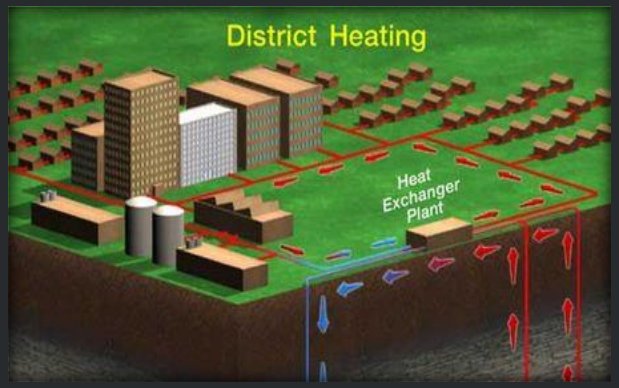
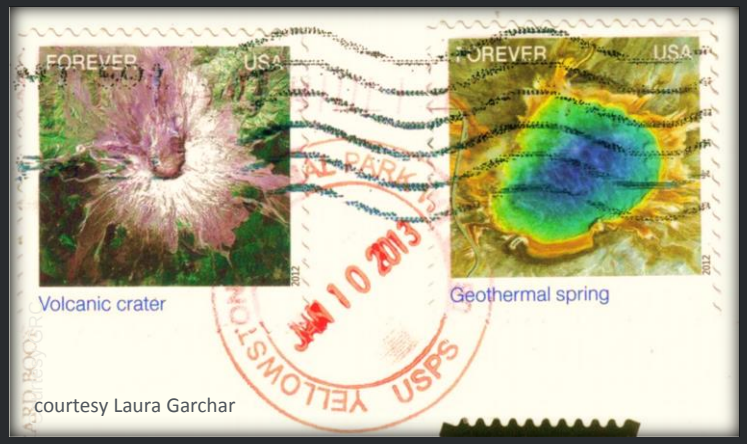
Geothermal Vision Study

May 11th, 2015





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

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Information Quality Act

IQA Compliance

The Office of Management and Budget's "Final Information Quality Bulletin" provides guidelines for properly managing peer review at Federal agencies in compliance with Pub. L. No. 106-554, § 515(a), the Information Quality Act. Consistent with those guidelines, meeting minutes will be recorded at the meeting and may be made publicly available subsequently.

Today's meeting invites your input regarding the DOE Geothermal Vision Study. It would be most helpful to us that you provide us your individual advice, based on your personal experience, information, or facts regarding this topic. It is not the object of this session to obtain any group position or consensus. Rather, the Department is seeking as many recommendations as possible from all individuals at this meeting. To most effectively use our limited time, please refrain from passing judgment on another participant's recommendations or advice, instead concentrating on your individual experiences.

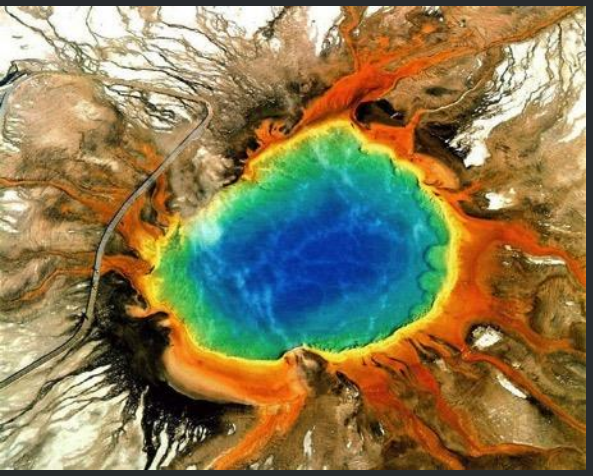
Project data sensitivity and confidentiality

Discussion or dissemination of in-process data or products can undermine Vision message and credibility

Geothermal - Potential

- Mean electric power generation potential from **Identified Geothermal Systems** alone is **9,057 MWe**, distributed over 13 states. (USGS National Geothermal Resources—Fact Sheet FS 2008-3082).
- Mean estimated power production potential from **Undiscovered Geothermal Resources** is **30,033 MWe** (USGS National Geothermal Resources—Fact Sheet FS 2008-3082).
- DOE estimates **100,000+ MWe** (http://energy.gov/eere/geothermal/downloads/enhanced-geothermal-system-egs-fact-sheet-1) could be generated through the implementation of **Enhanced Geothermal Systems (EGS)** technology for creating geothermal reservoirs in regions characterized by high temperature, but lower permeability rock formations.
- The preliminary analysis presented at 2013 DOE Peer Review on April, 24, 2013 shows the beneficial heat from Low Temperature Systems is ~**44,300 MWt** (http://energy.gov/sites/prod/files/2014/02/f7/gs_resource_assessment_peer2013.pdf).
- High Temperature Sedimentary resource potential evaluation analysis is underway.

GTO Vision Study



In 2016, DOE seeks to develop credible analysis jointly with the GEA/GRC community that:

I. Articulates clear ***GTO investment strategies*** across different sectors and has a cohesive plan to attain the goals;

II. Discusses ***geothermal growth scenarios*** for 2020, 2030 and 2050 backed by robust data, modeling and analysis;

III. Addresses *all market segments*: existing and potential hydrothermal, electrical and non-electrical usages, new EGS sector, and other value streams; and is

IV. Supported by *objective and* ***peer-reviewed industry data*** and *available to decision-makers*

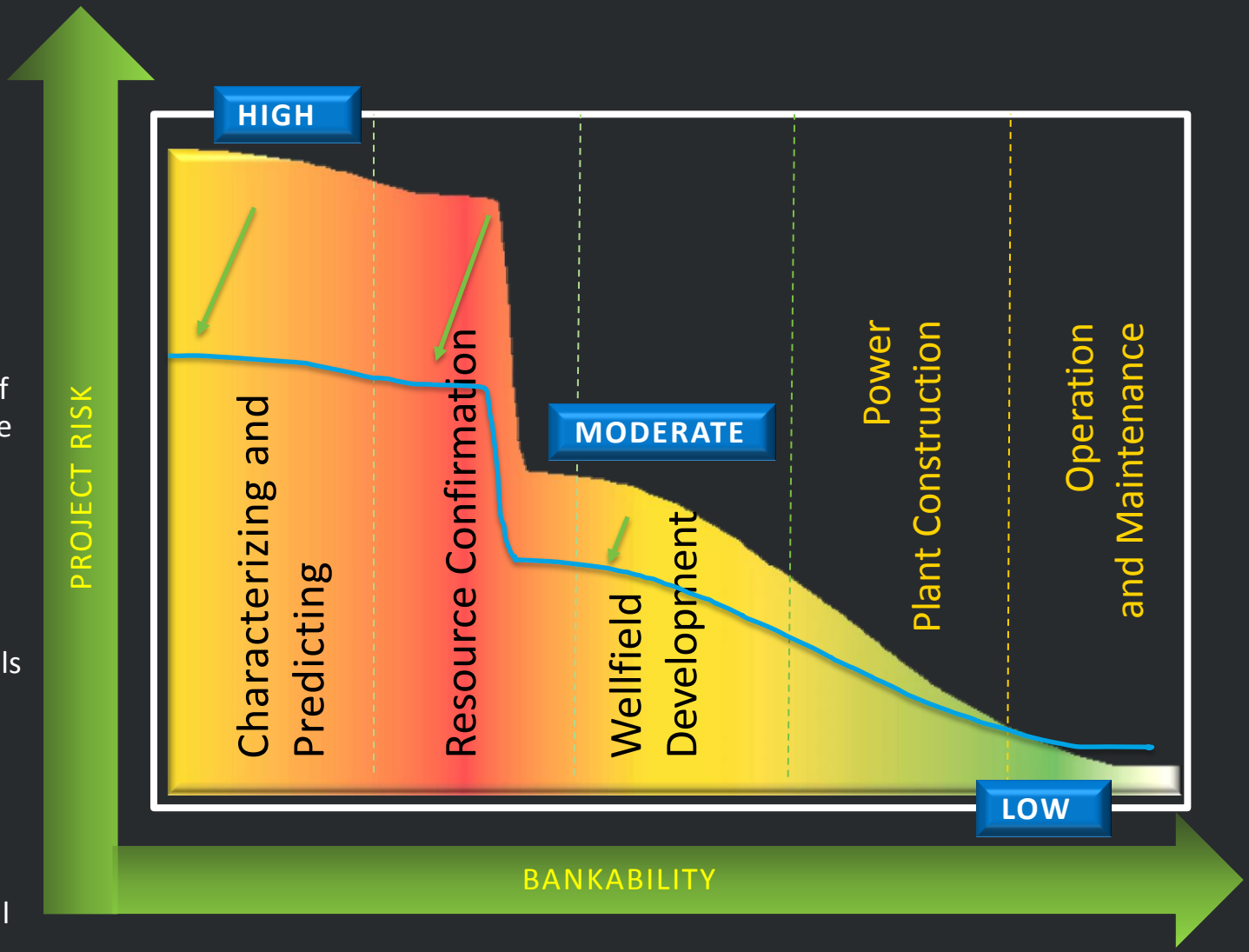
V. Is ***aspirational*** and ***inspirational***

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:

- Reducing exploration cost and risk - "Play Fairway Analysis and Validation, new signals
- Innovative new tools and techniques that improve and sustain reservoir life – EGS & Hybrid
- Developing additional revenue stream – thermal applications and mineral extraction

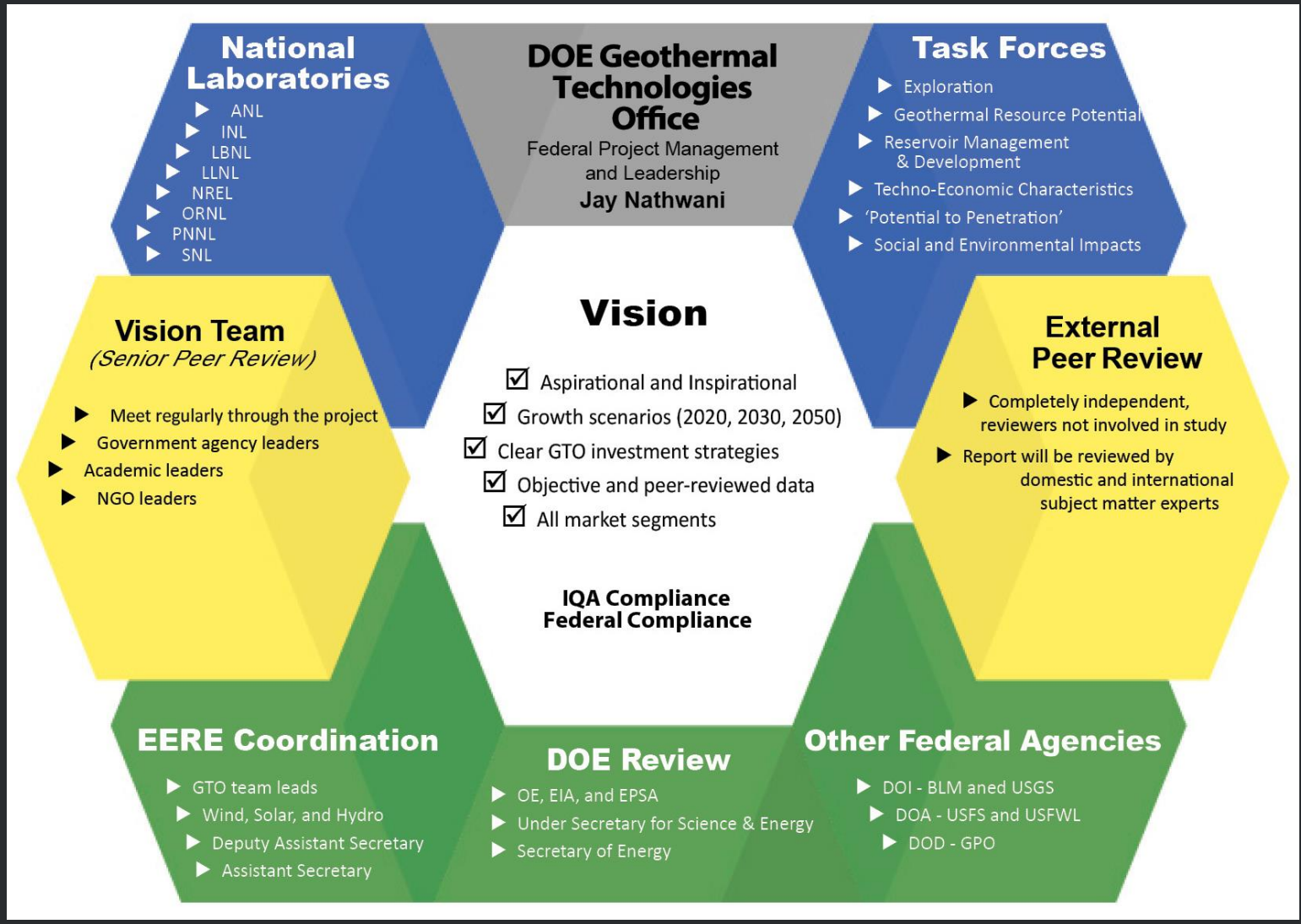


Key Questions

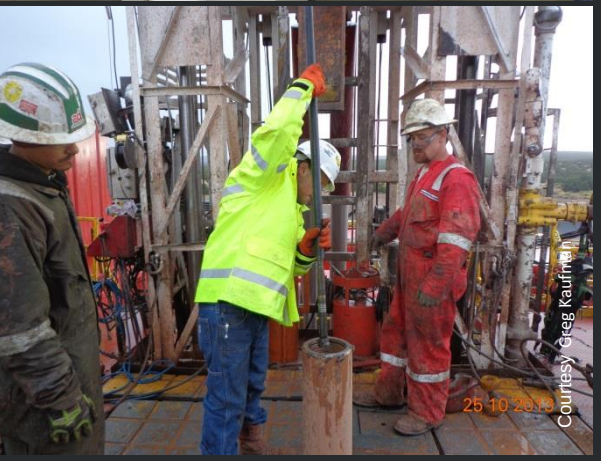
Current: DOE Geothermal Vision 2016
Redefine and Enhance Geothermal Vision

- What is the state of geothermal (power and heat) in the US today?
- Will it be competitive in the near-(2020), mid-(2030), and long-term (2050)?
- Where is it likely to be most competitive? Why?
- What are the costs, benefits, and impacts within the context of the broader sector trend?
- What technical and economic factors will be needed to sustain and enhance the growth of geothermal through 2020, 2030, and 2050?
- What are the high value pathways and priorities that will help us achieve our vision?
- How will geothermal be a key part of the national energy and climate change priorities?

Federal Project Management and Leadership

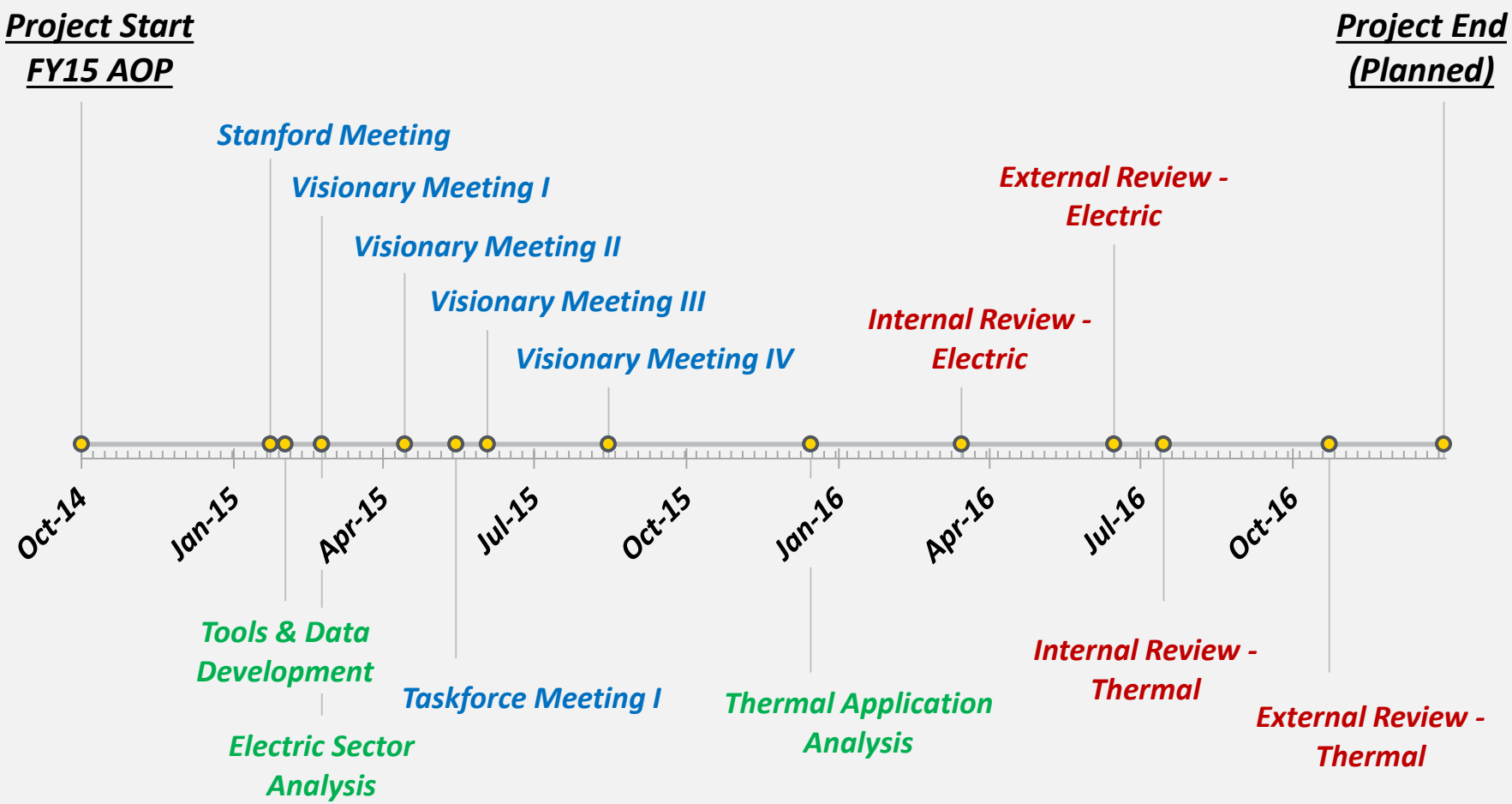


Geothermal Vision Approach



- **Models and tools first**
  - Establish current state of available models + data
  - Develop new/modified models as required
- **Phased Parallel Approach**
  - Assess what we have, what we need
  - Identify gaps (data, tools, models etc.)
- **Utilize general approach from recent DOE Wind Vision Study , but the content, structure and the analysis included in the study needs to be different as follows:**
  - Use existing technology roadmaps
  - New roadmaps would be update or modified as appropriate
  - Baseload renewable, unlike other renewables, will require modified analytical decision tools e.g., Regional Energy Deployment System (ReEDS)
- **Analysis will be conducted by National Laboratories**
  - NREL, LBNL, INL, SNL, ANL, LLNL, PNNL, ORNL
- **Stakeholder engagement**
  - Visionary Working Group
  - Briefings of early results with Industry and academia
- **Proposed completion of Phase I in 2016**

GTO Vision Study Timeline



Vision Study - Objective

The Geothermal Vision Study will conduct a credible analysis of potential geothermal growth scenarios for 2020, 2030, and 2050 across multiple market sectors.

Market Sectors: Power Generation, Thermal Application

Vision Study – Additional Goals

Assess the recent history of geothermal development in the United States

Assess and quantify the range of costs, benefits and impacts of the scenarios

Identify investment strategies to achieve the high-growth scenario target and articulate a clear GTO investment strategy to achieve this outcome.

Scope

- Market sectors will include the existing and potential growth for **geothermal electric generation**, **thermal applications**, and other **additive value streams**.
- Results of the Vision Study will identify the potential for geothermal energy to be a key part of the national energy and climate change priorities, and **articulate a clear GTO investment strategy** across the different sectors to achieve this outcome.
- The Vision Study will **analyze growth scenarios for 2020, 2030, and 2050**
- The Vision Study will initially focus on the electric sector in the first phase with adequate emphasis for **non-electrical applications**.
- The electric sector portion of the study is to be completed **by 2016**.
- During phase I, tools and data will be developed for **non-electric geothermal applications** necessary for second phase of the Vision Study,
- Phase II planned completion **in 2017.**

Vision Stakeholders

- Core Team – Responsible for key project deliverables.
- Working Groups – Specific analysis topics will be addressed by Task Forces. Each Task Force will produce a deliverable required in the project, and will be led by a member from a National Laboratory. The Task Forces will be coordinated by NREL.
- Visionary Team – This team will provide ongoing comments on the study direction and interim results. The team will have approximately 15-20 members, with each member required to participate in person (i.e., cannot be delegated) and will meet quarterly. Requirements for being selected for membership in the team include:
  - Respected Domain Knowledge
  - No Financial COI
  - Ability to commit the time for the duration of the project
  - Ability to collaborate with a diverse team of geothermal industry and subject experts to advance objectives of the Vision Study
- DOE Review Team – Includes multiple organizations at DOE that are responsible for ensuring all aspects of the quality of the final product.

Roles

Function	Lead
Executive Sponsor	Jay Nathwani – GTO (Acting) Director
Project Coordinator	Christopher Richard - BCS, Incorporated (GTO Contractor)
GTO SALT	Timothy Reinhardt
GTO EGS	Lauren Boyd
GTO Hydrothermal	Eric Hass
Project Support	Stacy Morris – Redhorse (GTO Contractor)
NREL Project Manager	Tom Williams
NREL Analysis Lead	Chad Augustine

Taskforce Areas

I. Exploration:

Lead – Lawrence Berkeley National Laboratory

- How geothermal resources are identified today
- Exploration costs and risks
- Advanced technologies and potential future impacts

II. Geothermal Resource Potential:

Lead – National Renewable Energy Laboratory

- Hydrothermal
- Coproduction
- Near-Field EGS
- Greenfield EGS

Taskforce Areas – Continued

III. Reservoir Development and Management :

Lead – Sandia National Laboratory

- Drilling
- Understanding today's approaches for managing existing hydrothermal fields
- EGS technology
- Development costs and risks
- Advanced technologies and potential future impacts

IV. Techno-Economic Characteristics :

Lead – Idaho National Laboratory

- Capturing all the costs and technical issues not included above.
- Advanced technologies and potential future impacts

Taskforce Areas – Continued

V. Supply Curves and Market Impact

Lead – National Renewable Energy Laboratory

- Calculation of geothermal capacity
  - By geographic location
  - Initial capital cost, O&M, and LCOE
- Market Penetration Modeling
  - ReEDS model
  - Dozens of scenarios
  - Two Reference Scenarios
    - Business as usual
    - High renewable

VI. Social and Environmental Impacts:

Lead(s) – TBD

- Greenhouse (GHG) emissions
- Water Access and Usage
- Jobs and Economic Impact
- Induced seismicity and other environmental concerns

Taskforce Areas – Continued

VII. Soft Costs:

Lead – National Renewable Energy Laboratory

- Non-technical barriers that create delays, increase risk, or increase the cost of project development. Examples are permitting time, challenges in developing PPA, access to transmission, etc.

GTO Vision Study Taskforce – Lab Capabilities

Primary	Secondary

Taskforce Area	ANL	INL	LBNL	LLNL	NREL	ORNL	PNNL	SNL	USGS
I. Exploration: How geothermal resources are identified today, advanced technologies that can improve this.		Secondary	Primary					Secondary	
II. Geothermal Resource Potential: How much resource is available, where is it located, what are the technical requirements to develop it. This team will create scenarios of location-specific resource profiles (hydrothermal and EGS) that can be used in estimating the LCOE as a function of location (Task 4). Primary tasks include characterizing current resource potential data and determining if and how resource potential estimates can be improved for Vision Study.					Primary				Secondary
III. Reservoir Management and Development: Understanding today's approaches for managing existing hydrothermal fields and opportunities for EGS (both near-field and green-field). Also includes drilling.			Secondary	Secondary			Secondary	Primary	
IV. Techno-Economic Characteristics *: This task captures all the costs and technical issues not included above. The team understands current technology and opportunities for technology improvement.		Primary			Secondary	Secondary		Secondary	
V. "Potential to Penetration" **: This task integrates resource information and the LCOE results of Task 4 to develop location-specific estimates of an LCOE supply curve (how much geothermal can be produced as a function of the total cost of development). This team has an understanding of technology competition in national markets and utilization of the ReEDS model. One responsibility of the team is to ensure that assumptions and analysis in the geothermal vision study are consistent with that of the wind and solar vision studies (NREL staff have supported those studies using the ReEDS model).		Secondary			Primary			Secondary	Secondary
VI. Social and Environmental Impacts: This team has knowledge of both the benefits and areas of concern for geothermal power development. Examples include water use, greenhouse gas impacts, jobs creation, land use, induced seismicity.	Primary		Primary		Secondary				
VII. Soft Costs: This team understands the current business and regulatory issues related to geothermal power development. Captures non-technical barriers that create delays, increase risk, or increase the cost of project development. Examples are permitting time, challenges in developing PPA, access to transmission, etc.					Primary				

Activities to Date:

January 27th, 2015

- Plenary Meeting – Stanford Geothermal Workshop

February 23rd, 2015

- Visionary Meeting – Washington, D.C.
  - Presenters: NREL and INL

April 14th, 2015

- Visionary Meeting – Berkeley, CA (Lawrence Berkeley Lab)
  - Presenters: USGS, NREL, and INL

May 11th, 2015

- Taskforce Announcement – Denver, CO (GTO Peer Review)

Future Activities:

June 2015

- Visionary Meeting – Reno, NV

August 2015

- Visionary Meeting - TBD

Q2/2015 to Q1/2016

- Model Validation and Analysis
  - DOE, USGS, NREL, INL, LBNL, LLNL, ORNL, PNNL, ANL, and SNL

Q3/2015 to Q4/2016

- Taskforce Analysis and Development of Report
  - DOE, USGS, NREL, INL, LBNL, LLNL, ORNL, PNNL, ANL, and SNL

Q1/Q4 2016

- Report Peer Review (external subject matter experts)

Conclusions:

I. Articulates clear ***GTO investment strategies*** across different sectors and has a cohesive plan to attain the goals;

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Questions

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General Comments/Questions:

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