



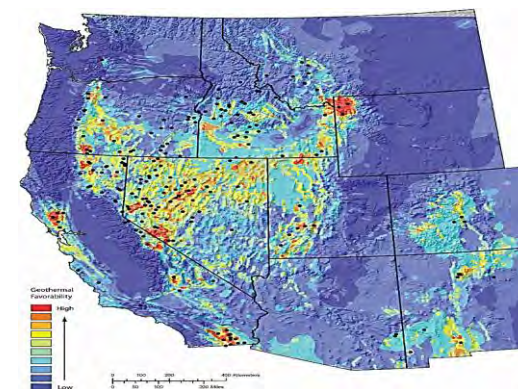
Desert Peak (Source: Ormat Nevada, Inc)

Geothermal Technologies Office  
SMU Geothermal Conference  
March 13, 2013

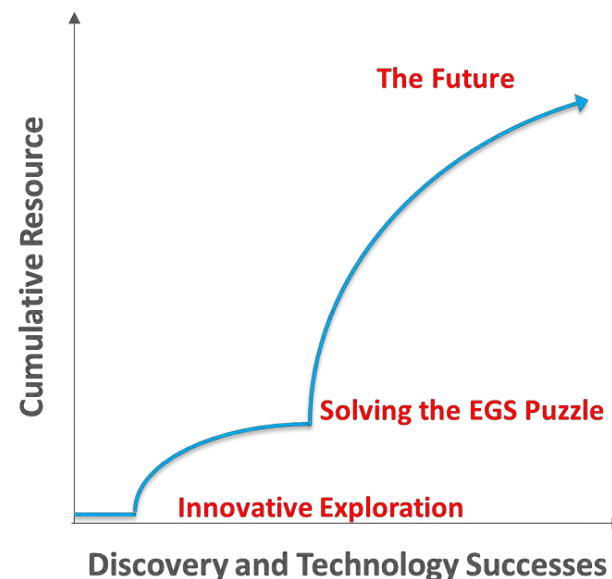
*Doug Hollett, Director*  
Office of Energy Efficiency and Renewable Energy  
U.S. Department of Energy

## Increased Focus

- **Identify New Geothermal Opportunities**
  - Lowered risk and cost
  - New prospecting workflow
- **EGS R&D and Underground Field Observatory**
  - New techniques and technologies
- **Non-Technical Barriers**
  - Regulatory Roadmaps and Optimization
- **Project Synergies**
  - Co-Production and Distributed Power
  - Strategic Resources



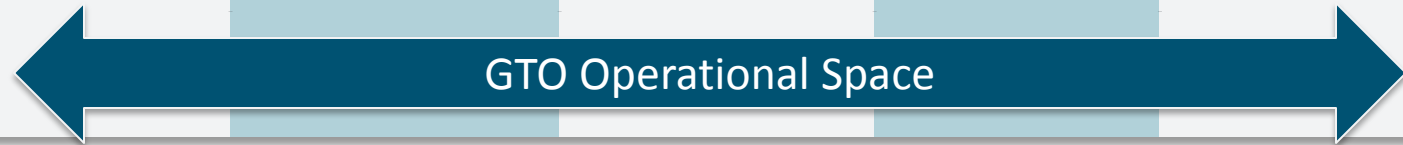
**Geothermal  
Development Potential**



# Geothermal Program Balance

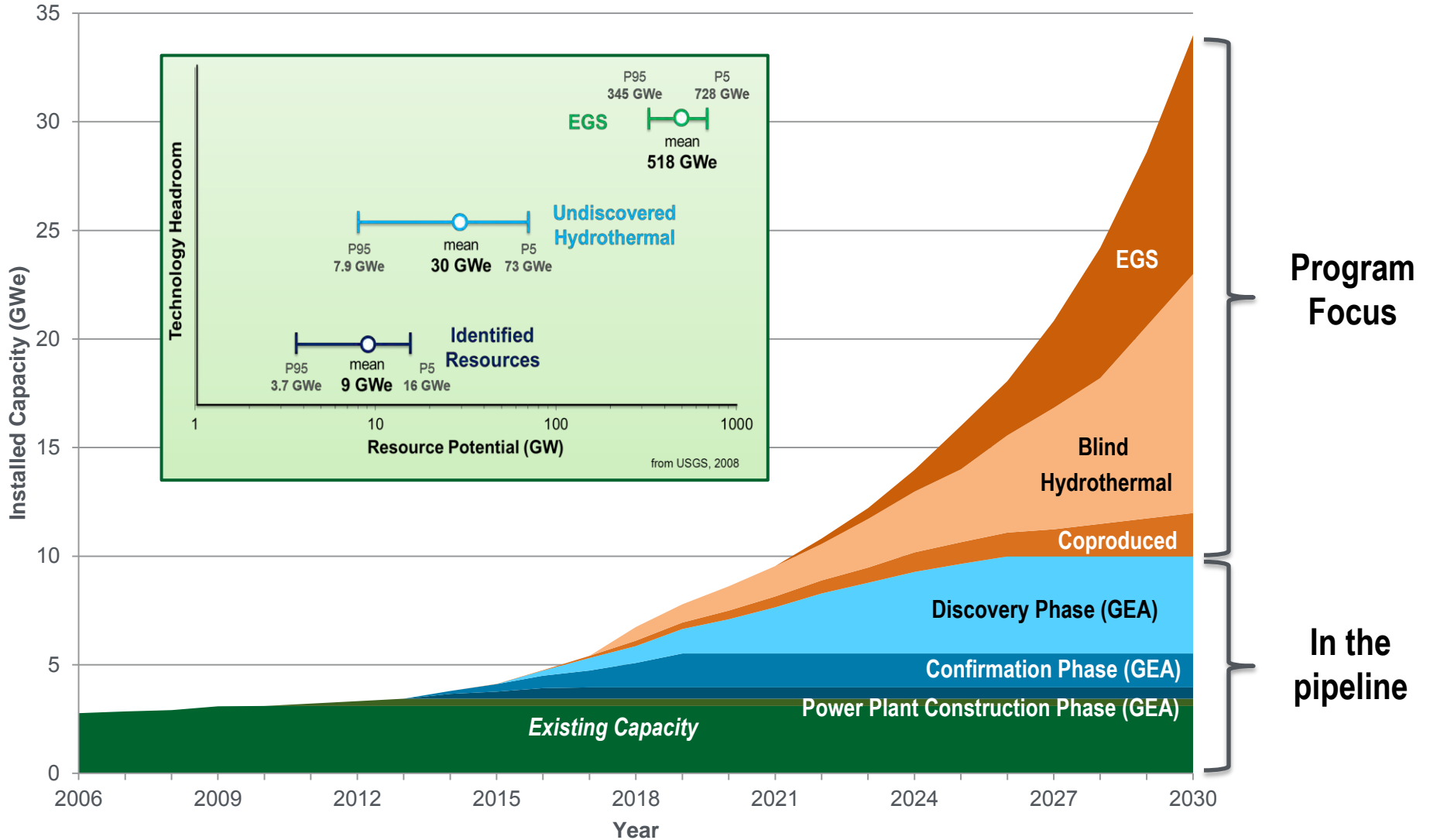
*Transition from Near to Long Term*

	Low Temp	Co-Production	Blind Hydrothermal	In-Field EGS	Greenfield EGS
<i>Timeline</i>	Near Term	Near Term	Near to Intermediate	Near to Intermediate	Long Term
<i>Strategy</i>	Utilize waste-heat / promote distributed energy	Leverage O&G infrastructure	Promote Sector Growth	Maintain /expand existing fields	Develop replicable model for commercial scale-up
<i>Scale</i>	100's KW to several MW scale	10's-100's MW, aggregate to GW potential	10's GW additional potential	10-100's GW potential- low risk	10's - 100's GW potential -high risk
<i>Constituency</i>	Local or Rural, Direct Use	Growing Interest, New Potential Sector	Majority of the Private Sector	Private Sector	Fewer Players



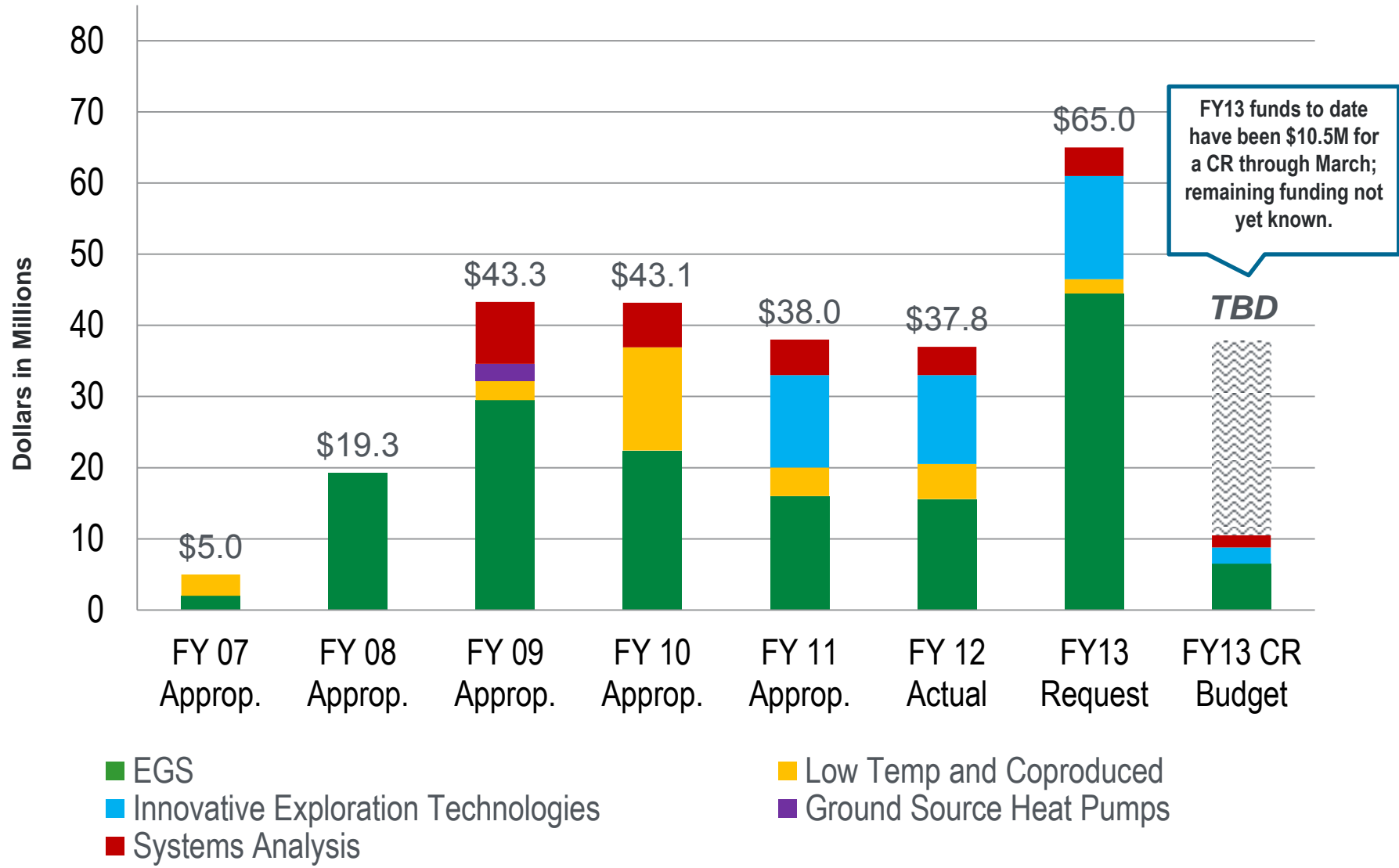
# Geothermal Potential by 2030

## Pathway to Growth



# Budget Overview

Challenging but a good path forward

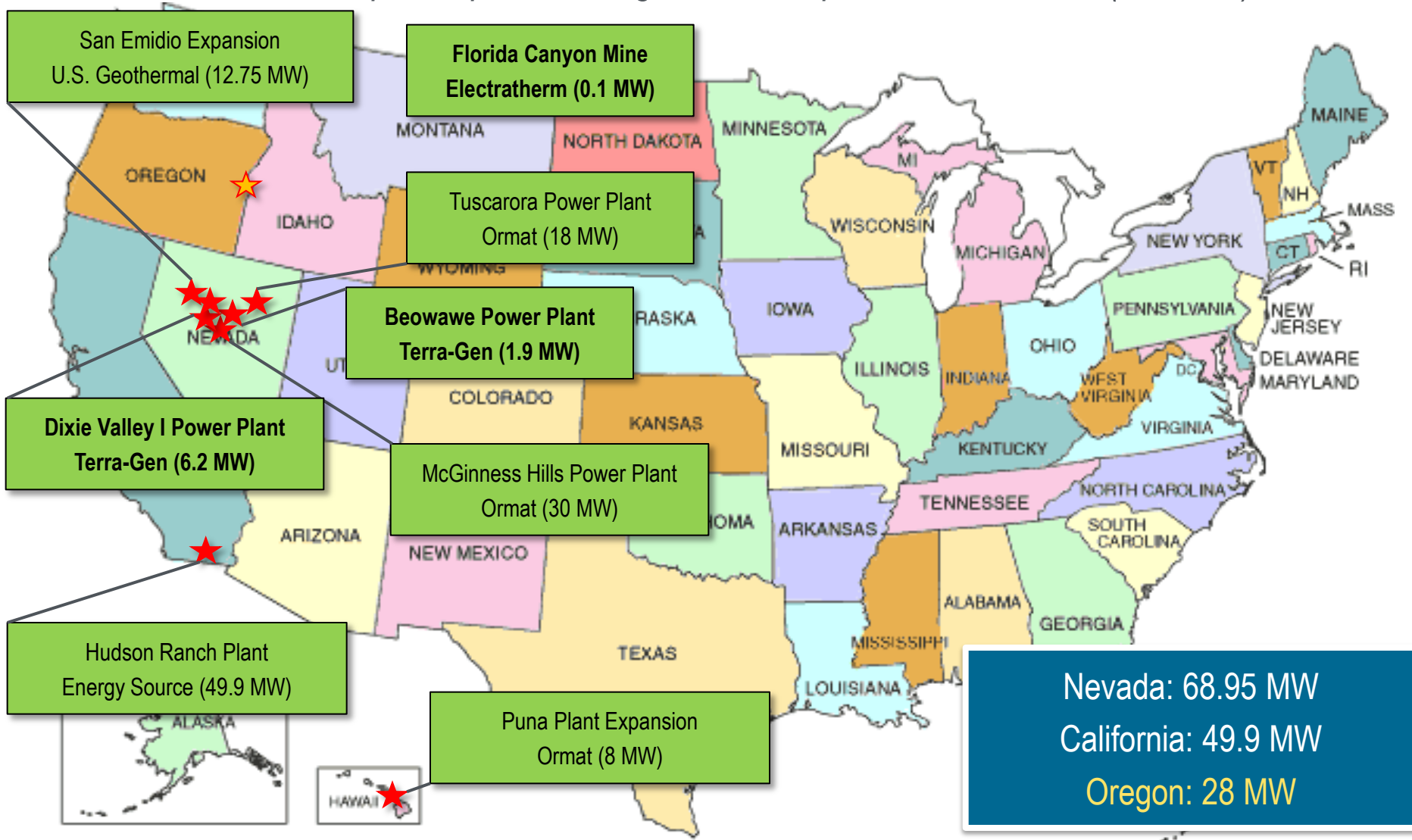




# Geothermal Power Plants

2011-2012

*Geothermal power plants brought online/expanded in 2012-13 (154 MW)*

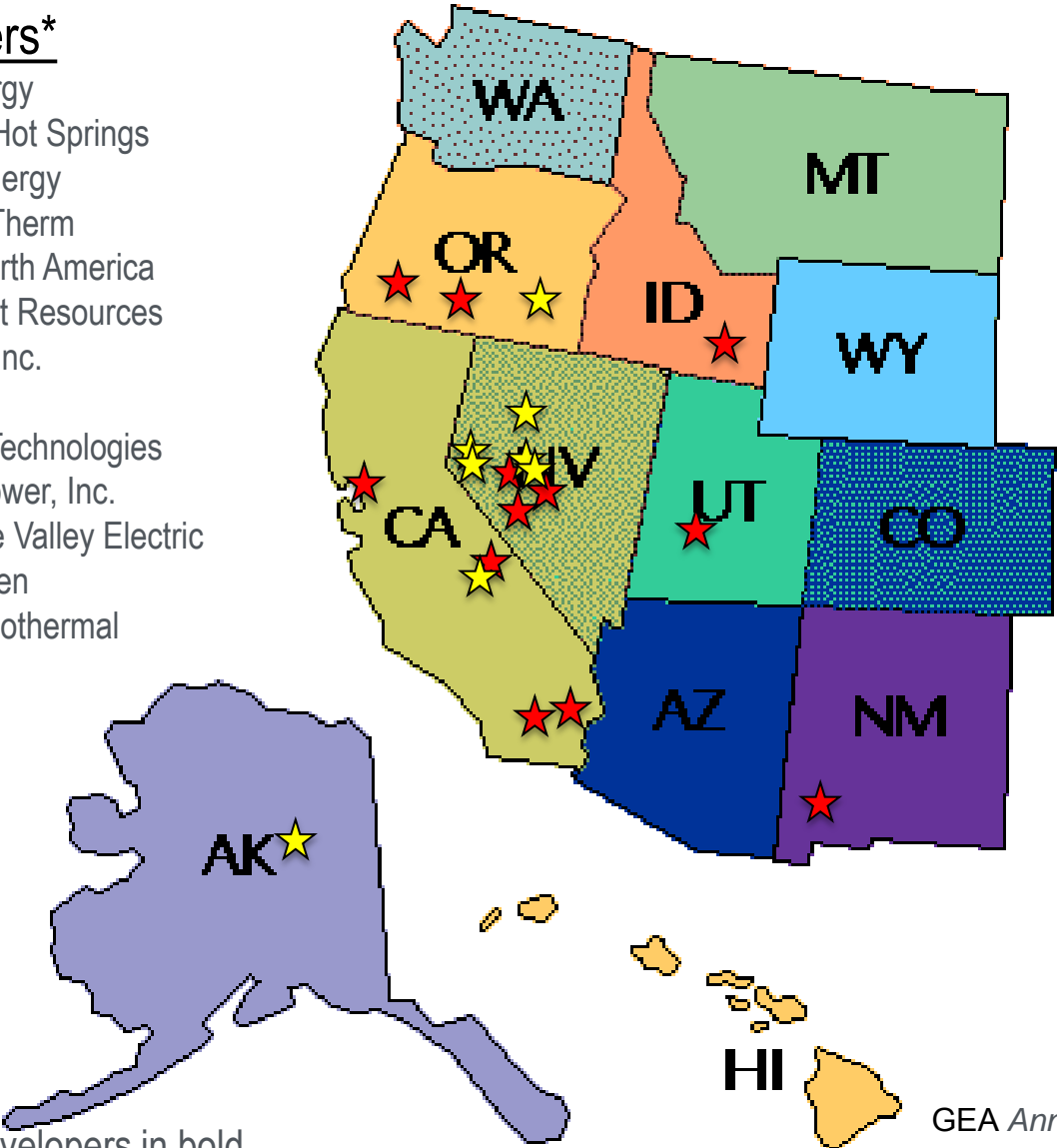


# Geothermal Projects

## Phase III and IV Development

### Developers\*

- CalEnergy
- Chena Hot Springs
- Cyrq Energy
- ElectraTherm
- Enel North America
- Gradient Resources
- Kodali, Inc.
- OIT
- Ormat Technologies
- Ram Power, Inc.
- Surprise Valley Electric
- Terra-Gen
- U.S. Geothermal



★ Phase III

~750 MW

*(Planned Capacity Addition)*

★ Phase IV

~200 MW

*(Planned Capacity Addition)*

Phase III: Permitting and Initial Development

Phase IV: Resource Production and Power Plant Construction

SOURCE:

GEA Annual US Geothermal Power Production and Development Report (April 2012)

\*Nevada Developers in bold.

# Technology as the Pathway to Growth

Accomplishments in 2011-2012

## Low Temp

## Co-Production

## Blind Hydrothermal

## In-Field EGS

## Greenfield EGS

### Low-temperature:

- **Beowawe Power:** Beowawe, NV – 2.5 MW added
- **TerraGen Sierra Holdings:** Dixie Valley, NV – 6 MW online

### Co-Production:

- **Simbol Materials:** Lithium extraction plant groundbreaking expected 2013
- Deploying two binary systems in operating O&G fields.

### Hydrothermal:

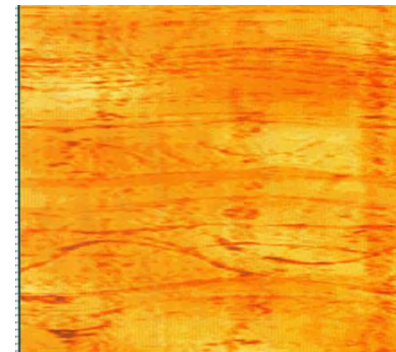
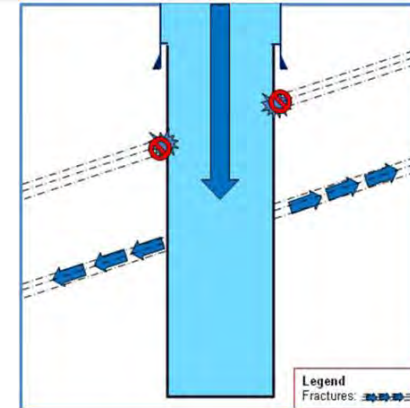
- ~150+ MW of new hydrothermal capacity
- 26 wells drilled to date

### EGS Demonstrations:

- **IN-FIELD:** **Ormat:** Desert Peak, NV
- **NEAR-FIELD:** **Calpine:** The Geysers, CA - 5 MW
- **GREENFIELD:** **AltaRock:** Newberry, OR

### Cross-Cutting Research & Development:

- **CSI Technologies /AltaRock-** Diverters
- **Baker Hughes** – Ultrasonic Fracture Imager
- **Sandia National Lab** – PDC Bits



Baker Hughes





### Beowawe Power, LLC

- Funding Source: ARRA
  - DOE Funds: \$2M
  - Awardee Cost Share: \$2.4M
- Completed construction in 2011 of a binary power plant
- Plant came online in the Spring of 2011 producing 2.5 MW gross



Completed Beowawe Power Plant  
(Photo credit: TG)

### Terra-Gen Sierra Holdings, LLC (Dixie Valley)

- Funding Source: ARRA
  - DOE Funds: \$2M
  - Awardee Cost Share: \$13.4M
- Binary Power Plant online and producing 6 MW gross since September 2012
- Unit has operated over 500 hours as of November 2012



Image by Google Maps

*We've identified the resource and have talked about it for years –  
what are the challenges to deployment?*

- DOE investment is increasingly mature
- Technical risks? Technology?
- Upfront costs/capital requirements; opex?
- Regulatory or permitting uncertainty?
- Fundamental economics, or how communicated?
- Need for complementary revenue streams?
- Financing?
- Do we need more demonstration projects?

*Do we have a clear understanding, or roadmap, of the costs, issues, barriers  
and best practices which industry can use to make informed decisions?*

*When can we expect broader adoption of low temp and co-production?*

## Add value to co-pro revenue stream

- Use/recycle/leverage stranded or flared gas
  - Densify: micro LNG, CNG, GTL?
  - Onsite generation
  - Capture NGL's – can be key to economics
  - Fertilizer
- Economic and environmental benefits; displace on-site diesel
- Micro-grid and distributed energy challenge and value
- Battery/storage technologies?

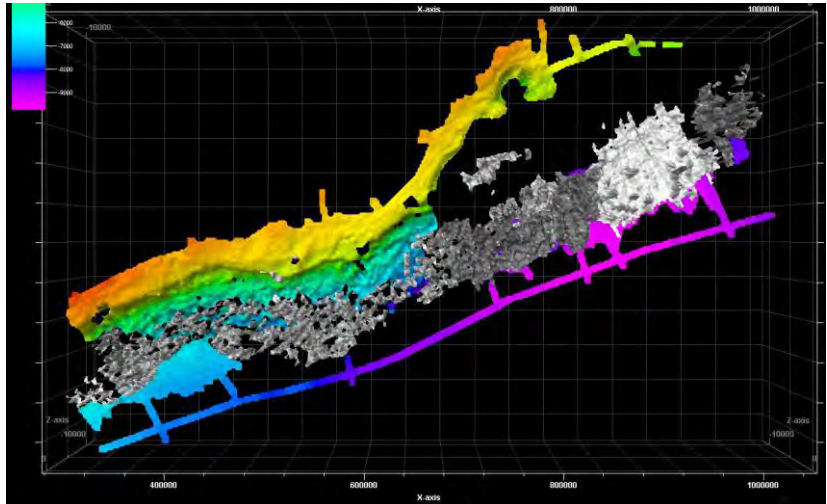




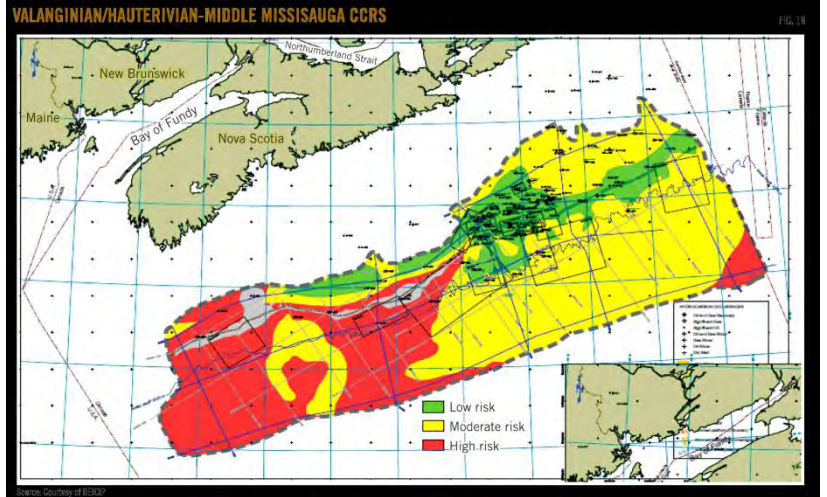
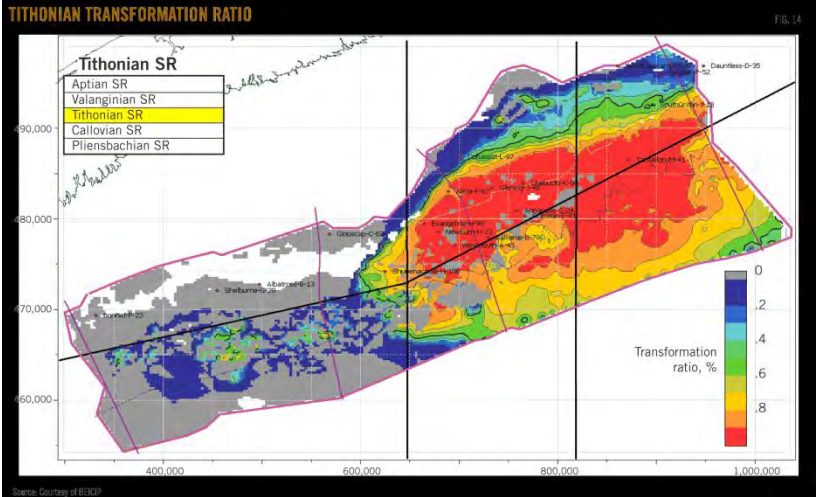
# What's next for Hydrothermal?

Tools, Maps, Analysis, "Plays"

- Continue to advance Innovative Exploration Technologies (IET) and demonstrations
- New drilling technologies
- Play fairway analysis (borrowed from oil and gas); observational, analytical integration, interpretation, basin and systems evolution



Source: CNSOPB, Nova Scotia



# Core Program Focus

## EGS Demonstration Projects

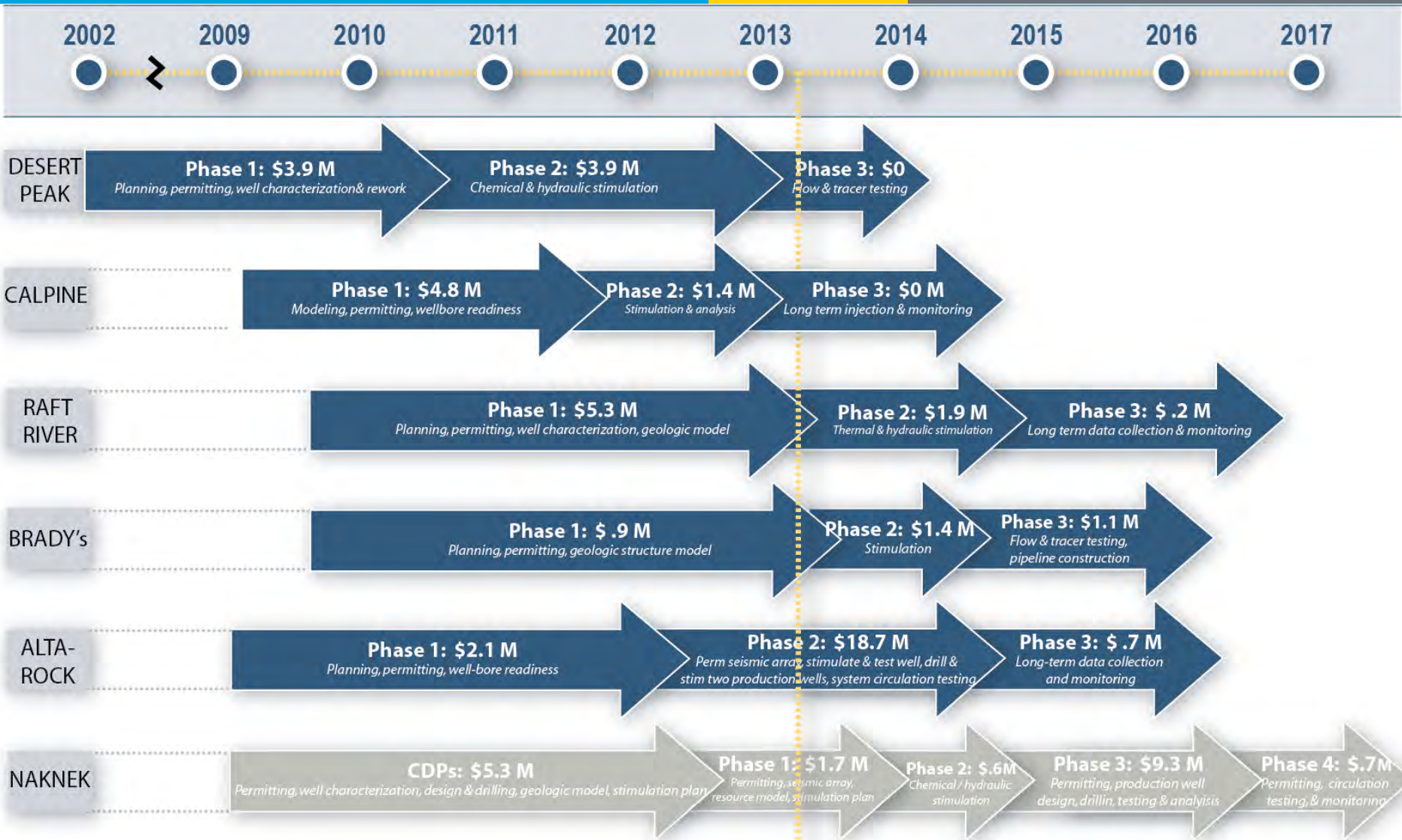


Performer	Project Site	Site Information	Stimulation Timeline	Funding
Ormat Technologies Inc.	Desert Peak, NV	Adjacent to existing hydrothermal sites	<i>Successful initial injection, more work planned 2013</i>	\$ 4.3 M
Geysers Power Company, LLC	The Geysers, CA	Reopen two existing wells to deepen for injection and stimulation	<i>Successful stimulation</i>	\$ 6.2 M
University of Utah	Raft River, ID	Improve the performance of the existing Raft River geothermal field	Initiating in early FY13	\$ 8.9 M
Ormat Technologies Inc.	Bradys Hot Springs, NV	Improve the performance of the existing Brady's geothermal field	Initiating in early FY13	\$ 3.4 M
AltaRock Energy Inc.	Newberry Volcano, OR	High potential in an area without existing geothermal development	<i>Initial data indicates successful stimulation</i>	\$ 21.4 M
NakNek Electric Association	NakNek, AK	Located in remote location in Alaska without existing geothermal development	Project on Hold	\$ 12.4 M



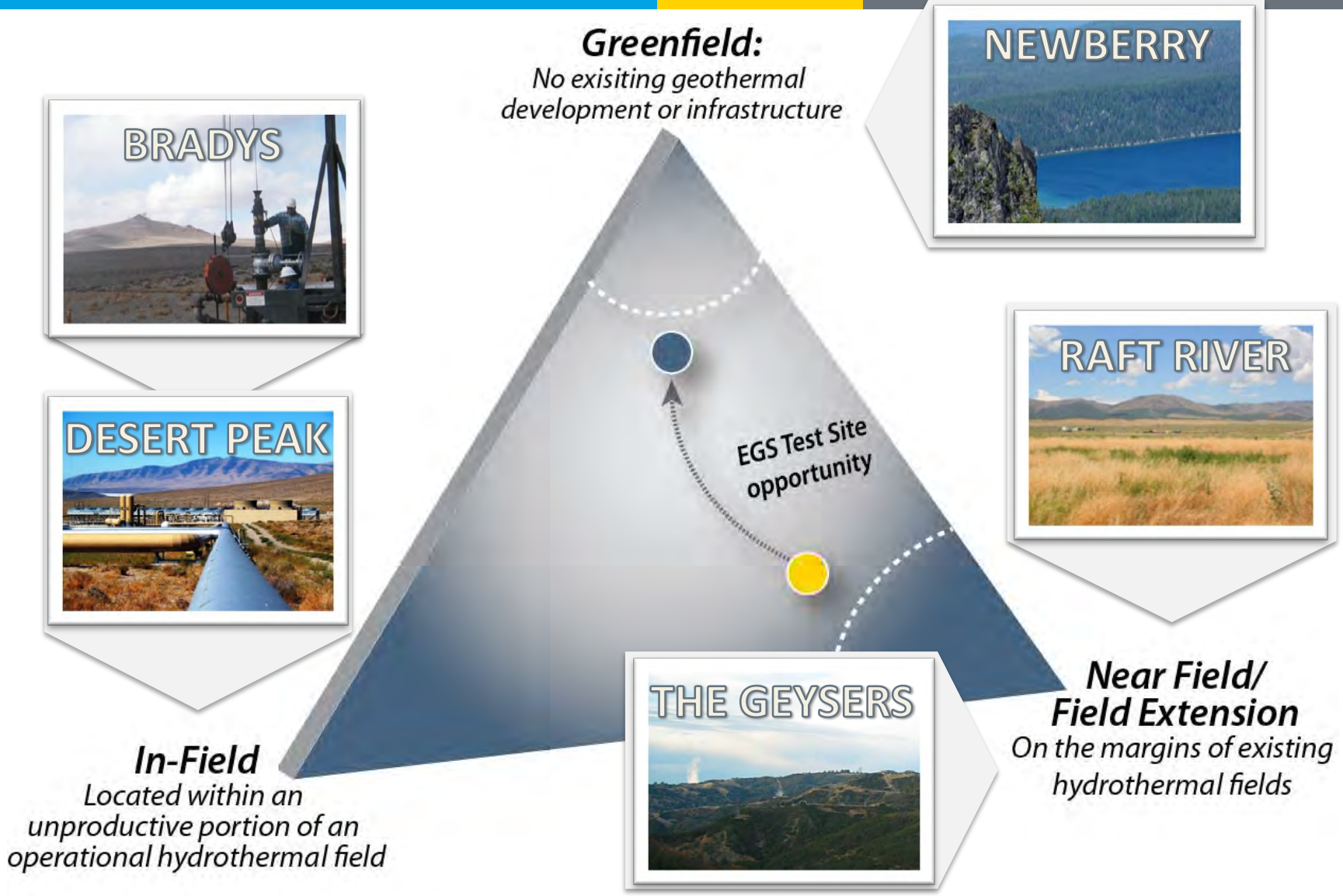
# Current EGS Demo Schedule

Spring 2013 status



# Enhanced Geothermal Systems (EGS)

## Facies Concept – A Continuum





## OUR VISION:

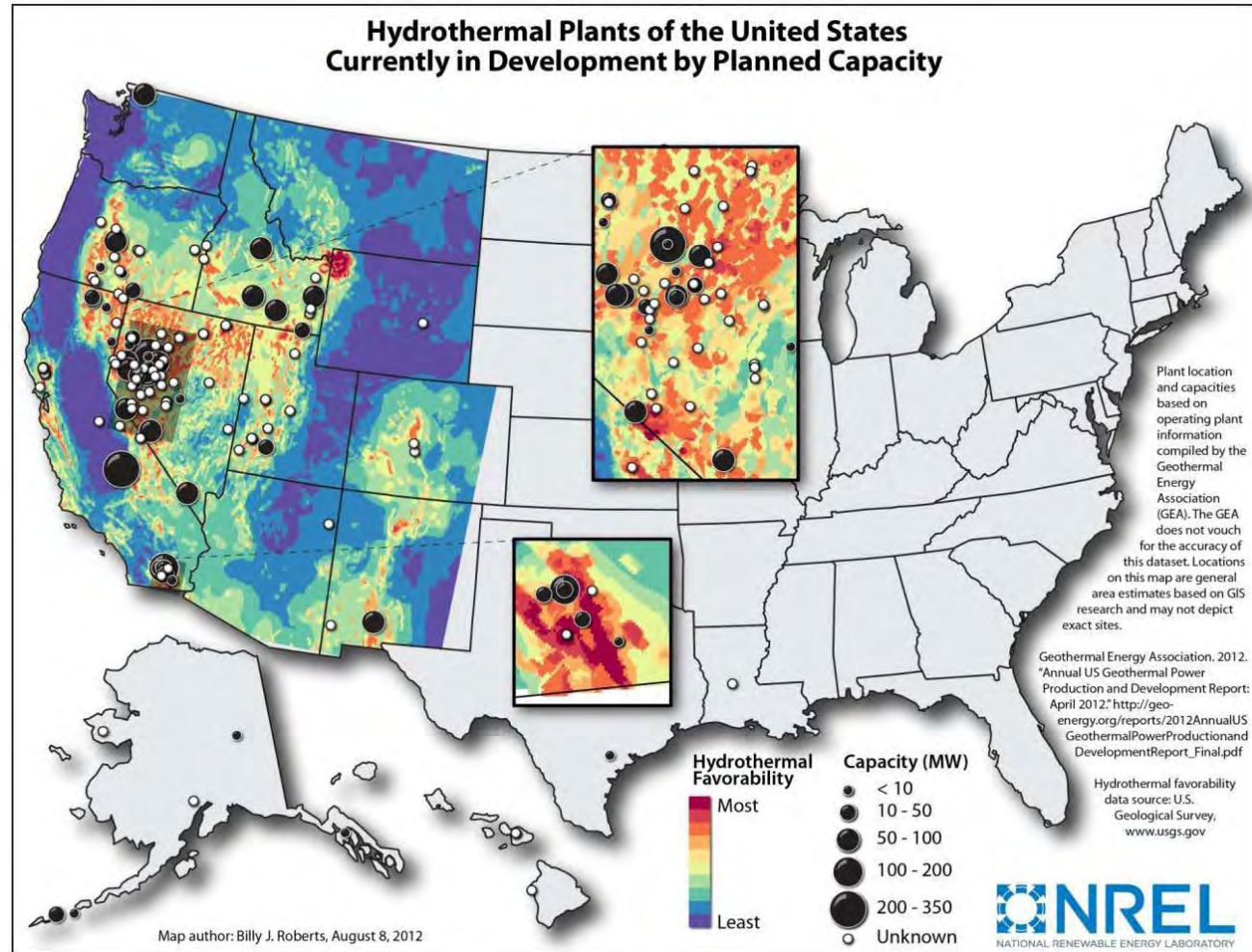
Increased success at  
Demo projects



Near term use on  
margins of existing fields  
as reservoir  
enhancement tool  
(many in NV!)



**Widespread deployment  
as routine reservoir  
enhancement tool at  
existing and fields in  
development**

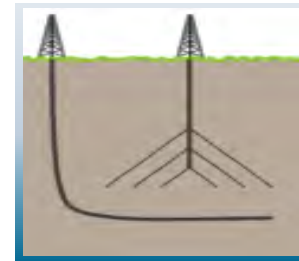


*Preparedness- strategy, funding, oversight*



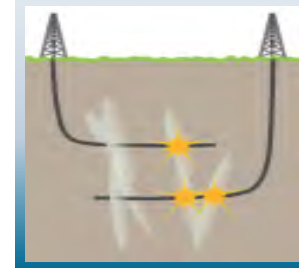
### WHY?

- Promote transformative science and engineering to:
  - Address key barriers
  - Validate and optimize EGS technology
  - Capture high fidelity data
  - Ensure deep understanding and reproducibility for commercial scale-up
- Federal Role:
  - Test technologies/take technical risks not possible in private sector
  - Work under aggressive timeframe
  - Gather and disseminate comprehensive data sets
- Direct benefits to all areas of research in the geothermal space



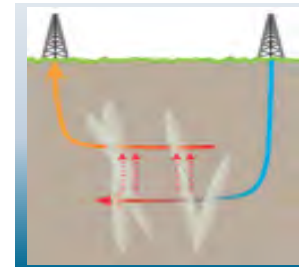
### Reservoir Access

New well geometries and concepts, optimized drilling



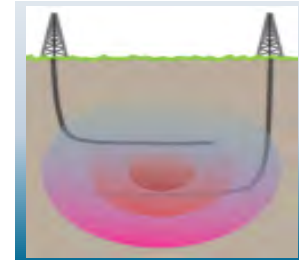
### Reservoir Creation

Characterize local stress, zonal isolation, novel fracturing methods, increase fractured volume per well



### Productivity

Increase flow rates without excessive pressure needs or flow localization



### Sustainability

Maintain productivity with minimal thermal drawdown and water losses



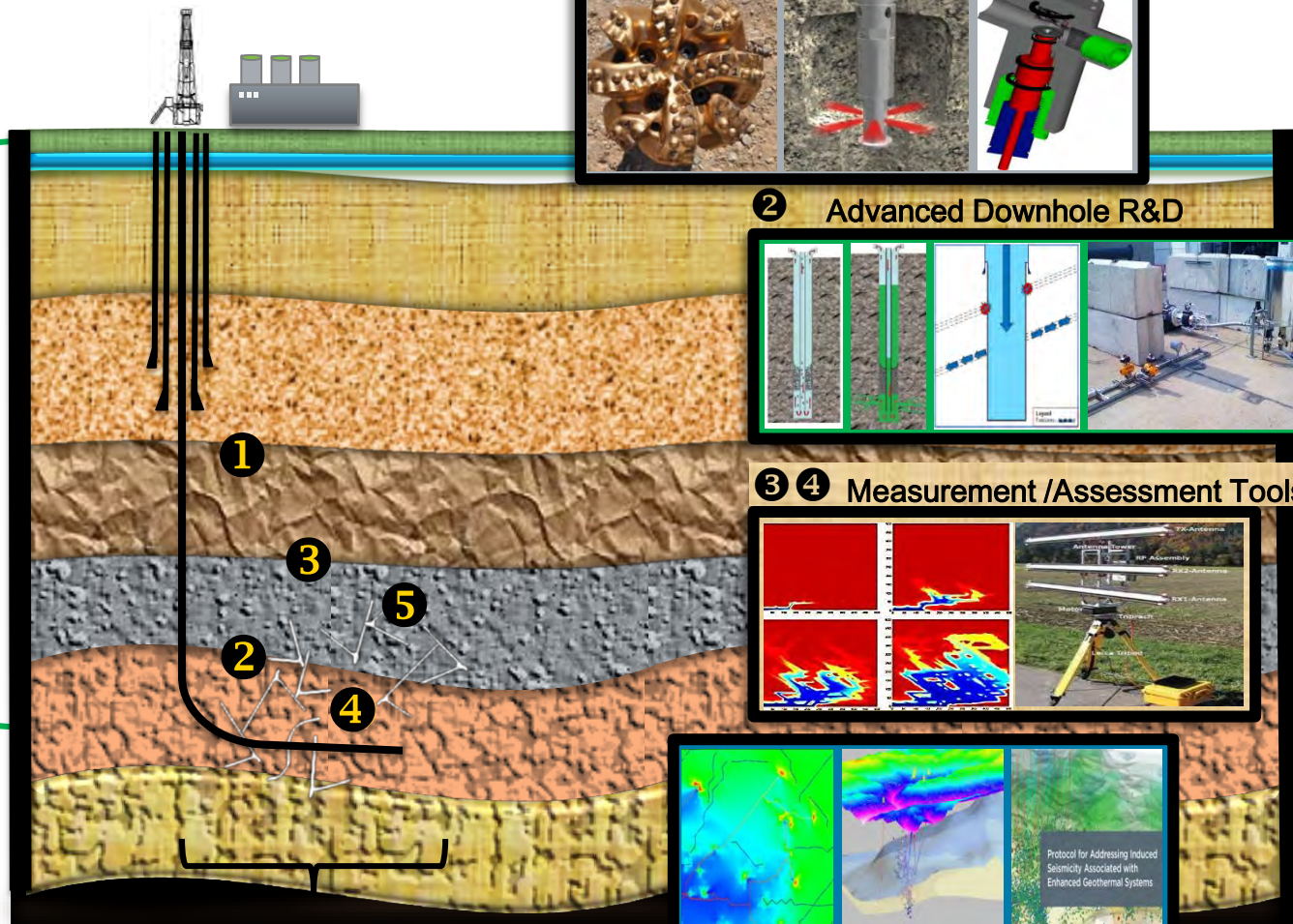
### Challenges

### Innovative Solutions

#### Barriers

1. High Cost of Drilling
2. Creating a Reservoir
3. Subsurface Characterization
4. Sustained Reservoir Production
5. Risk Management & Mitigation

6,000 – 12,000 ft.

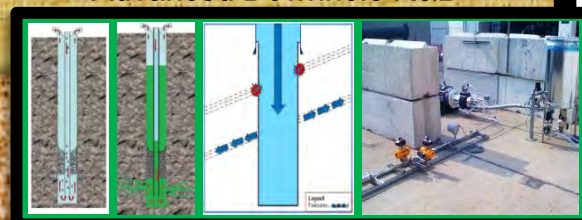


2,000 – 6,000 ft.

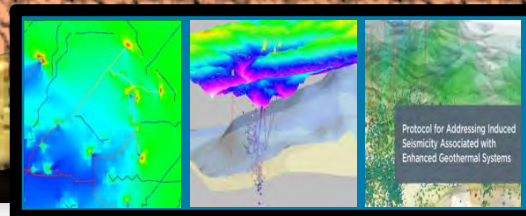
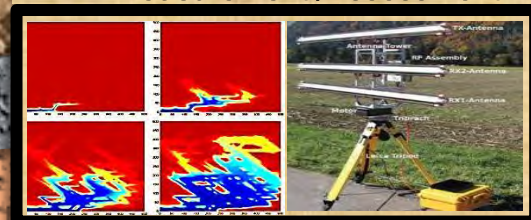
#### 1 Faster, More Efficient Drilling Technologies



#### 2 Advanced Downhole R&D



#### 3 4 Measurement / Assessment Tools



#### 5 Seismic Modeling, Monitoring & Protocols



**What is descriptive, accurate, does not imply permanence, and is acceptable to a diverse constituency?**

- Geothermal Experimental and Operational Development Site (**GEODES**)?
- Federal Observatory for Research in Geothermal Energy (**FORGE**)?
- Subsurface Research for Geothermal Energy Lab (**SURGE Lab**)?
- Underground Field Observatory – (**UFO**)?

# What's next for EGS?

## Growth sequence

### Immediate / Primary Focus

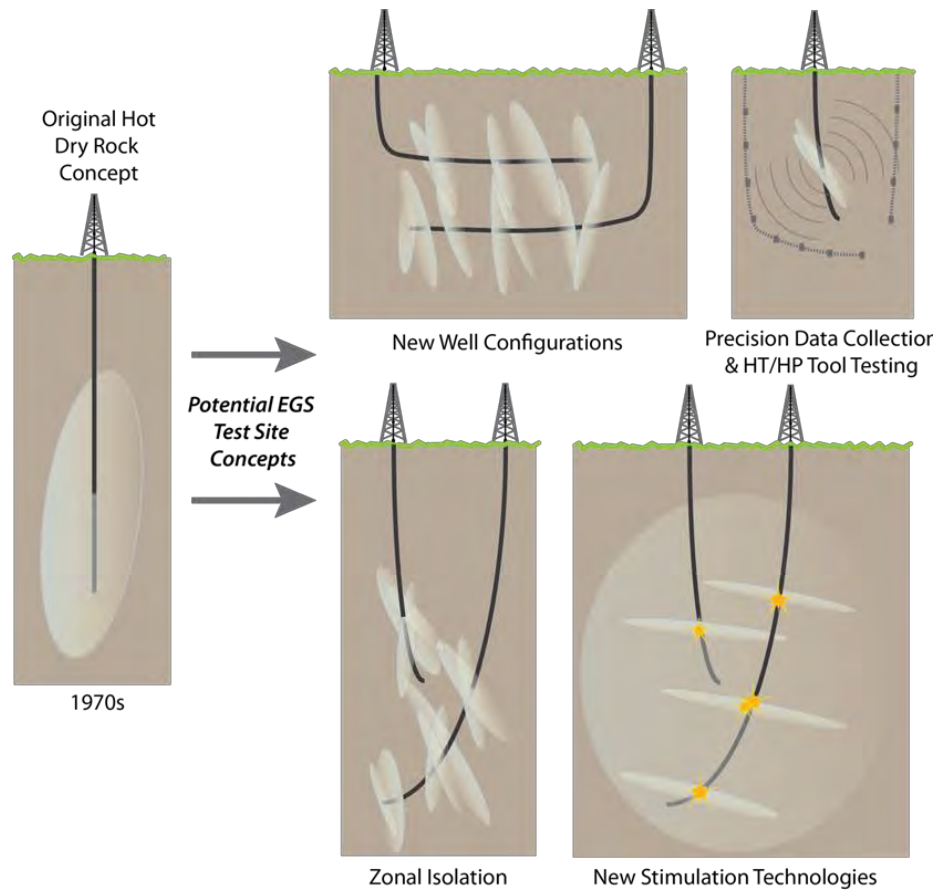
- Progressive adoption based on demonstration successes
- Accelerated in-field use
- Advance into field extension applications

### Subsequent Focus

- EGS “Underground Field Observatory”
- EGS in new or “greenfield” settings
- Pathway to significant sector growth

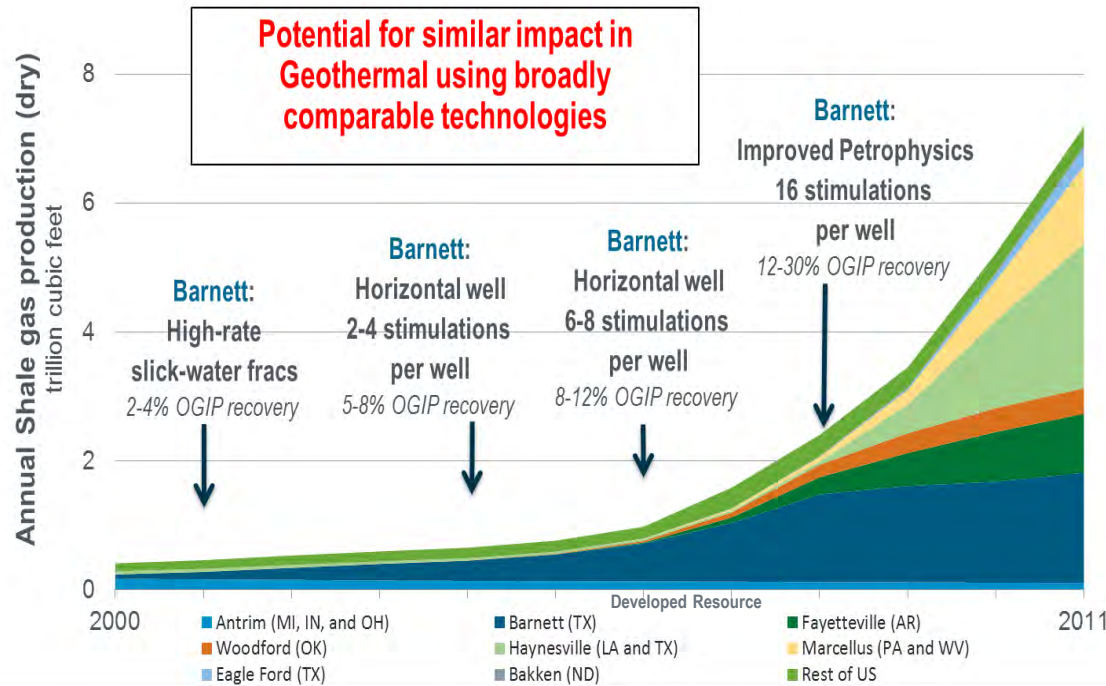
### Future?

- Lower Temp EGS?
- Deployment into non-traditional basins/regions?
- As an integral technique in “green” mining?

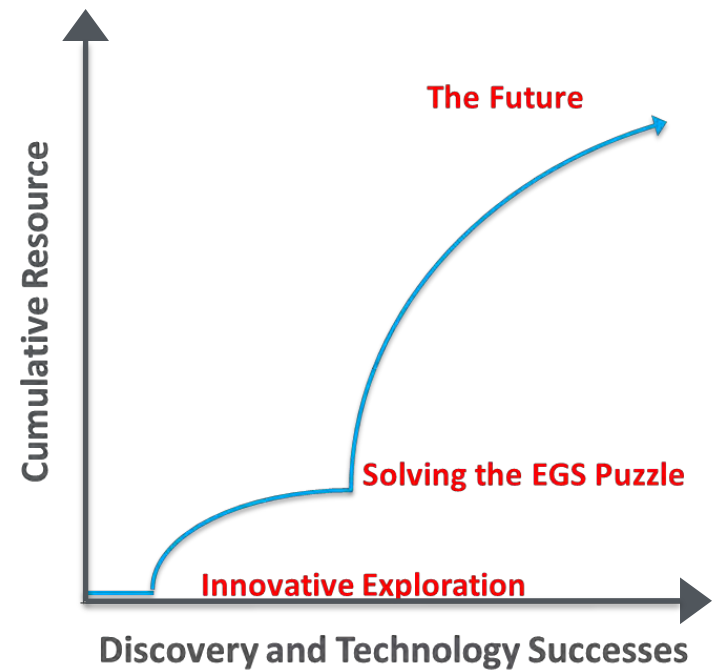


- Innovative exploration technologies: new imaging, measurement technologies for geothermal environments
- Radically new drilling technologies
- Innovative ways to map/identify prospective geothermal targets
- Determine how to fully advance larger-scale low temp, co-production and direct use deployment
- Exploring new rock systems – geothermal in traditional sedimentary basins
- Horizontal drilling in geothermal systems; multi-stage stimulation, adapted for geothermal environment
- Integrated technologies: cascading systems; gas densification + geothermal coproduction; low temp + direct use; geothermal + solar

## Shale Gas: Technology Innovations Spawed Sector Transformation



## Geothermal Development Potential



Sources: Lippman Consulting, Inc. 2011. Technology advances from King, 2012 (SPE 152596)

## Position all major initiatives for initiation and execution over next 2 years

- ***EGS Field Observatory:***
  - Competitive Solicitation early FY14
- ***Play Fairway mapping***
  - 1<sup>st</sup> go-by completed 2013
- ***Low Temp and Oil and Gas Co-Production***
  - Equipment in the field Q3, first data by year end
  - Increased low temp deployment
- ***Regulatory Roadmap and NGDS***
  - Completion Q2 and support optimization
  - 5 of 10 white papers on key topics
  - NGDS deployment – leverage the power of data
- ***Interagency Collaboration:***
  - ***DOE-DOD collaboration***
    - Identify and pursue activities where missions align
  - ***Strategic Materials***
    - Project kickoff with key agency stakeholders