Geothermal Technologies Office (GTO)

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

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Systems Analysis and Low Temperature (SALT)

Geothermal Perspectives

Why is it Important – and Why Should We Care?

Large, Global Resource

- 3.4 GWe US installed
- 12 GWe worldwide
- 12 GWe global under development

Baseload, Renewable Energy, with Low Emissions

Potential for expansion beyond the traditional "hot" regions in the U.S.

- +30 GWe hydrothermal "yet-to-find"
- +100 GWe possibility for EGS
- Significant "low temp" potential

Opportunity for Significant Growth

will require more knowledge of and R&D regarding subsurface

GTO Key Goals, Objectives, and Priorities

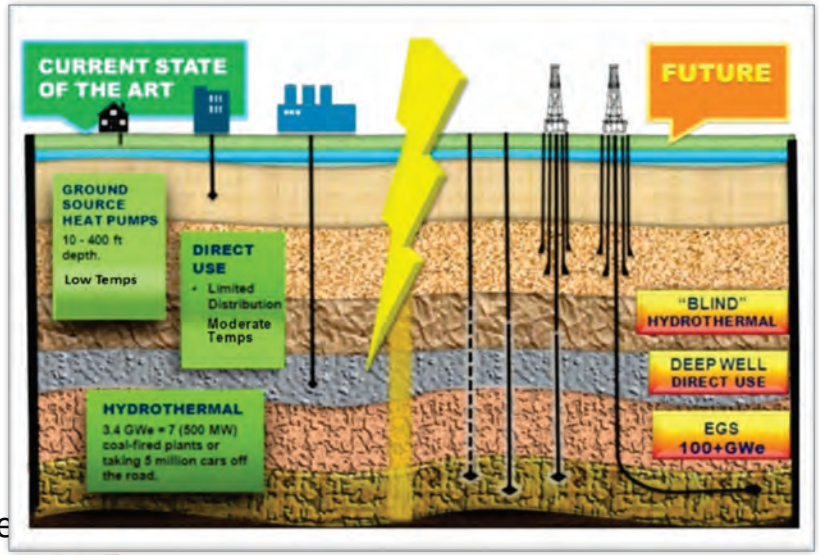
Transition from Near to Long Term

	Low Temp	Co-Production	Blind Hydrothermal	In- and Near-Field EGS	Greenfield EGS
Timeline	**Near Term**	**Near Term**	**Near to Intermediate**	**Near to Intermediate**	**Long Term**
Strategy	Utilize waste-heat / promote distributed energy	Leverage O&G infrastructure	Promote Sector Growth	Maintain / expand existing fields	Develop replicable model for commercial scale-up
Scale	**100's KW to several MW scale**	**10's-100's MW, aggregate to GWs potential**	**10's GW additional potential**	**5 - 10GWs potential- low risk**	**10's - 100's GW potential - higher risk**
Constituency	Local Direct Use	Growing Interest, New Potential Sector	Majority of the Private Sector	Private Sector, very few companies to date	High potential for growth and new entrants resulting from EGS Field Observatory

GTO Key Goals, Objectives, and Priorities

Identify New Geothermal Opportunities

- Lowered risk and cost
- New prospecting workflow/*"Play Fairway"*
- "*Play Fairway* " validation and industry engagement



Accelerate a Commercial Pathway to EGS

- Frontier Observatory for Research in Geothermal Energy (FORGE)
- Reservoir characterization/creation technologies

Subsurface Engineering Crosscut

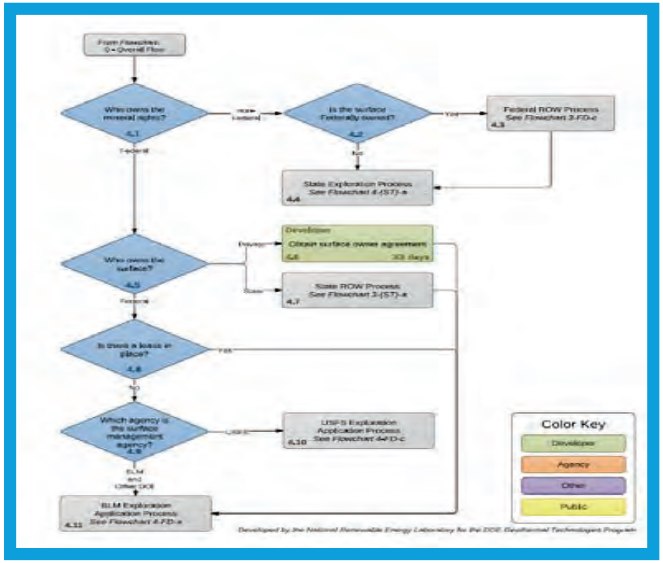
- Intra- and inter-agency efforts to address common subsurface challenges and better leverage DOE funding

Overcome Deployment Barriers

- National Geothermal Data System: Reducing upfront exploration cost

Additive Value

- Co-production and Distributed Power
- Mineral Recovery



Vision Study/Strategic Analysis

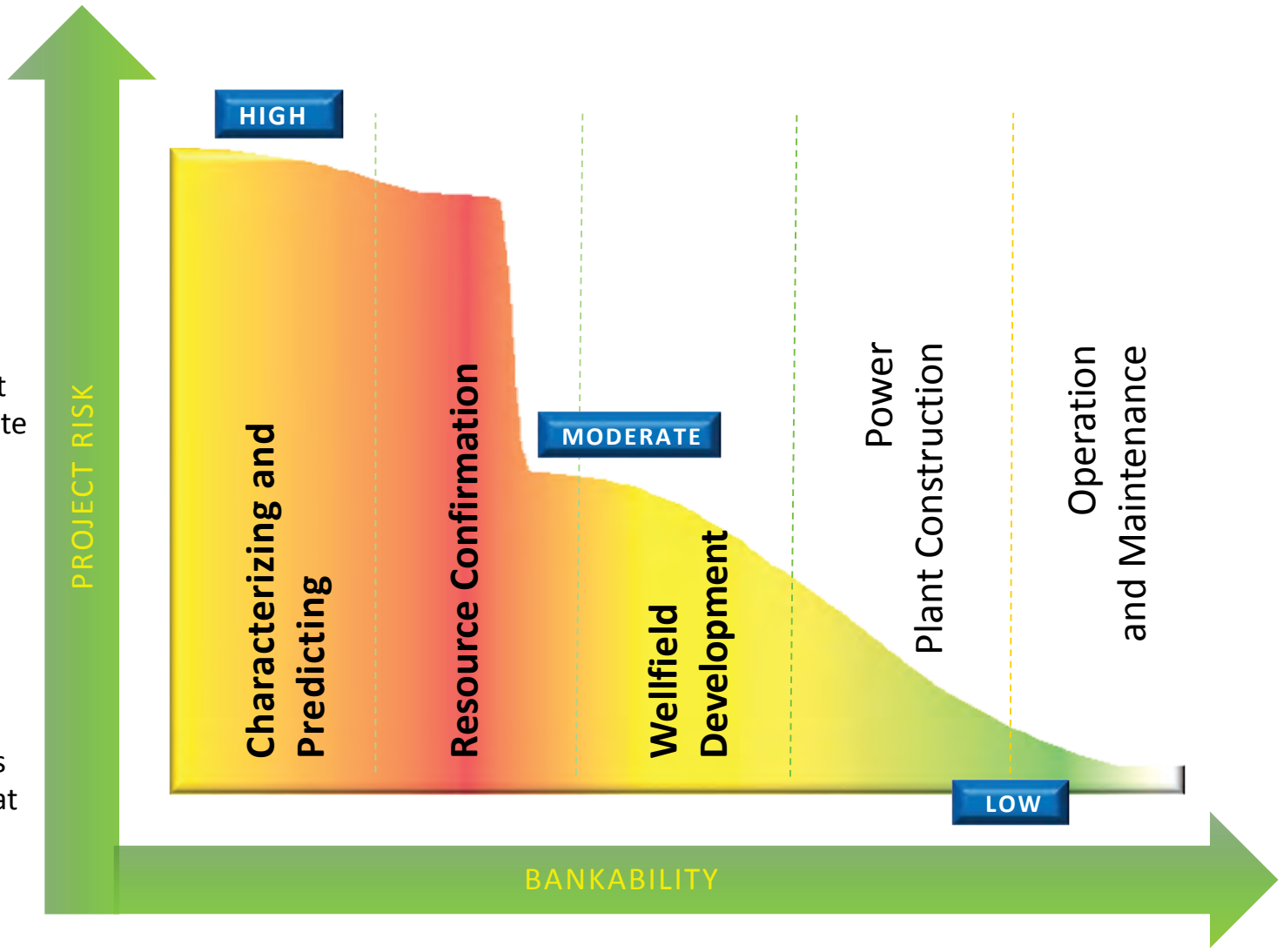
- Identify likely out-year issues for GTO
- Better guide funding decisions

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:

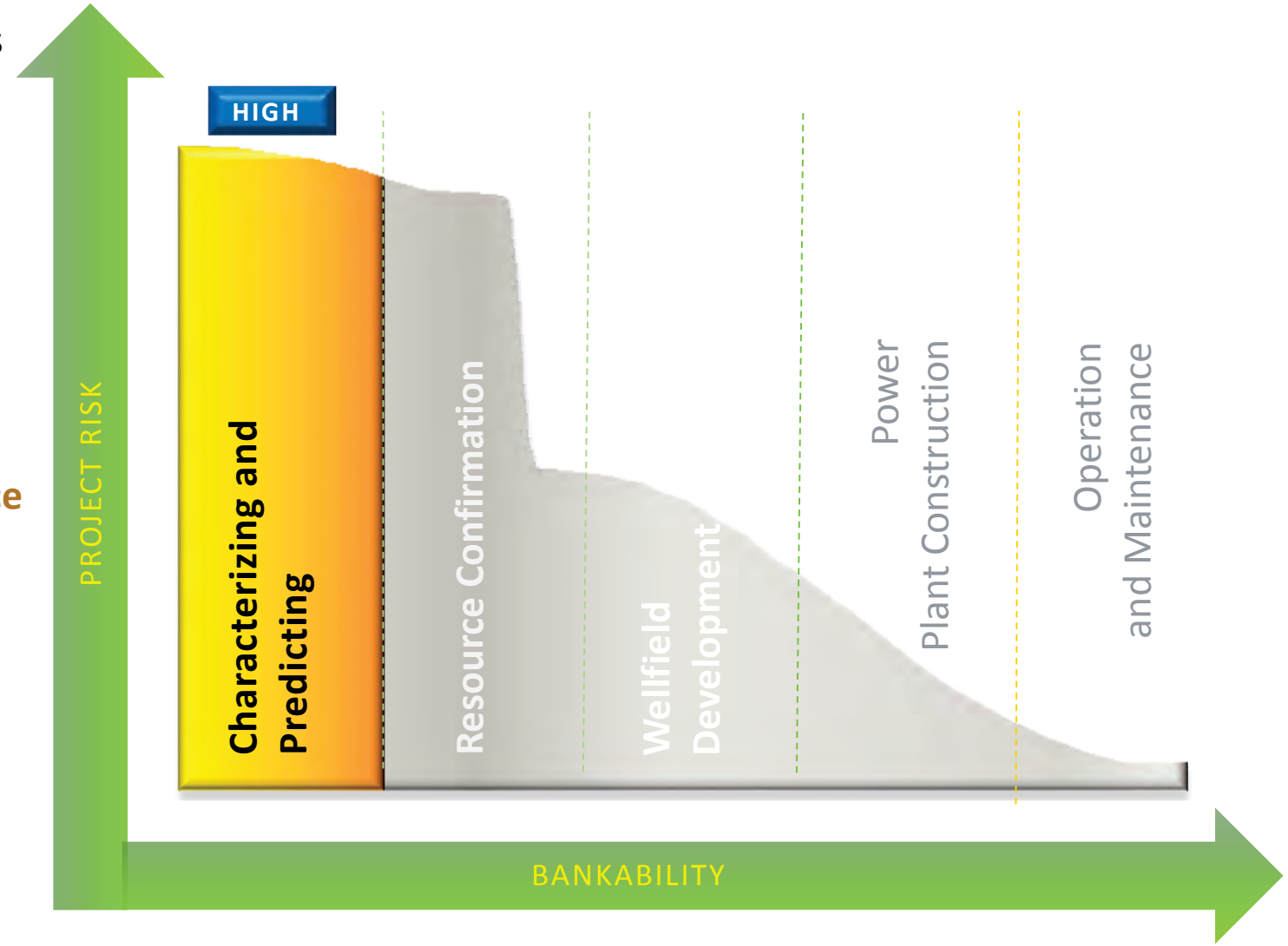
- Better targeted drilling
- Improved under-standing of the subsurface
- Innovate new tools and techniques that improve the value equation
- Lower upfront costs



Stage One: Characterize the Subsurface

Mitigate the risks of geothermal exploration

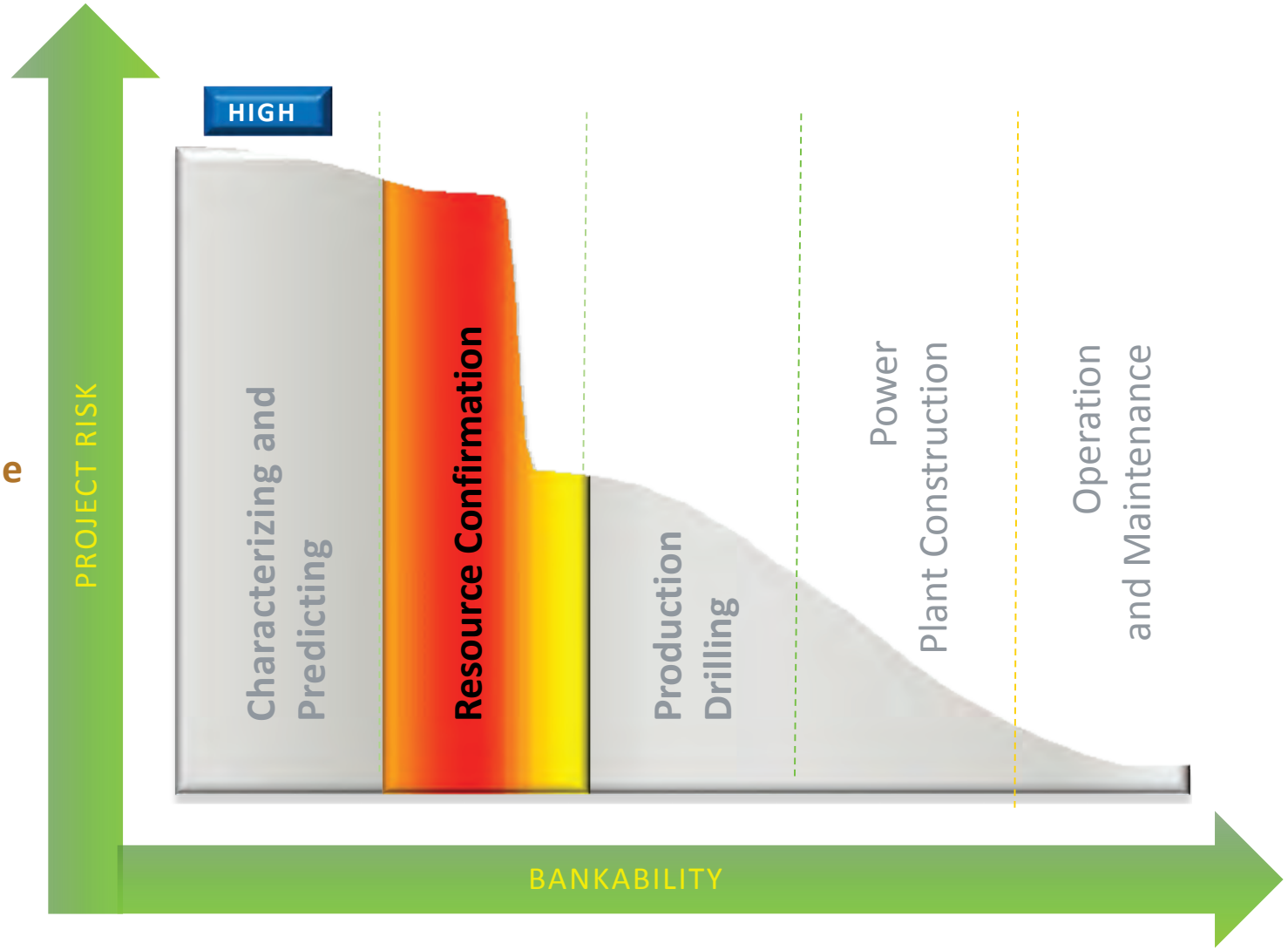
- National Geothermal Data System
- Play Fairway Analysis
- New Subsurface Signals
- Geochemical/ Geo-physical Tools
- Exploration Decision Tree



Stage Two: Resource Confirmation

Validate and confirm the resource with:

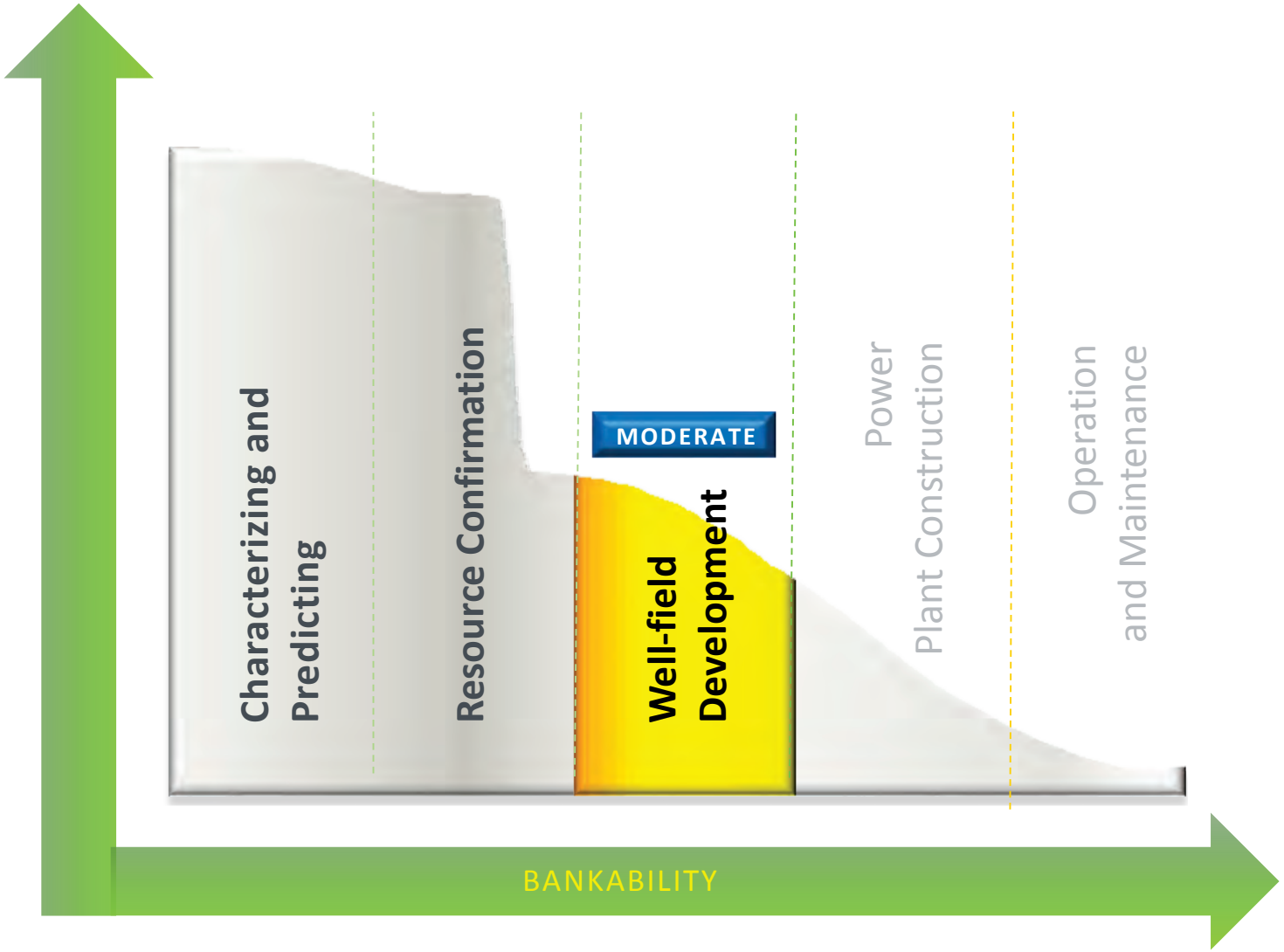
- **Innovative exploration drilling**
- **Microdrilling**
- **Novel downhole tools**
- **Flowtesting**



Stage Three: Wellfield Development

Reservoir engineering & optimization

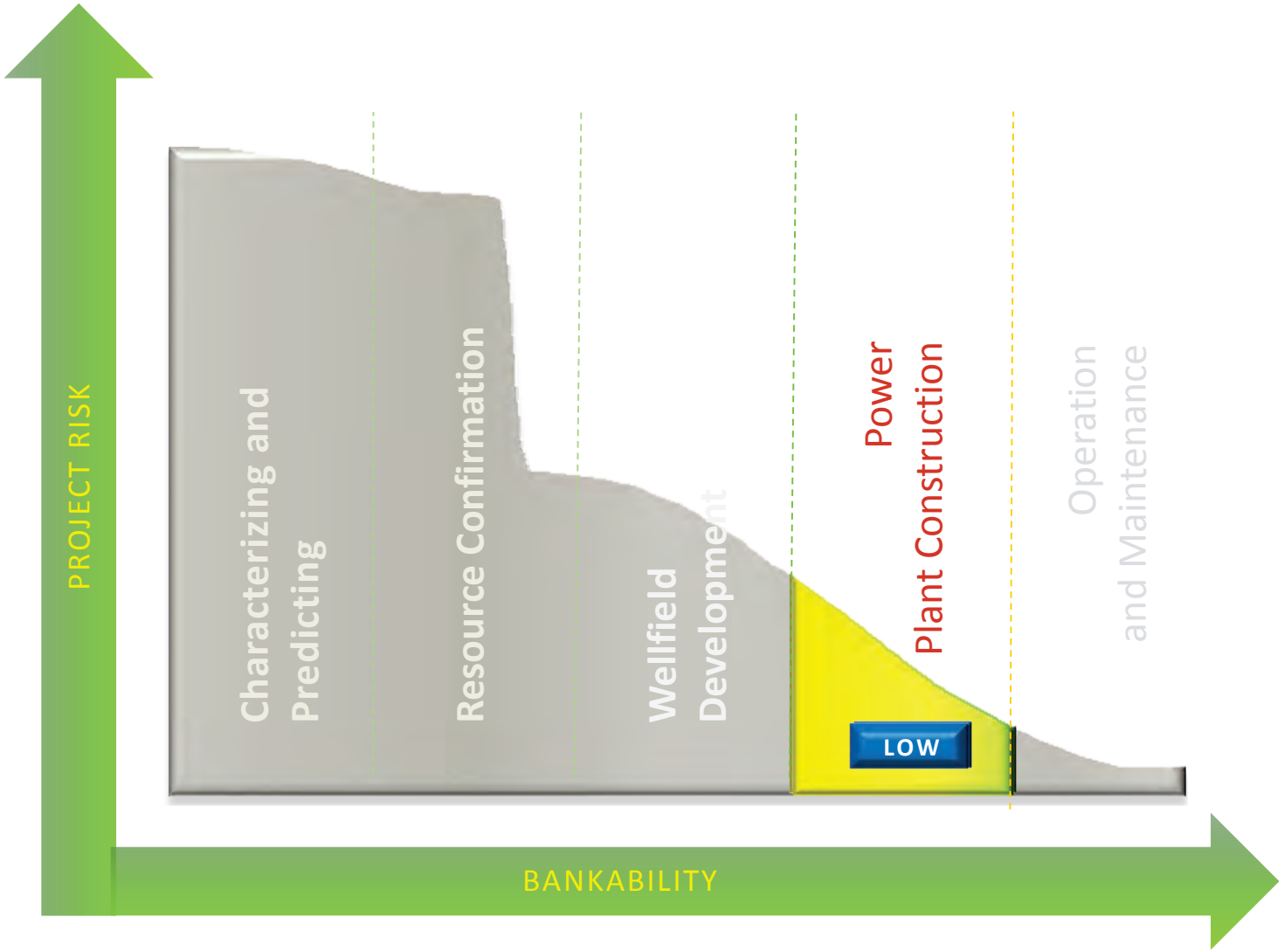
- EGS R&D
- FORGE Laboratory
- Subsurface Crosscut



Stage Four: Power Plant Construction

Enhancing efficiencies

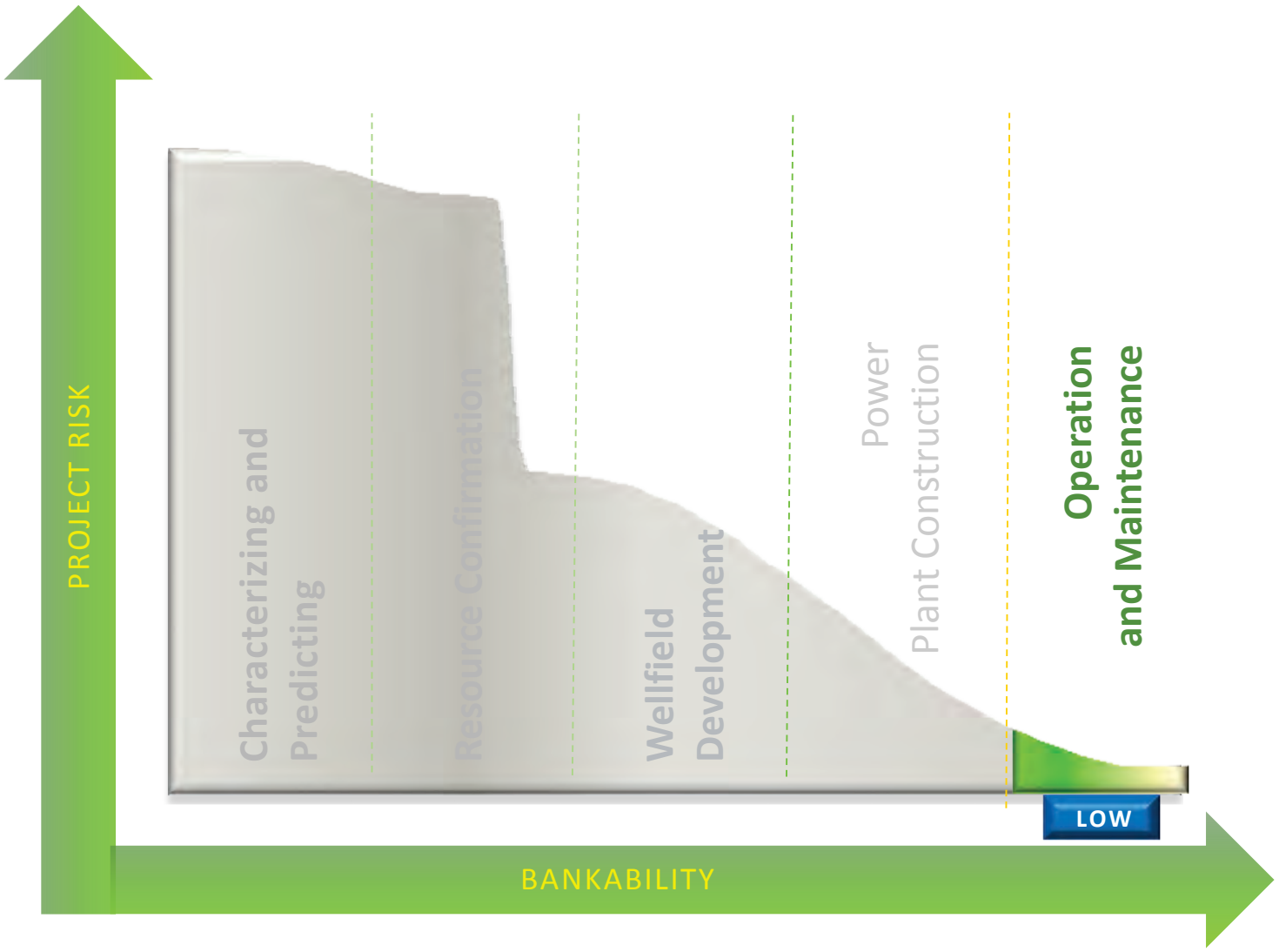
- Hybrid Power Systems
- Advanced heat transfer cycles
- Low-temperature applications
- Direct use & cascaded use



Stage Five: Operation & Maintenance and Additive Value

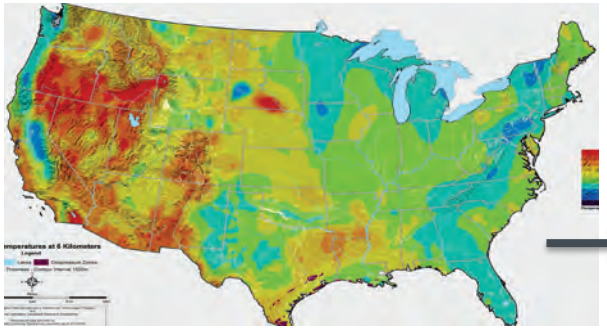
Increasing value propositions to make geothermal more economical

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

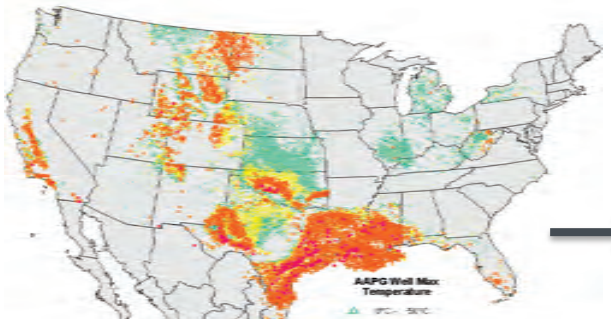


Low Temperature and Coproduced Resources

Low temperature, coproduced and geopressured resources are geographically widespread



Low temperature geothermal resources more widely distributed than conventional hydrothermal resources, spreading into the upper Midwest and Gulf Coast region



Coproduction – hot water is a by-product of oil & gas wells. Resource quality depends on the amount of water produced & temperature .*The map shows oil & gas wells by temperature (red = hottest; green = coolest*)

Geopressured wells primarily located in the Gulf region, in the lower cretaceous shelf margin (*yellow band in the map*)

Key Elements

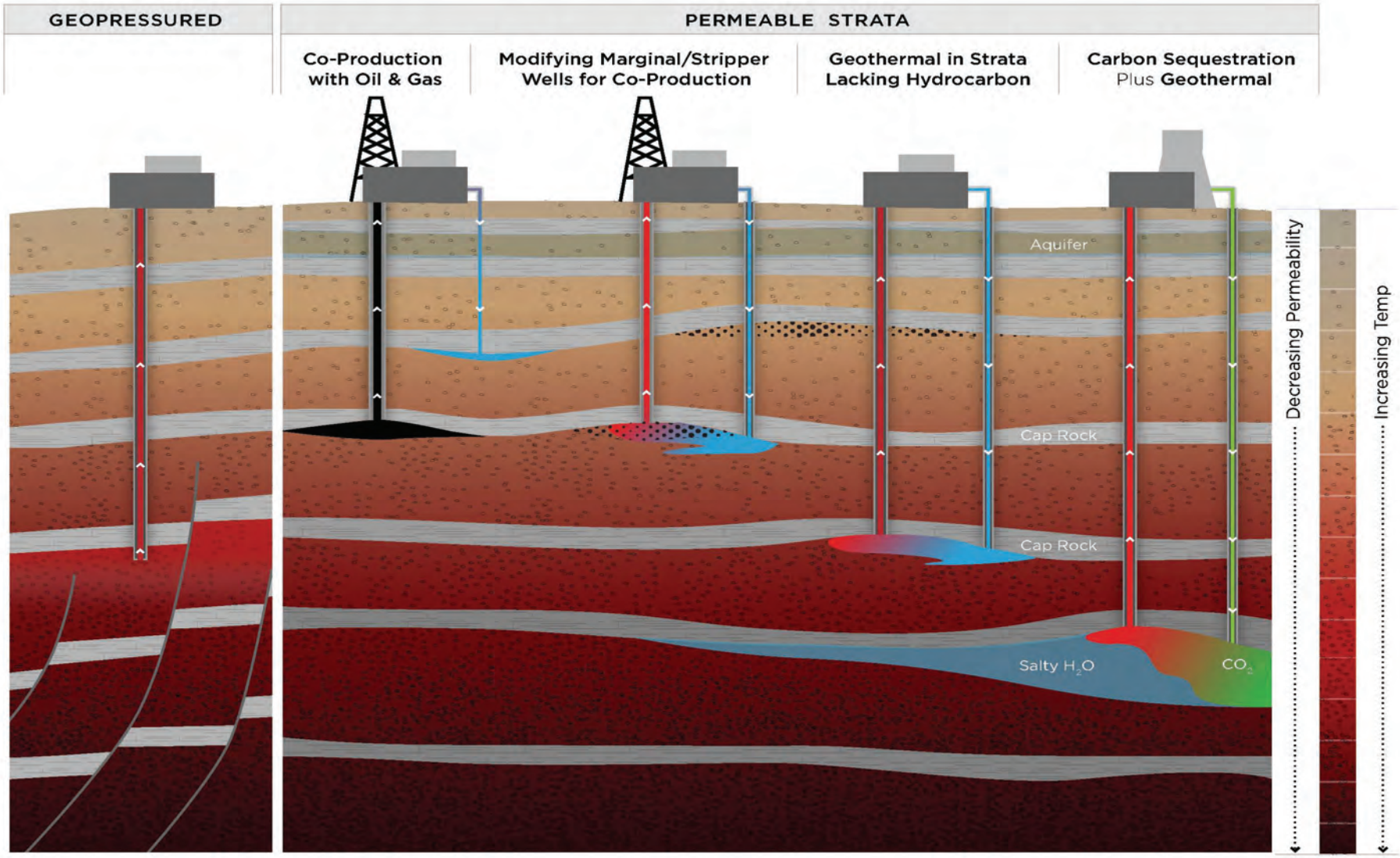
These resources include:

- Low temperature (under 150° C) hydrothermal
- Resources coproduced with oil or gas
- From geopressured wells
- Other revenue streams

Opportunity

These largely untapped resources can open up new geographic areas to geothermal development and bring more MW online in the near-term

Spectrum of Low Temperature and Coproduced Resources

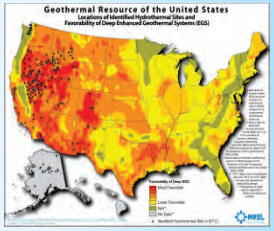


Key Barriers to Low Temp Expansion

Technology Barriers	*GTO-Funded Solution Set*	*GOAL*

Cooling Technologies

Air-cooled systems are constrained in hotter areas of the arid, but geothermal-rich Western U.S.



Fluid Value

Need additional uses/value streams to accommodate lower electricity value from low temp fluids

Energy Conversion

Improve efficiencies for lower temperatures, operation & maintenance, cost

Leveraging O&G infrastructure

Innovative conversion cycles

Hybrid cooling cycles

Materials Extraction

Desalination Technologies

Improved binary system components

Hybrid Technologies

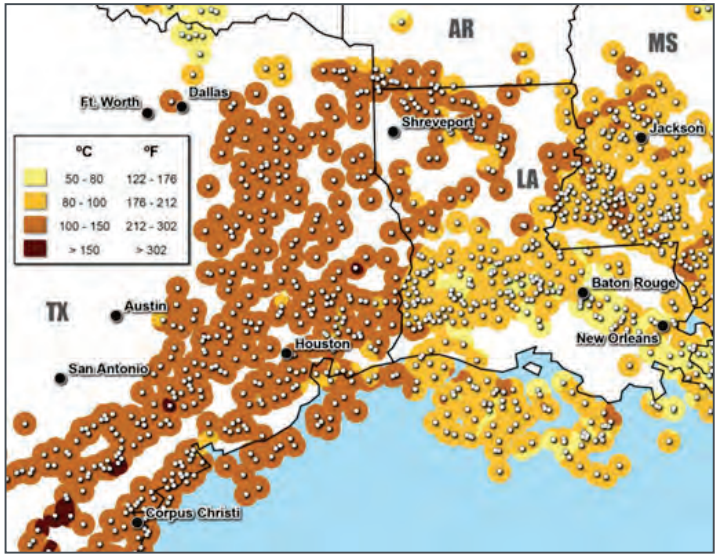
Coproduction

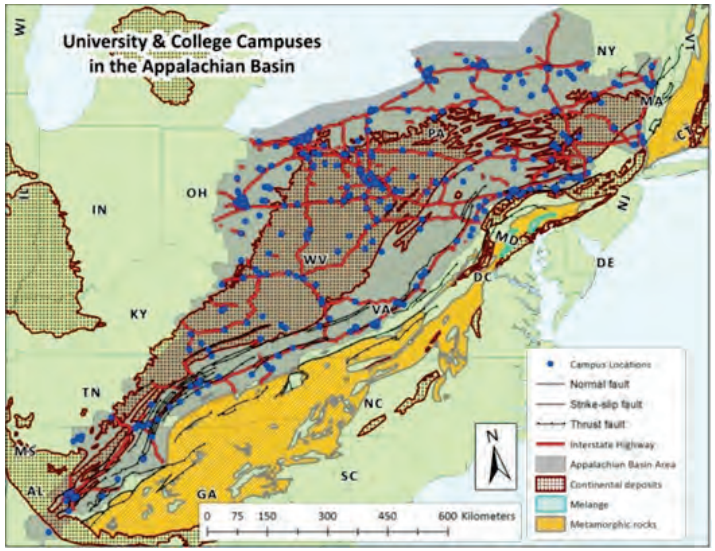
Low-Temp & Co-pro Growth

Game-changers

What's next for Low Temperature?

Materials Extraction, Direct-Use, Hybrid Systems





- Execute on **Coproduction** initiative
- **Mineral Recovery** - Resource assessment and feasibility
- Large-scale **Direct Use**: where does it make technical and commercial sense?
- **R&D** on innovative energy conversion/Hybrid Systems

Low Temperature Geothermal Mineral Program 2014

GTO awarded 9 phase I projects to industry, national labs, and universities totaling $3M for project periods ranging from 12-24 months.

Contingent on availability of funds, GTO may issue future FOAs for additional phases of research.

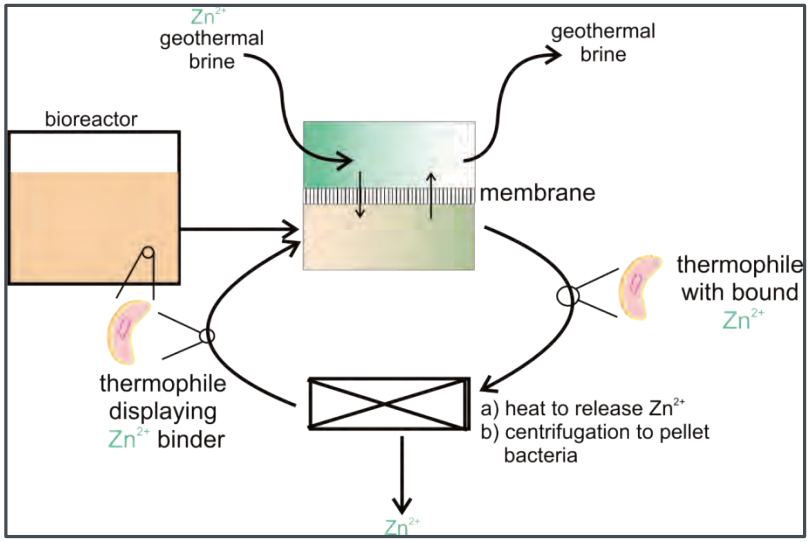


Figure above provided by Lawrence Berkeley National Laboratory showing their process schematic for mineral extraction using thermophiles

Funding Opportunity Objectives

Strategic mineral extraction as a path to optimize the value stream of low-to-moderate temperature resources. Technologies to economically extract and capture, concentrate, and/or purify valuable materials contained within geothermal brines work in tandem with advancing thermal energy processes capable of converting geothermal heat sources to power.

Background

- Rare earth and near-critical metals are essential for clean-energy technologies, but subject to supply risk with ever increasing demand.
- Minerals like tellurium, lithium, manganese, and zinc supply the raw materials for cathodes, glass, ceramics, lubricants, and many other products.
- Many minerals also have critical value for advanced manufacturing technologies.

Relocation Project-Value Proposition: *Public/Private Partnerships*

DOE Geothermal Technologies Office (GTO) explores opportunities to partner with Industry to deploy binary systems in operating commercial oil and gas (O&G) fields. These GTP units could be available for two year demonstration periods.

100% proceeds/electricity goes to industry partner

The Rocky Mountain Oilfield Testing Center in Wyoming – one of the first projects to validate the use of coproduced geothermal fluids from oil and gas wells for power generation – generates 200 kW of electricity at this binary cycle plant.

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 Partners Provide:

- 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

Coproduced geothermal resources deliver near-term energy savings, diminish emissions, extend the economic life of oil and gas fields, and profitably utilize oil and gas field infrastructure.

(System Analysis) Market Barriers: Many Unique to Geothermal

Market Barriers	*Potential Solution Set*	*Goal*

Permitting Challenges
A non-competitive process can doom projects

Data Access
Creates more prospects, lower risk and cost, more efficient geothermal research and resource development

Financing
Relatively small size of the Industry + perceived risk = project financing challenges

Grid Integration
Solutions to supply geothermal electricity to the grid

- Regulatory streamlining
- National Geothermal Data Repository
- National Geothermal Data System
- Techno-economic analysis
- Modeling
- Market reports
- Vision study
- Environmental analysis

A Clearer Pathway for Geothermal Development

Game-changers

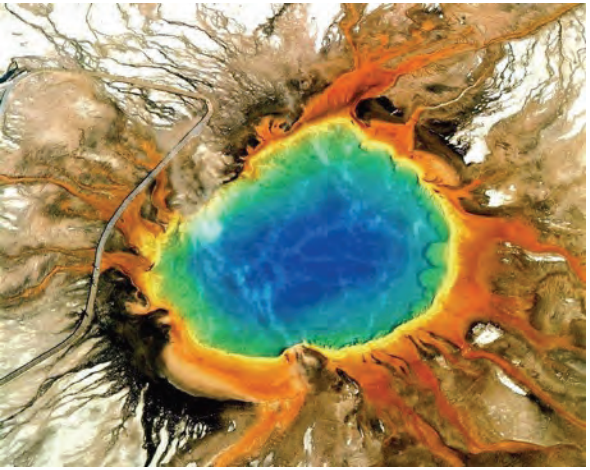
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

What's Next for Systems Analysis?

Techno-Economic Analysis and Validation, Regulatory Streamlining, Data Sharing

- Geothermal Vision Study
- Continued validation of GTO-funded efforts, including tracking of commercial and emerging commercial projects
- Continued collaboration with CEQ, BLM, state regulatory agencies, and industry to identify opportunities to responsible streamline the geothermal development permitting process
- Continued life-cycle analysis of environmental impact of geothermal (GHG, water)
- Continued development of data and tools to enable public sharing of GTO-funded RD&D results

GTO Vision Study



By 2016, DOE seeks to develop credible analysis jointly with the Geothermal 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***

Vision Study Objective

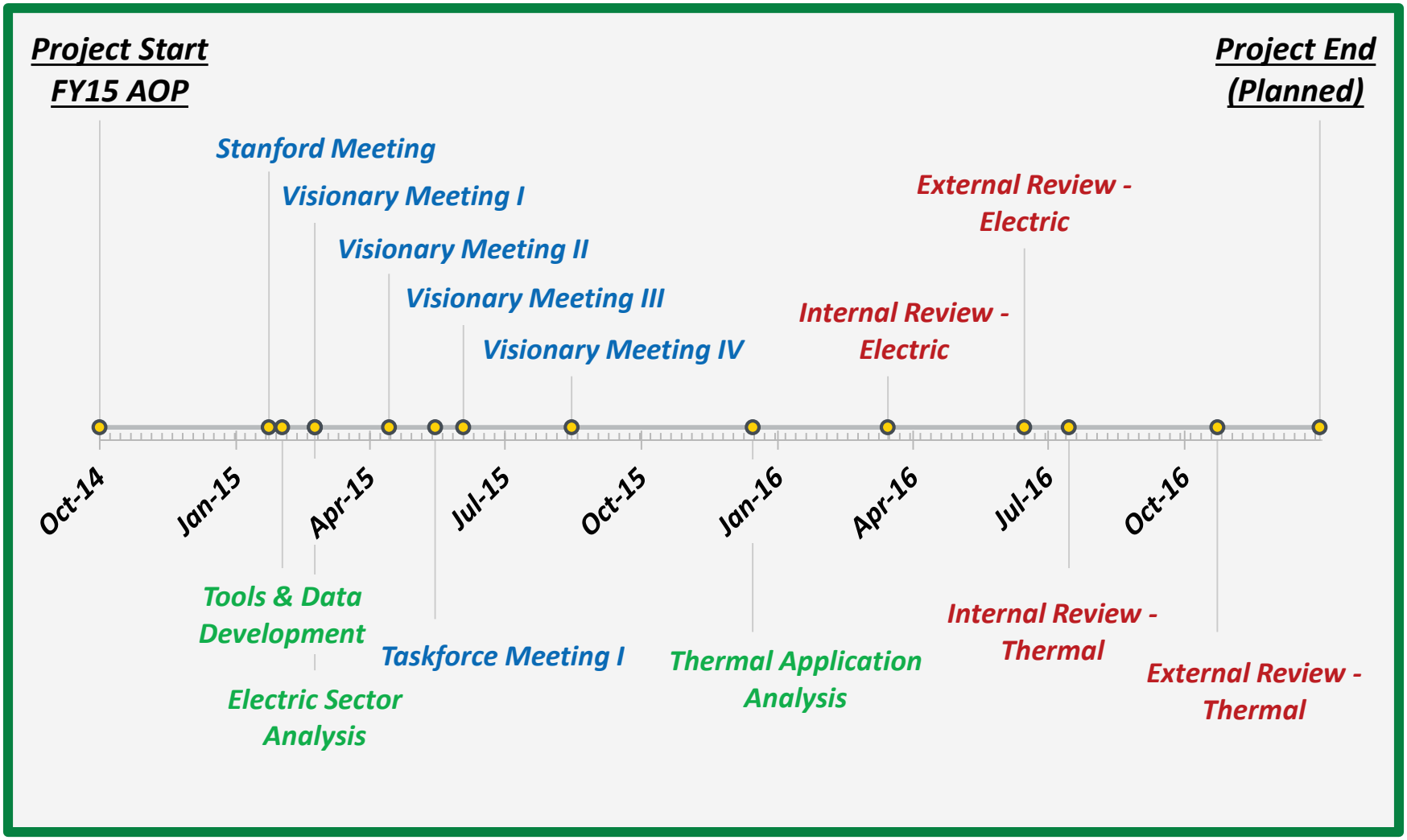
The Geothermal Vision Study will conduct a **credible** analysis of potential geothermal growth scenarios for 2020, 2030, and 2050 across multiple market sectors.

Market Sectors: Power Generation, Thermal Application

GTO Vision Study 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

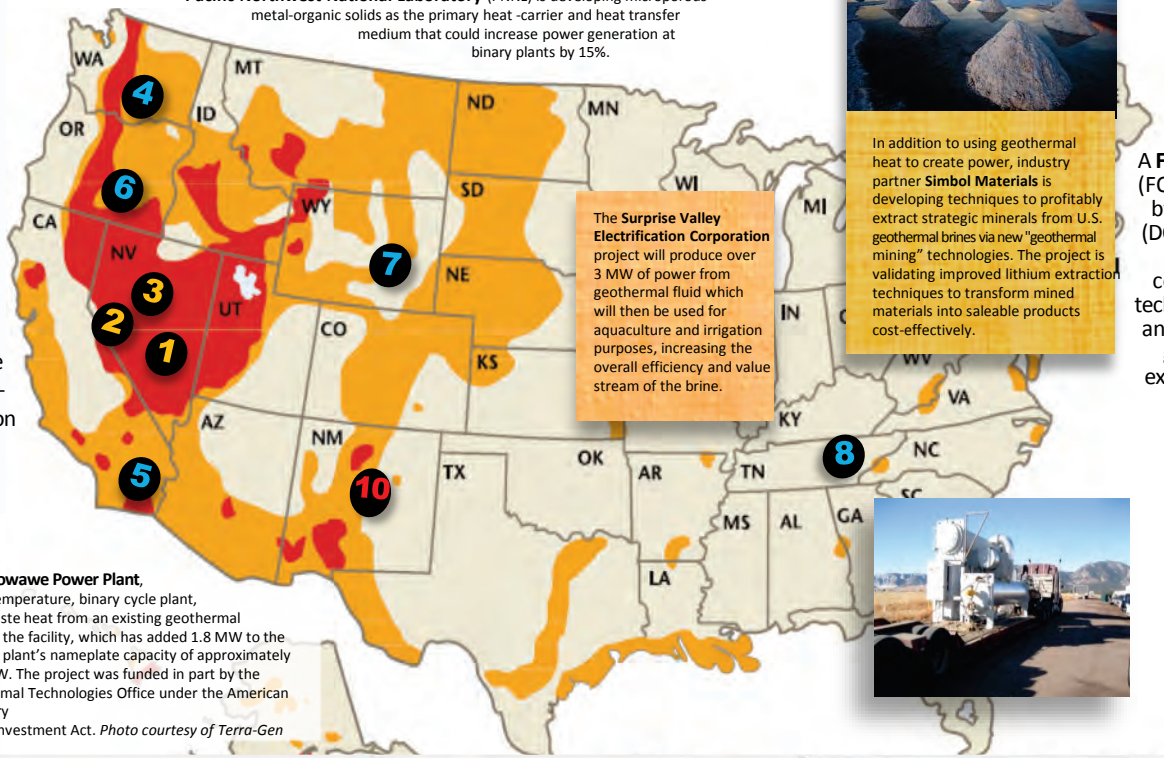


Questions?

Low Temperature Potential in the Near–Term

Low-temperature and co-produced resources represent a small but growing sector of hydrothermal development, in geothermal resources below 150°C (300°F). Considered non-conventional hydrothermal resources, these technologies are bringing valuable returns on investment in the near-term, using unique power production methods.

Pacific Northwest National Laboratory (PNNL) is developing microporous metal-organic solids as the primary heat -carrier and heat transfer medium that could increase power generation at binary plants by 15%.



The **Surprise Valley Electrification Corporation** project will produce over 3 MW of power from geothermal fluid which will then be used for aquaculture and irrigation purposes, increasing the overall efficiency and value stream of the brine.

In addition to using geothermal heat to create power, industry partner **Simbol Materials** is developing techniques to profitably extract strategic minerals from U.S. geothermal brines via new "geothermal mining" technologies. The project is validating improved lithium extraction techniques to transform mined materials into saleable products cost-effectively.

Significant Growth Opportunities in the Future

A **Funding Opportunity Announcement** (FOA) is slated for release in FY 2014 by the U.S. Department of Energy's (DOE) Geothermal Technologies Office (GTO) to advance thermal energy conversion processes and promote technologies that capture, concentrate, and purify strategic materials within geothermal brines for economical extraction and added revenue streams.

The **Beowawe Power Plant**, a low-temperature, binary cycle plant, uses waste heat from an existing geothermal plant at the facility, which has added 1.8 MW to the existing plant's nameplate capacity of approximately 17.7 MW. The project was funded in part by the geothermal Technologies Office under the American Recovery and Reinvestment Act. *Photo courtesy of Terra-Gen*

The **Rocky Mountain Oilfield Testing Center (RMOTC) Relocation Project** is designed to reduce the risks associated with co-production by operating binary units in commercial oil and/or gas fields. Technical site data will be collected to significantly reduce cost and performance uncertainties and lower the barrier for market uptake.

Terra-Gen at **Dixie Valley** is demonstrating the technical and economic feasibility of nonconventional geothermal resources (223°F), employing the first commercial use of a supercritical cycle at a geothermal power plant inlet temperature of less than 300°F. Since September 2012, the plant has been online and producing 6 MW.

Small Scale Power Generation from Co-Produced Geothermal Fluid – Electratherm has successfully demonstrated the technical and economic feasibility of geothermal energy production through a state-of–the-art Organic Rankine Cycle (ORC) heat-to-power generator.

COMPLETED

1. Beowawe
2. Dixie Valley
3. Electratherm

ONGOING

4. Pacific Northwest National Laboratory
5. Simbol
6. Surprise Valley Electrification Corporation (SVEC)
7. Rocky Mountain Oilfield Testing Center Relocation project
8. Oak Ridge National Laboratory

INITIATED

9. FY2014 Funding Opportunity
10. Idaho National Laboratory project

Value-Added Streams - Forward Osmosis Purification of Co-Produced Water
Idaho National Lab

Waters produced during oil and gas operations are typically in the range of lower temperature geothermal resources (<150°C). In addition, these wells generally are not prolific producers of fluid and the power production is less than what is typical of a well on a hydrothermal resource. This project seeks to purify these produced waters to establish an additional revenue stream for a project, and reduce the magnitude of the costs currently being incurred to dispose of these waters. By doing so, the additional revenue stream and lower operating costs will lower generation costs from this unconventional geothermal resource.

TIMOTHY REINHARDT CO-PRODUCTION TECHNOLOGY MANAGER