Geothermal Technologies Research: the Federal Perspective

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Dr. Susan Hamm

Acting Director, Geothermal Technologies Office

May 24, 2016

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

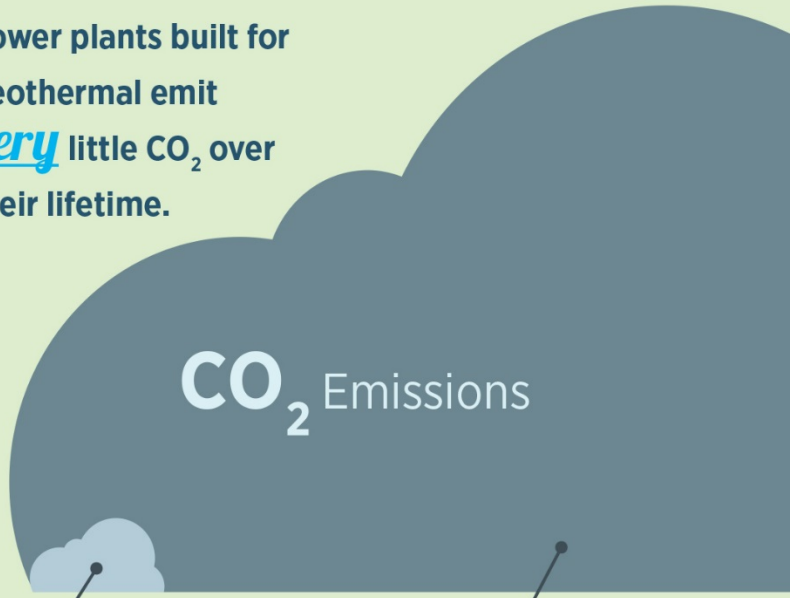
Why spend money on geothermal technology development?

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.

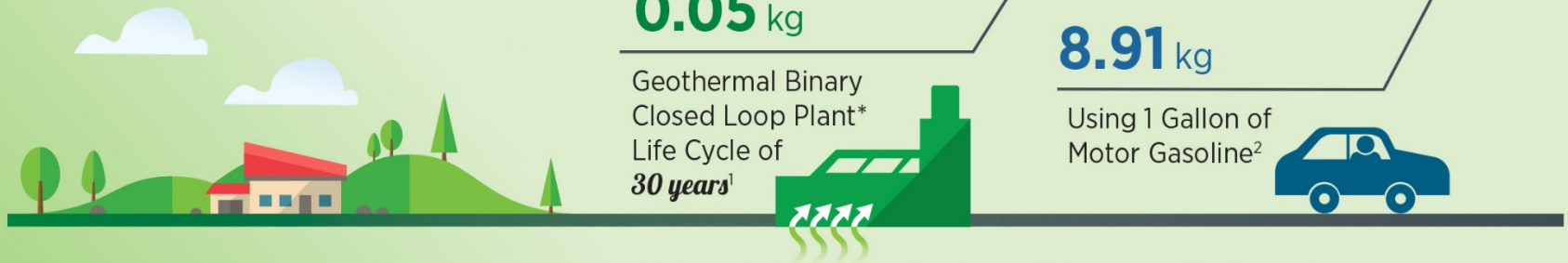


0.05 kg

Geothermal Binary Closed Loop Plant* Life Cycle of *30 years*[1]

8.91 kg

Using 1 Gallon of Motor Gasoline[2]



[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.

GTO Major Initiatives

Geothermal Technologies Office

Enhanced Geothermal Systems

- Frontier Observatory for Research in Geothermal Energy (**FORGE**)

Hydrothermal

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

Low Temperature

- **Deep Direct Use**
- Hybrid Systems
- Desalination

Systems Analysis

- **Geovision** Study

GTO Major Initiatives

Enhanced Geothermal Systems

- Frontier Observatory for Research in Geothermal Energy (**FORGE**)

Hydrothermal

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

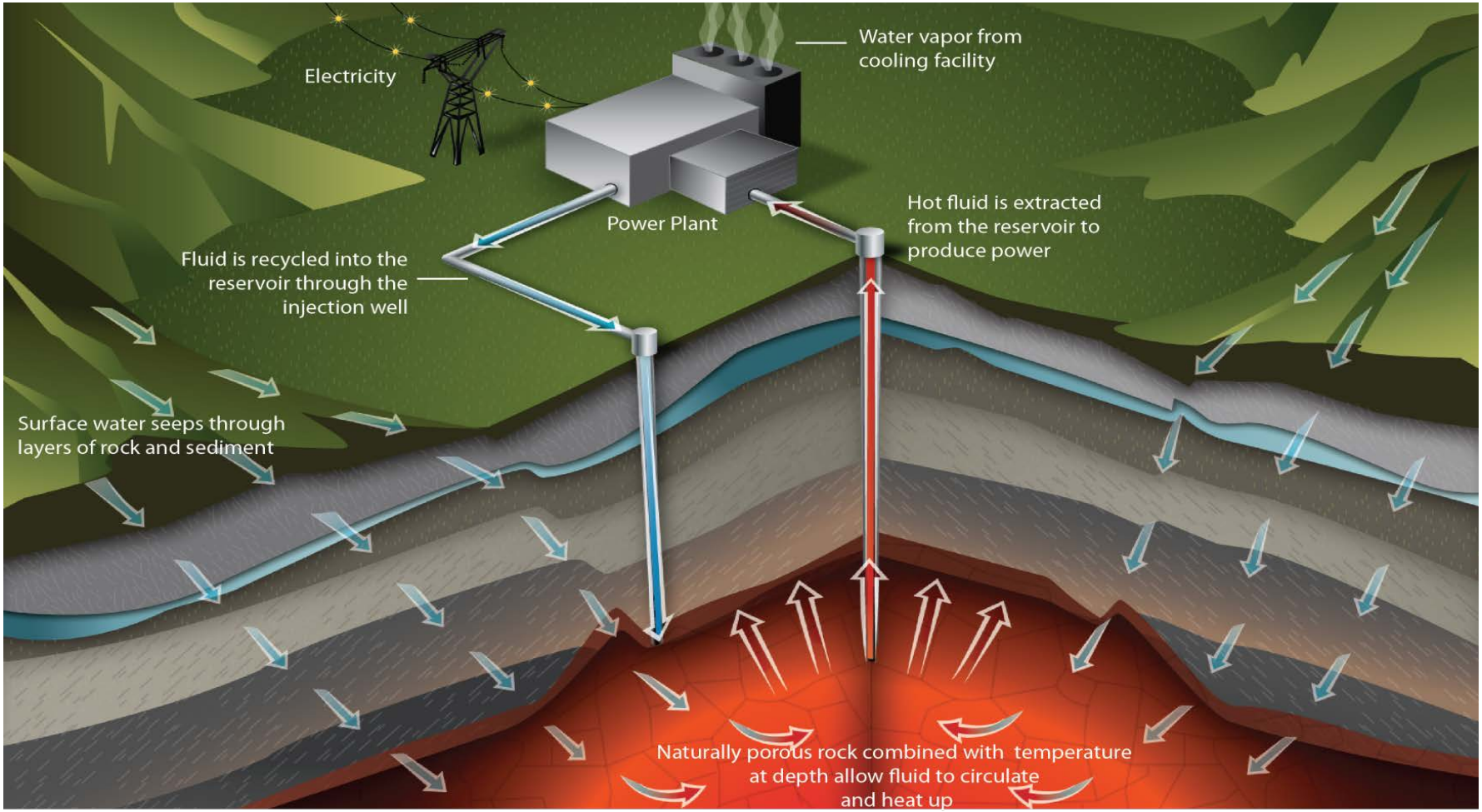
Low Temperature

- **Deep Direct Use**
- Hybrid Systems
- Desalination

Systems Analysis

- **Geovision** Study

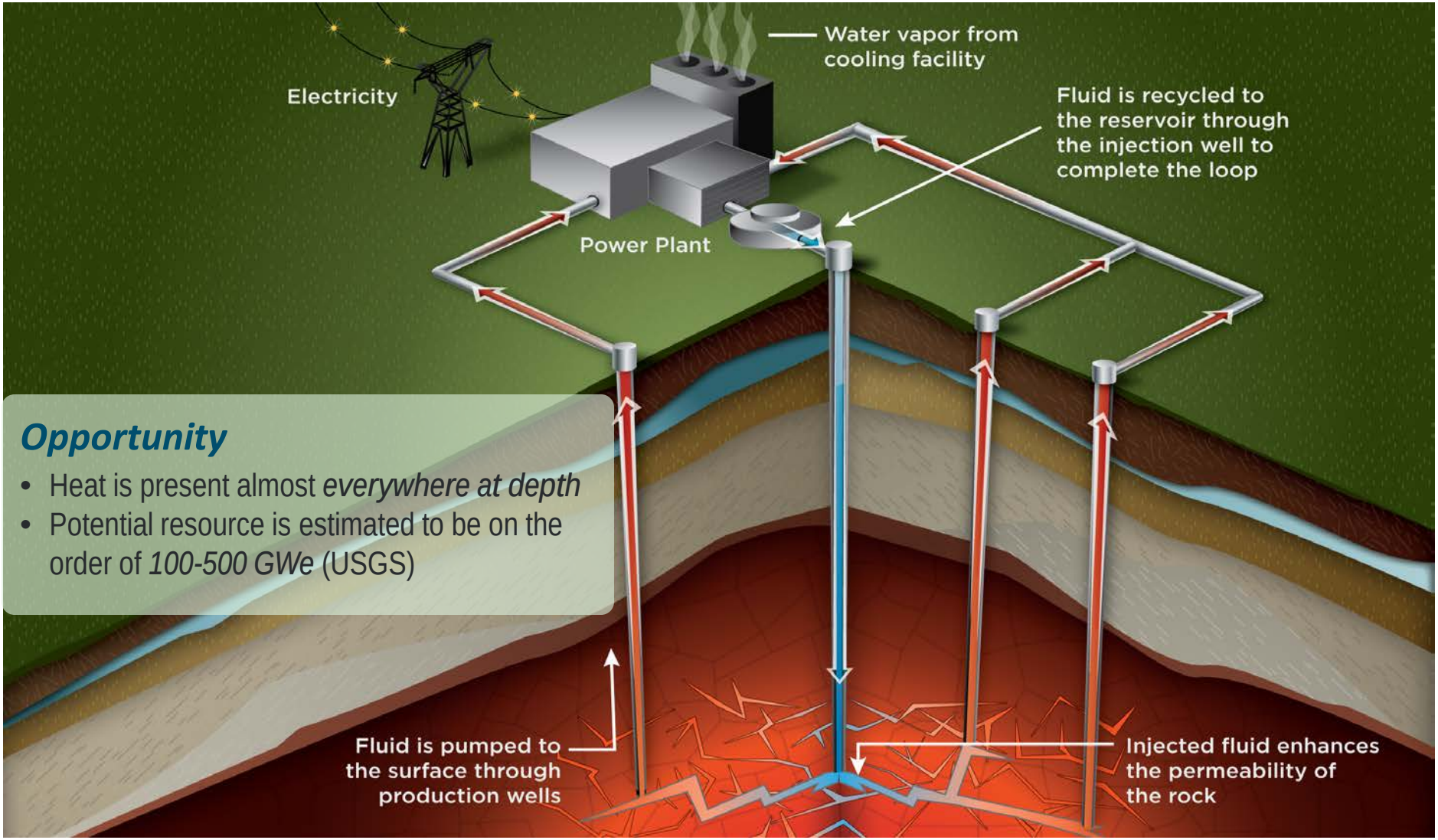
Typical Geothermal Power Plant



Hot fluid (water, steam, or both) produced from wells drilled into ground → **Fluid passed through power plant to generate electricity** → **Fluid (usually) re-injected back into ground**

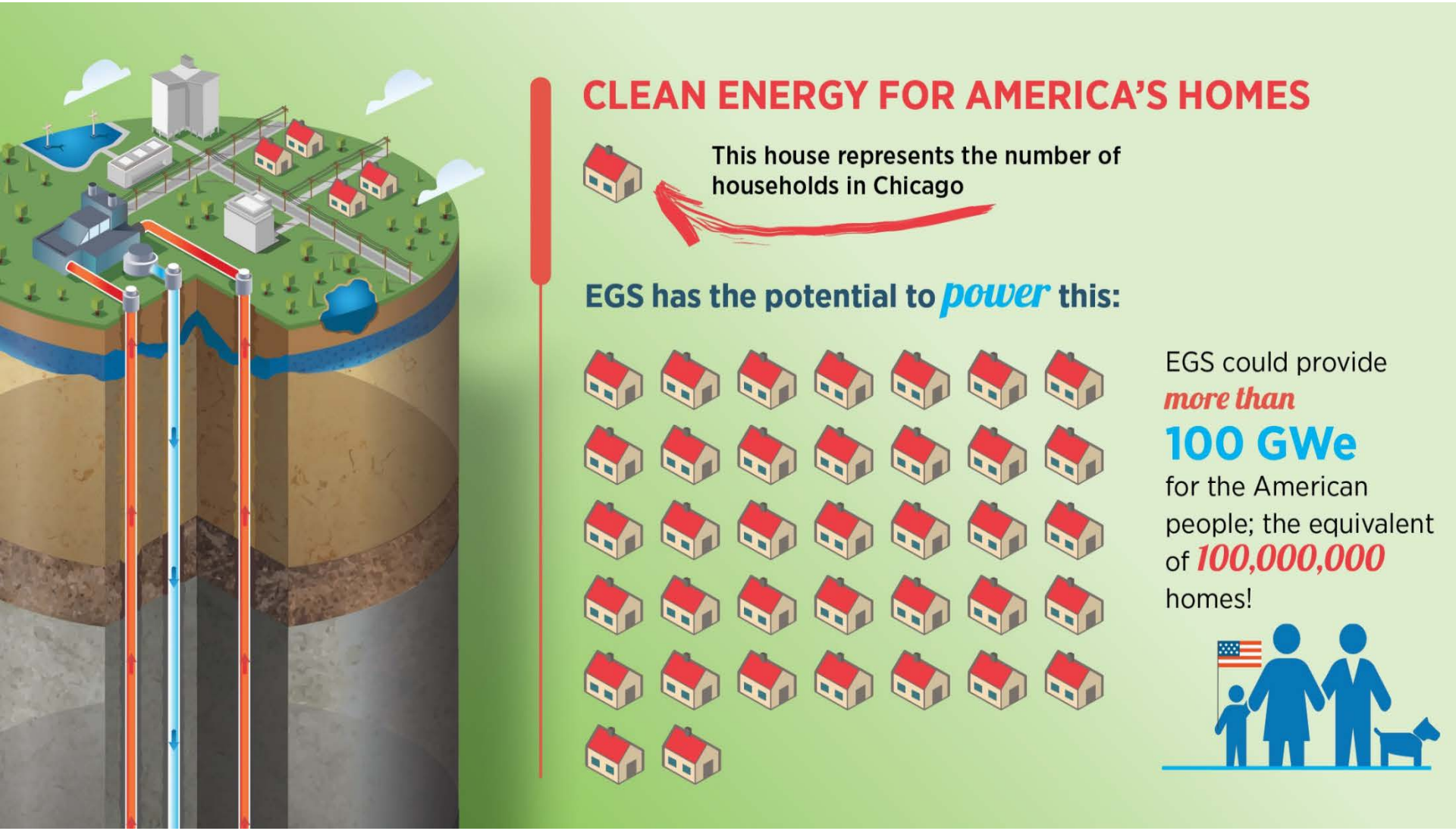
The Future: Enhanced Geothermal Systems

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



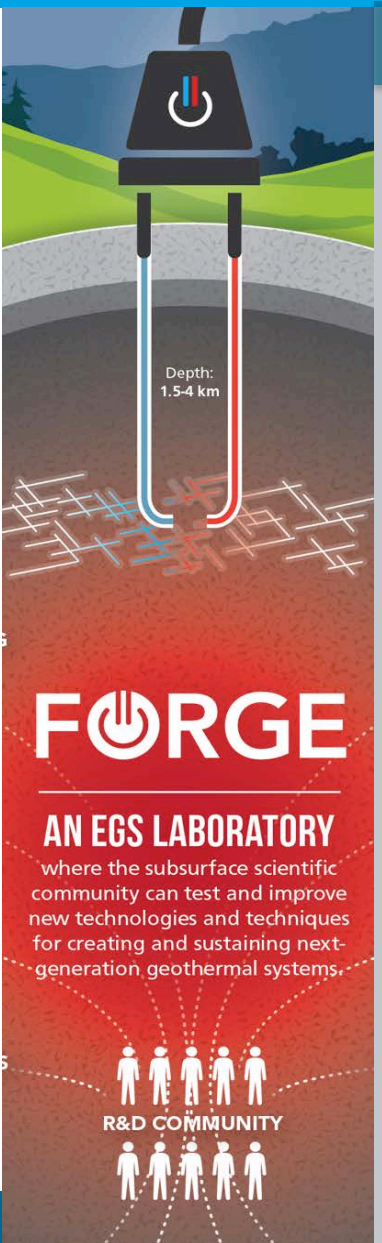
Opportunity

- Heat is present almost *everywhere at depth*
- Potential resource is estimated to be on the order of *100-500 GWe* (USGS)


CLEAN ENERGY FOR AMERICA'S HOMES
This house represents the number of households in Chicago
EGS has the potential to power this:
EGS could provide more than 100 GWe for the American people; the equivalent of 100,000,000 homes!

FORGE Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



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***

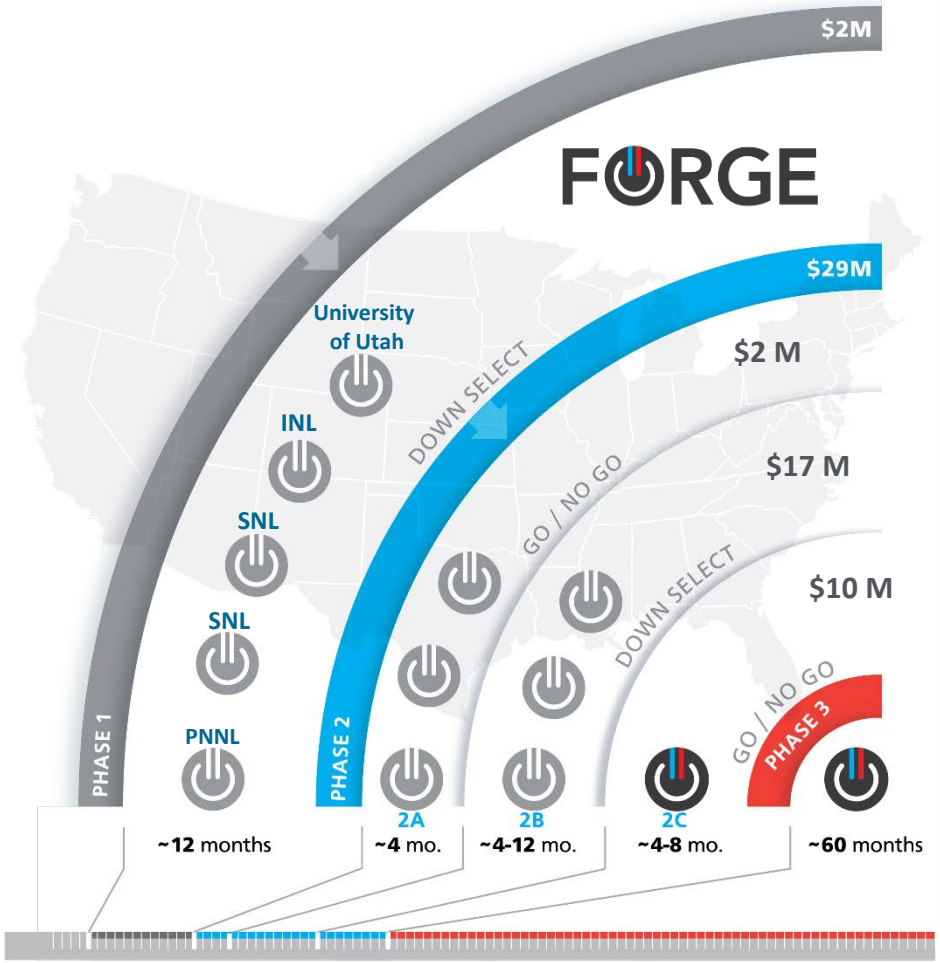
Federal Role:

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

FORGE: Why / Where are We Now?

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

The objective of FORGE is to design and test a rigorous & reproducible approach for large-scale, sustainable Enhanced Geothermal Systems



End Phase 1: down select to **1-3** sites

GTO Major Initiatives

Geothermal Technologies Office

Enhanced Geothermal Systems

- Frontier Observatory for Research in Geothermal Energy (**FORGE**)

Hydrothermal

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

Low Temperature

- **Deep Direct Use**
- Hybrid Systems
- Desalination

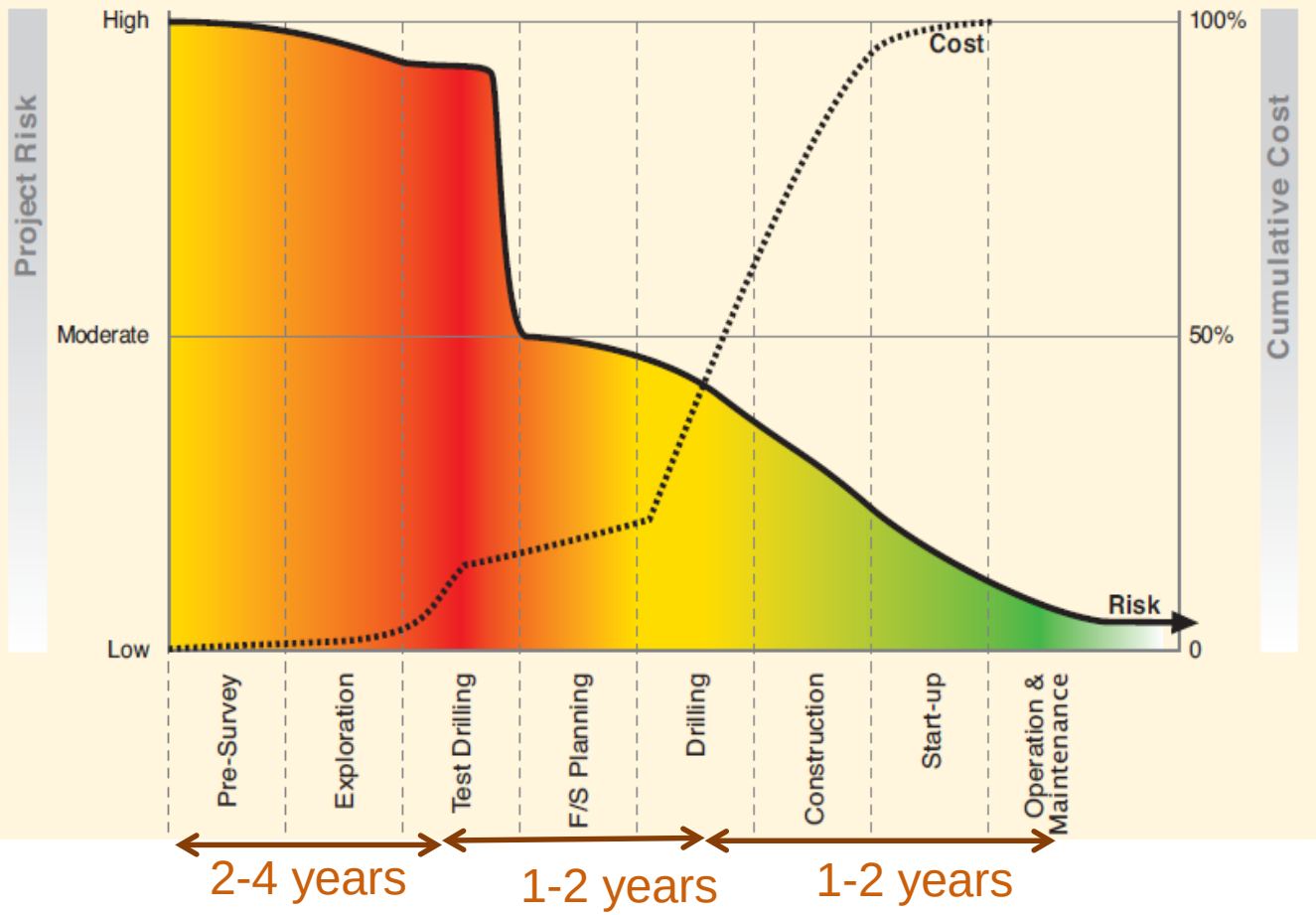
Systems Analysis

- **Geovision** Study

Risk and Cost Curves for Geothermal

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- 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



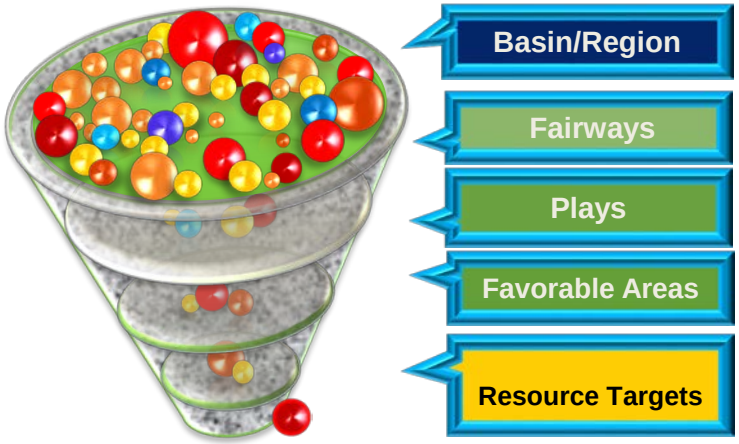
Adapted from ESMAP, 2012 Geothermal Handbook: Planning and Financing Power Generation

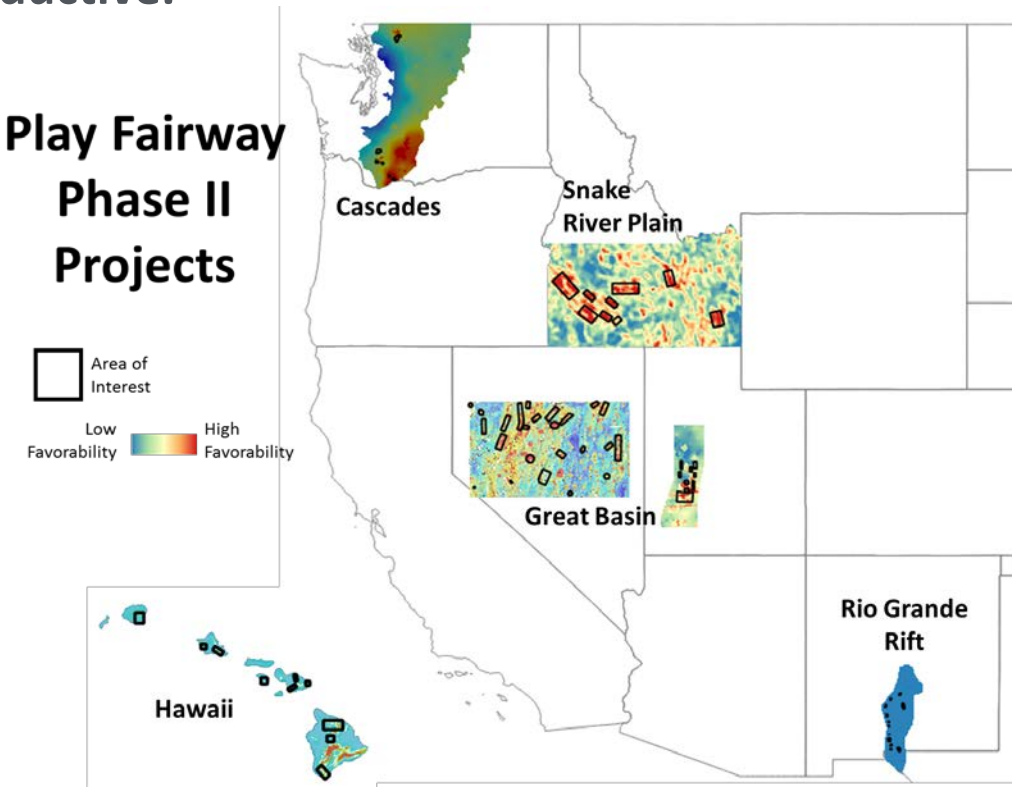
Play Fairway Analysis

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

PFA goal: to reduce the cost/risk of upfront exploration by highlighting areas where more detailed exploration would be productive.

- Technique borrowed from oil and gas
- Developing Statistical Risk Reduction
- Validating Exploration Methodology
- Creating Favorability Maps
- Reducing Exploration Costs
- Targeting Wells More Accurately
- Exploring under developed areas





GTO Major Initiatives

Enhanced Geothermal Systems

- Frontier Observatory for Research in Geothermal Energy (**FORGE**)

Hydrothermal

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

Low Temperature

- **Deep Direct Use**
- Hybrid Systems
- Desalination

Systems Analysis

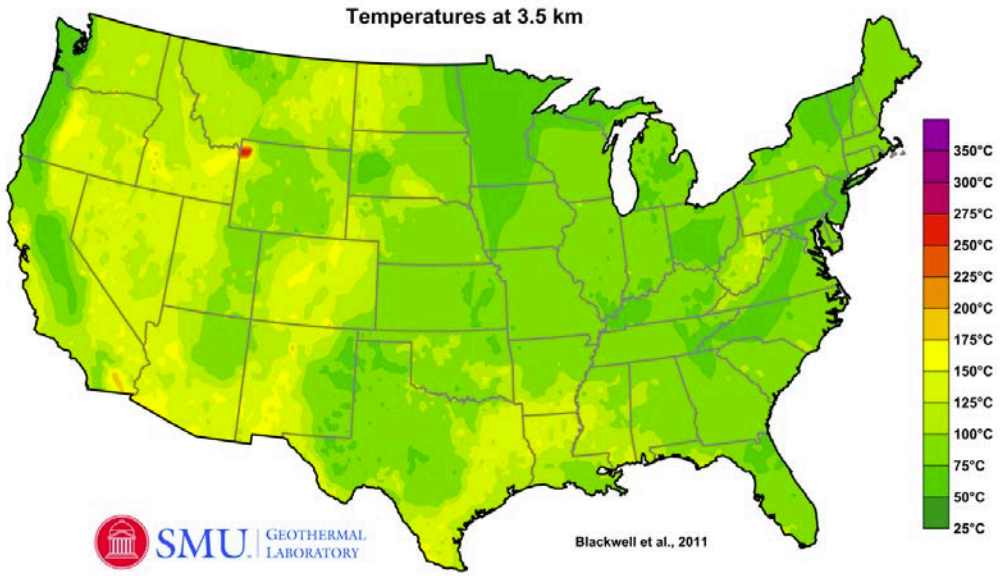
- **Geovision** Study

Deep Direct Use

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

What is Deep Direct Use?

- An emerging technology area in the geothermal sector
- Utilization of lower temperature geothermal resources that are shallower than most conventional hydrothermal resources, but deeper than geothermal heat pumps (GHPs) and other traditional direct use systems
- Deployable in a similar temperature range (40°C-150°C) as traditional direct use, but on a much larger scale



Low Temperature Efforts

- Ongoing effort in low-temperature **Mineral Extraction** - resource assessment and feasibility
- Upcoming opportunity in large-scale **Direct Use** of geothermal hot fluids for heating and cooling – technology development through commercial deployment
- 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

GTO Major Initiatives

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

Systems Analysis

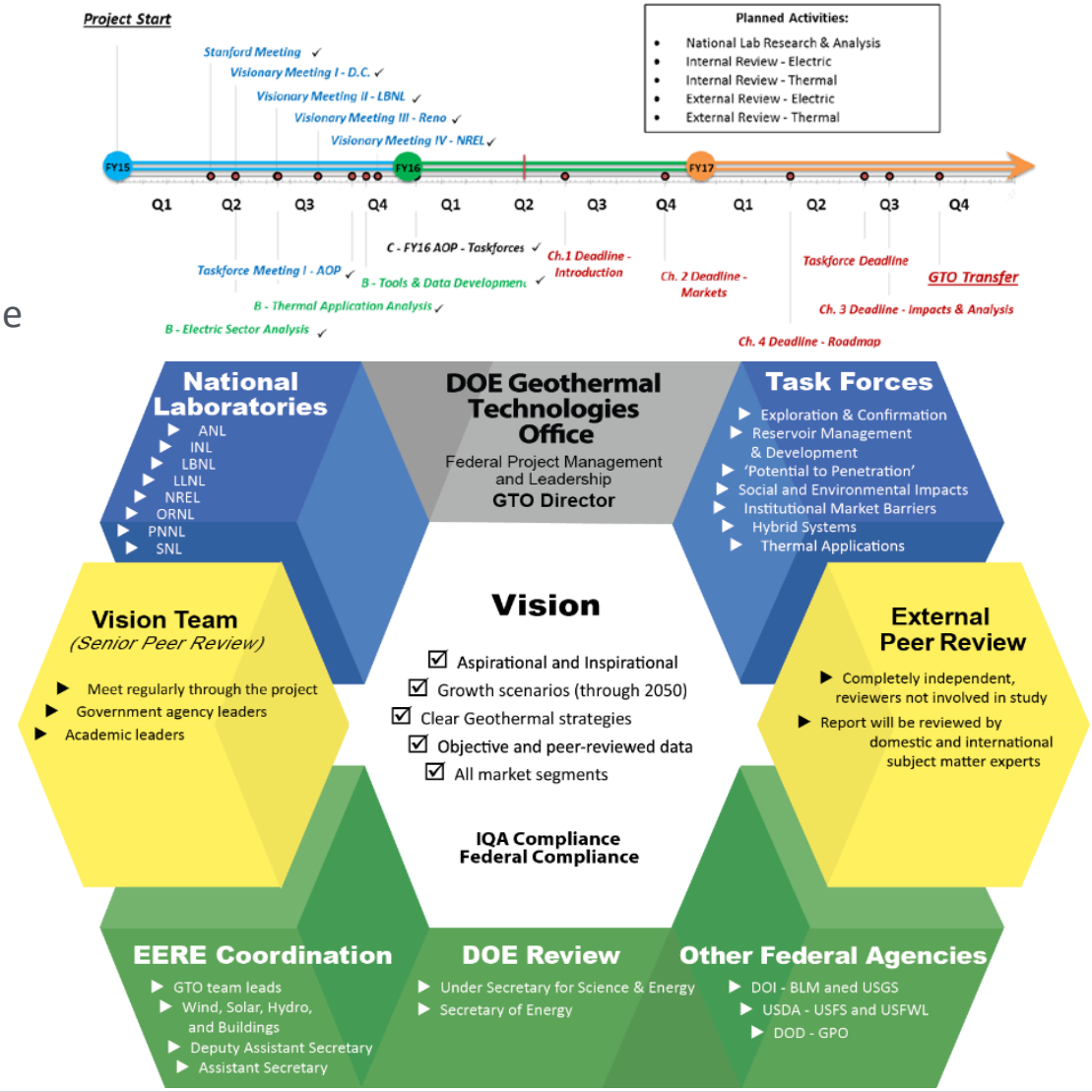
- **Geovision** Study

Geothermal Vision Study (GeoVision)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

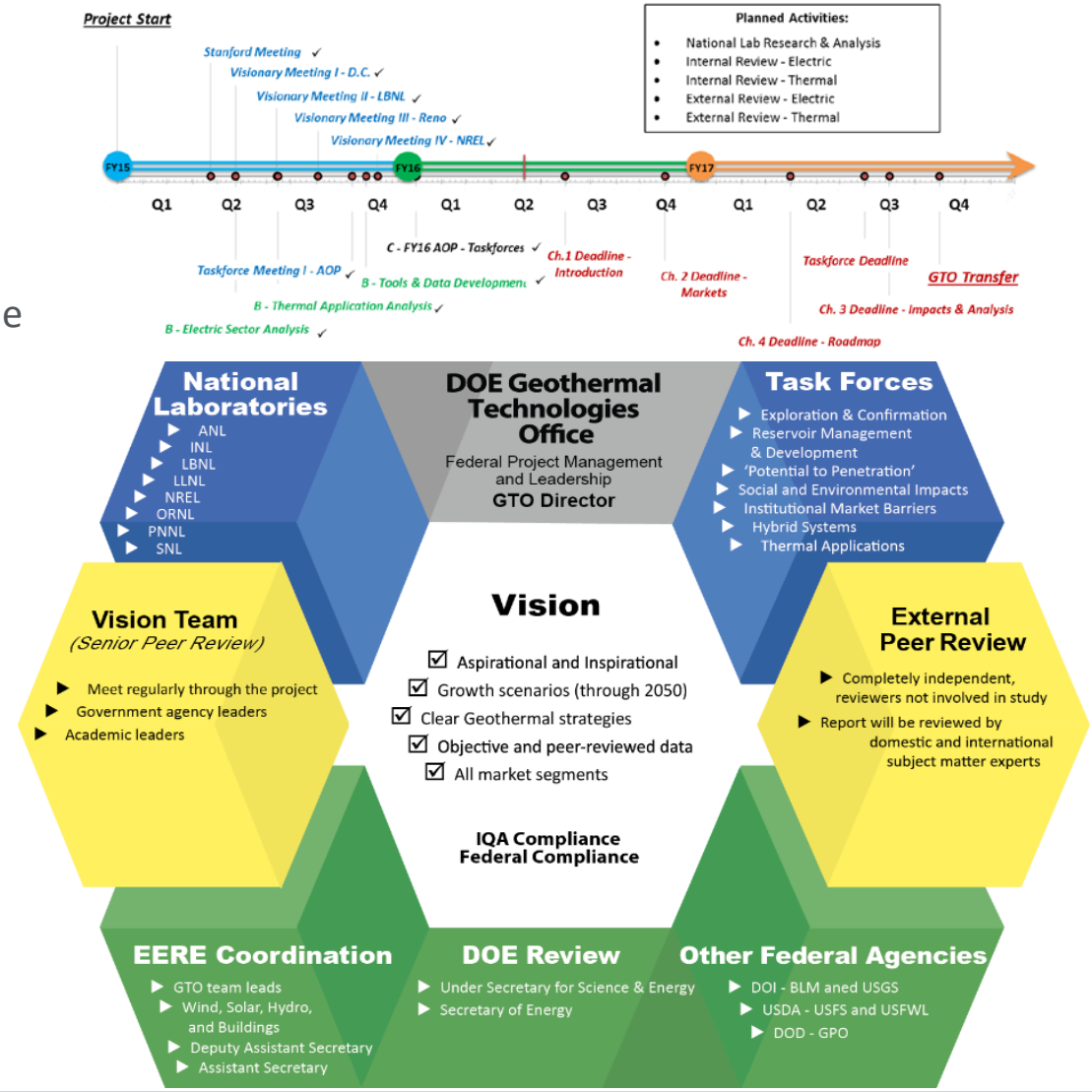
DOE seeks to develop credible analysis jointly with the geothermal community that:

- 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***



Geothermal Vision Study (GeoVision)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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***