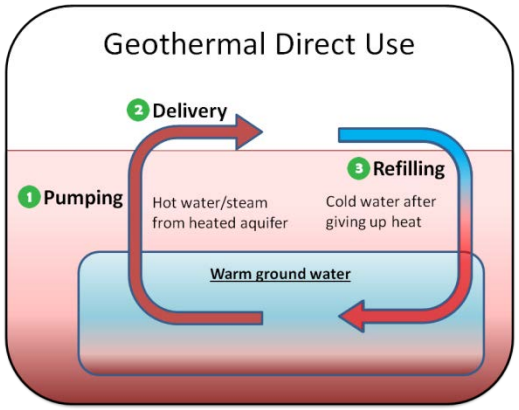
- Combination of early higher risk, higher costs, and regulatory uncertainty can impair projects
- Reinforces GTO focus on areas such as drilling cost, success probability, and new technologies

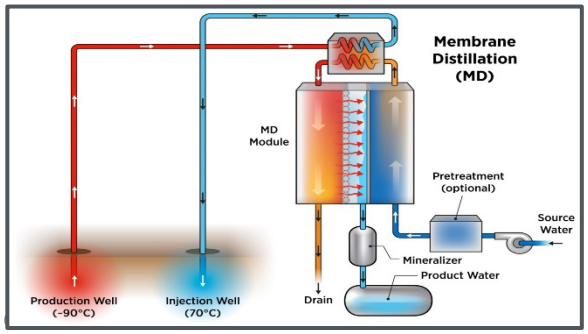


Adapted from ESMAP, 2012 Geothermal Handbook: Planning and Financing Power Generation

Moderate and Low Temperature

Adding Value - Materials Extraction, Direct-Use, Hybrid Systems & Thermal 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

The Subsurface Technology and Engineering Research, Development, and Demonstration (SubTER) Crosscut

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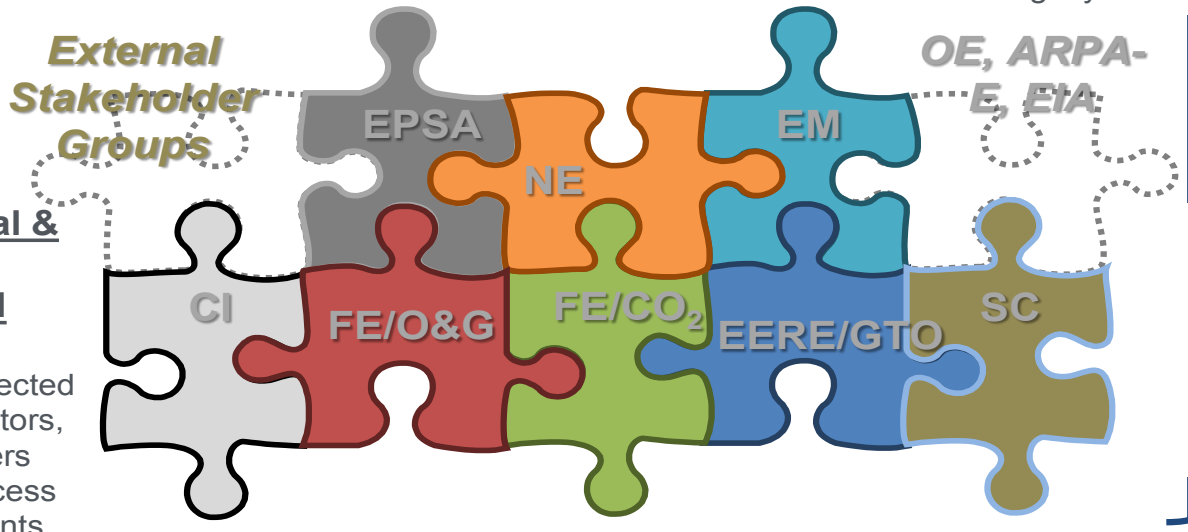
Energy Policy & Systems Analysis
- Advisement: Secretary of Energy
- Policy: low-carbon and secure energy economy
- Technical assistance: States and local entities

Nuclear Energy
- Policy and technology: disposition of used nuclear fuel and waste
- R&D: deep borehole disposal concept

Environmental Management
- Modeling and tools: subsurface evaluation and characterization
- Cleanup: nuclear weapons legacy



Congressional & Inter-governmental Affairs
- Interactions: elected officials, regulators, and stakeholders
- Information access for change agents

Science
- Basic research: geology, geophysics, and biogeochemistry
- Expertise: subsurface chemistry, complex fluid flow

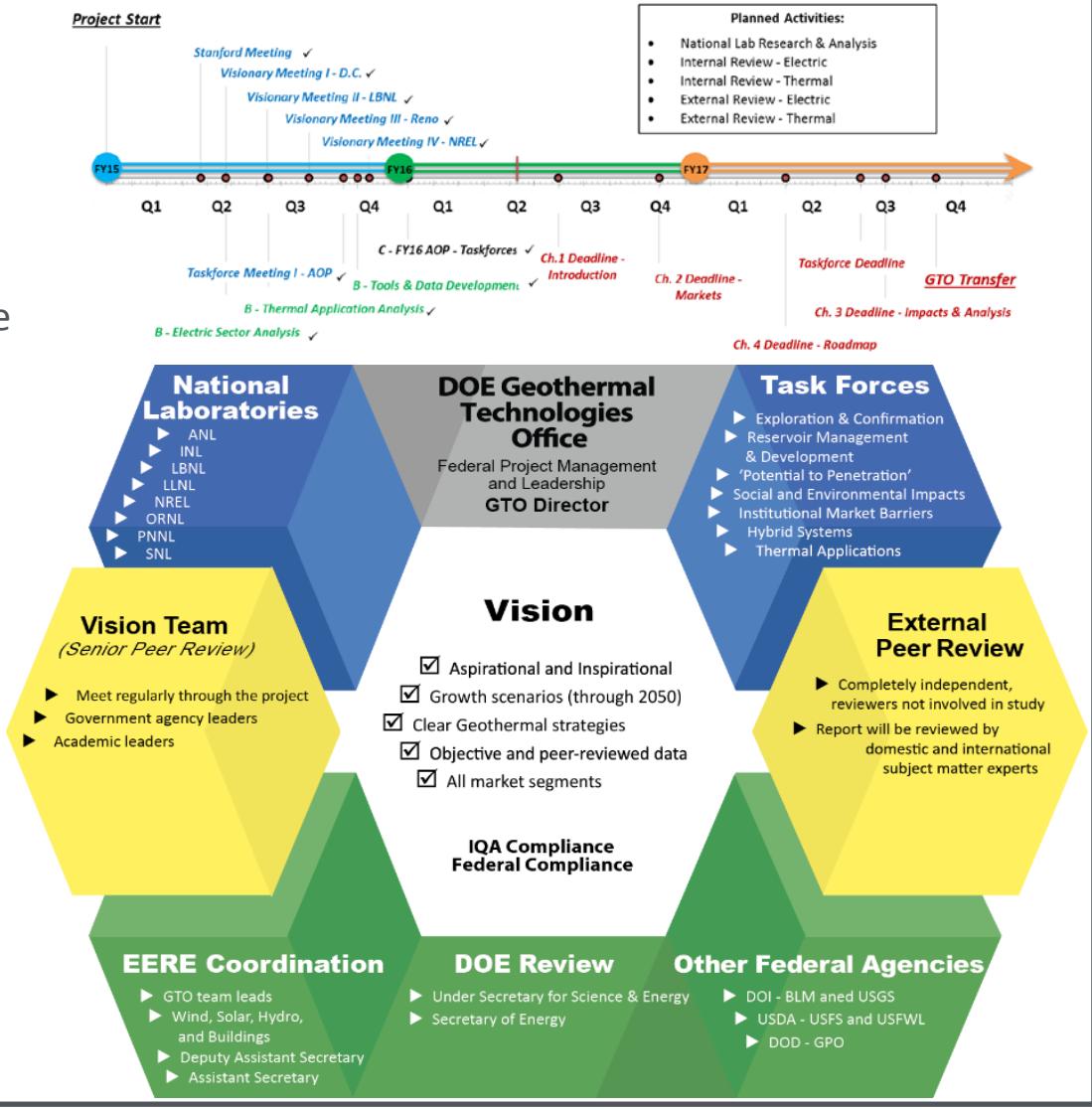
Fossil Energy/Oil & Gas
- R&D and access: clean, affordable traditional fuel sources
- R&D: drilling, well construction and integrity, and hydraulic fracturing technologies

Fossil Energy/Carbon Storage
- Policy and technology: challenges of CO_2 storage to inform regulators, industry, and the public
- R&D: CO_2 offshore and onshore storage

Geothermal Vision Study (GeoVision)

DOE seeks to develop credible analysis jointly with the geothermal community that:

- Articulates clear ***strategies*** across different sectors and has a cohesive plan to attain the goals;
- Discusses ***geothermal growth scenarios*** *through* 2050 backed by robust data, modeling and analysis;
- **Addresses *all market segments***: existing and potential hydrothermal, electrical and non-electrical usages, new EGS sector, and other value streams:
- Supported by *objective and* ***peer-reviewed*** **industry data** and *available to decision-makers; and*
- Is ***aspirational*** and ***inspirational***




YOU'VE PROBABLY NEVER HEARD OF GEOTHERMAL ENERGY
IT'S PRETTY UNDERGROUND.