



Geothermal Technologies Program GRC Presentation, Reno

October 1, 2012

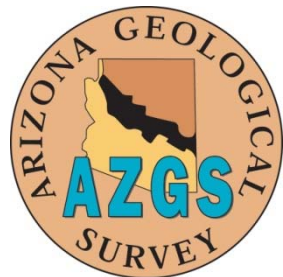
GTP Investments at GRC '12

Total 32 Projects

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

DOE Geothermal Technologies Program has invested over \$68M in research and development being presented by industry, national laboratories and academia.



Geothermal Program: Key Goals and Objectives

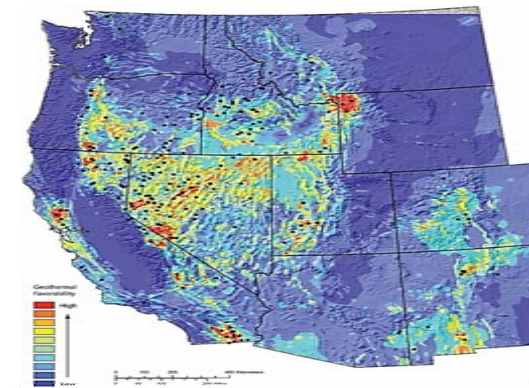
Creating Impact

U.S. DEPARTMENT OF
ENERGY

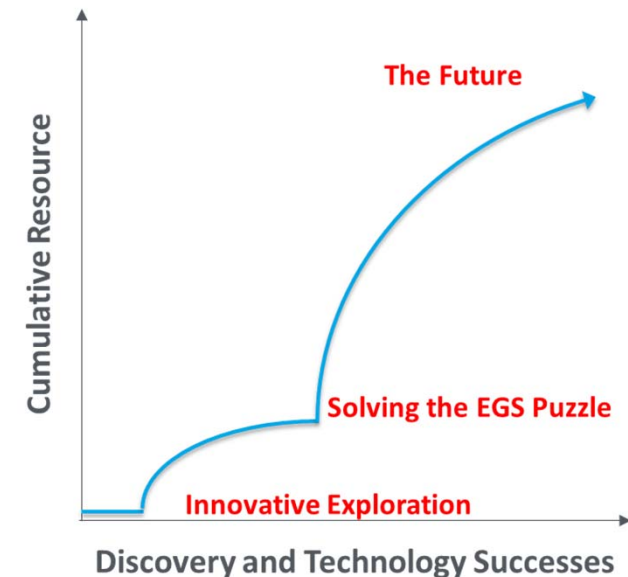
Energy Efficiency &
Renewable Energy

Increased Focus

- **Identify New Geothermal Opportunities**
 - Lowered risk and cost
 - New prospecting workflow
- **EGS R&D and Field Lab**
 - New techniques and technologies
 - Pathway to EGS success
- **Regulatory Roadmaps and Optimization**
 - Multi-stakeholder involvement
 - Competitive with other energy sources
- **Project Synergies**
 - Co-Production and Distributed Power
 - Strategic Resources

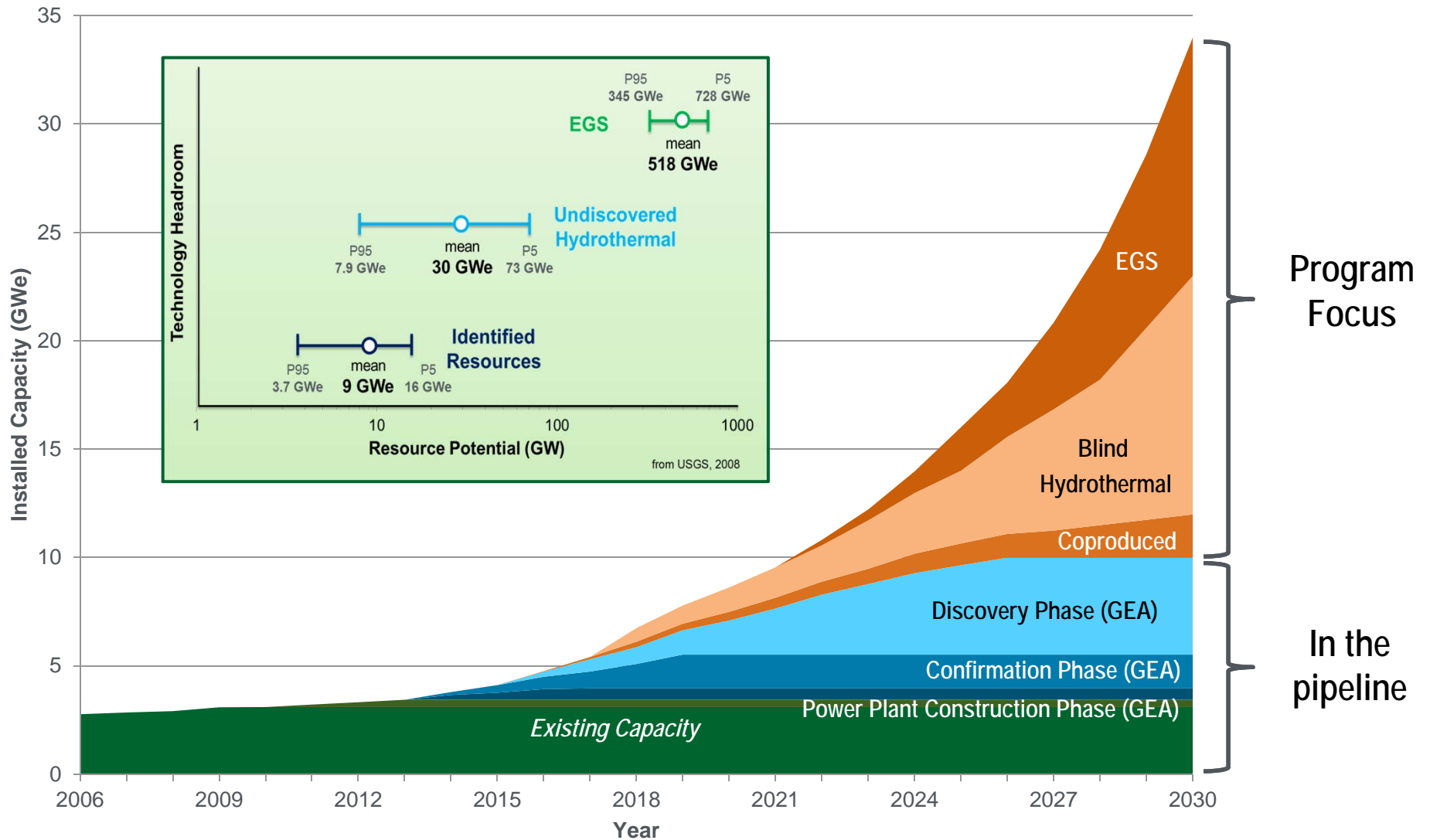


**Geothermal
Development Potential**



Geothermal Potential by 2030

Pathway to Growth



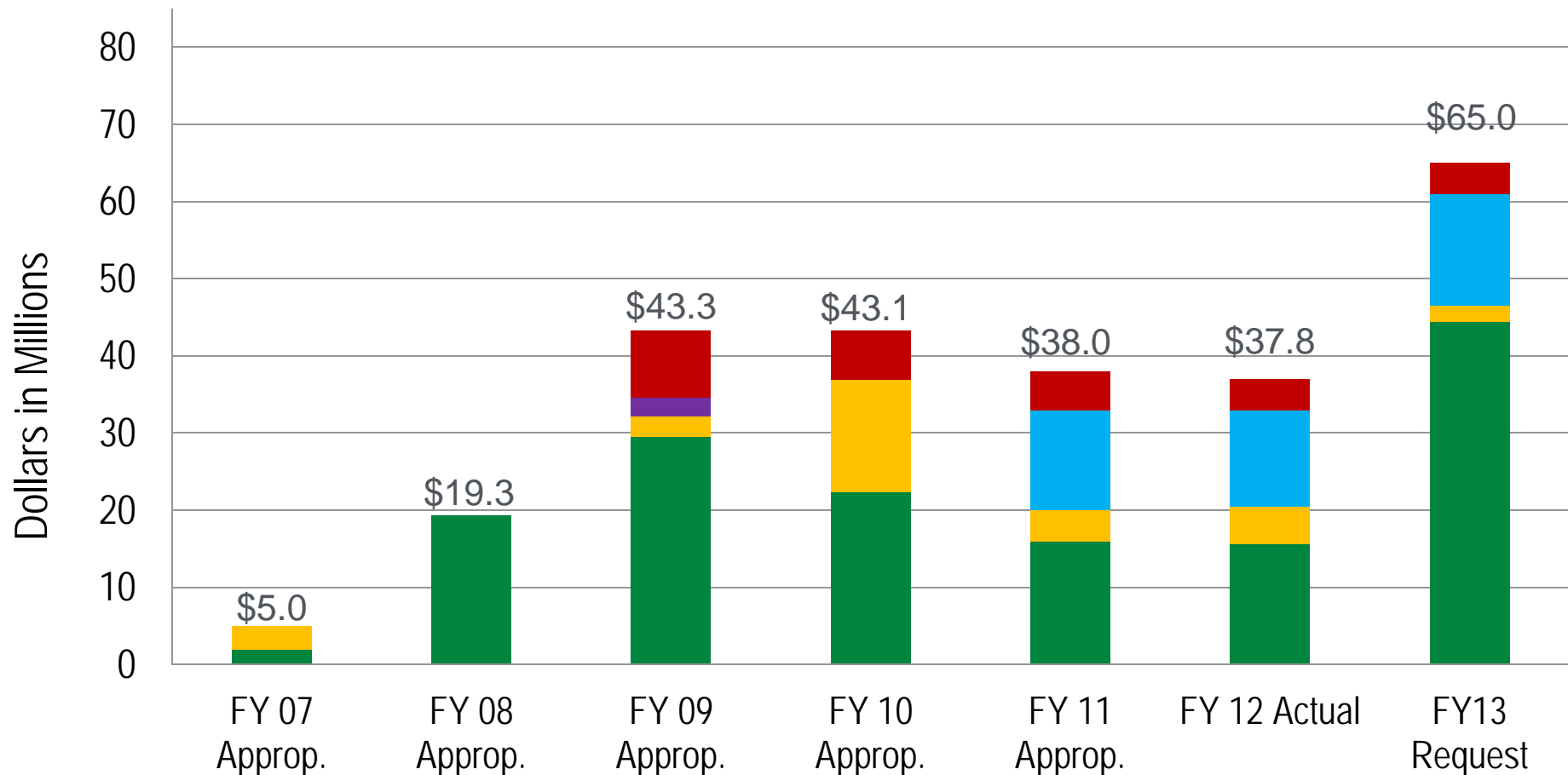
Geothermal Program Balance

Transition from Near to Long Term

	Low Temp	Co-Production	Hydrothermal	EGS
<u>Timeline</u>	Current	Near Term	Intermediate	Long Term
<u>Strategy</u>	Distributed Energy	Leverages O&G investment	Sector Growth	Transformation
<u>Scale</u>	100's KW to several MW scale	10's-100's MW scale, aggregate to several GW potential	10's GW additional potential	10's - 100's GW potential, but high risk
<u>Constituency</u>	Local or Rural, Direct Use	Growing Interest, New Potential Sector	Majority of the Private Sector	Fewer Players

Program Budget History

(ARRA not shown)



- EGS
- Innovative Exploration Technologies
- Systems Analysis
- Low Temp and Coproduced
- Ground Source Heat Pumps

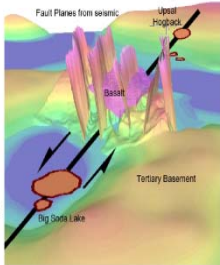
Challenges to Hydrothermal Expansion

Technology and Engineering Needs

Technology Barriers

Potential Solution Set

Goal



Resource Characterization

Non-unique signals, hidden resources, cost, downhole tools limited by temperature



Reservoir Access

Comparative lack of high performance drilling tools for large diameter, high-temperature, rock drilling, cost



Energy Conversion

Improve efficiencies for lower temperatures, operation & maintenance, cost

New occurrence models

Advanced seismic

Inverse techniques

High temperature tools

Horizontal wells

Rotary steering

Remote sensing

Advanced working fluids

Coproduction

Hydrothermal
Growth

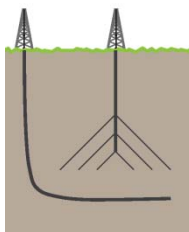
Challenges to EGS Development

Technology and Engineering Needs

Technology Barriers

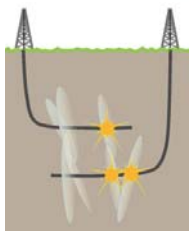
Potential Solution Set

Goal



Reservoir Access
New well geometries and concepts, optimized drilling

Hard/Hot-rock drilling, completion technologies

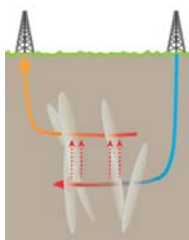


Reservoir Creation
Characterize local stress, zonal isolation, novel fracturing methods, increase fractured volume per well

Horizontal wells

Rotary steering

Stress-field diagnostics



Productivity
Increase flow rates without excessive pressure needs or flow localization

Smart tracers

Zonal Isolation

High-T sensors



Sustainability
Maintain productivity with minimal thermal drawdown and water losses

Cross-well monitoring

Diverter and Zonal Isolation Technologies

**EGS
Success**

Key Market Barriers

Many Elements Unique to Geothermal

Market Barriers

Potential Solution Set

Goal



Permitting challenges

A non-competitive process can doom projects

Regulatory road-mapping Initiative, Programmatic EIS



Data Access

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

National Geothermal Data Repository



Financing

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

Demonstrations

Techno-economic analysis

Modeling

Market reports

Working groups



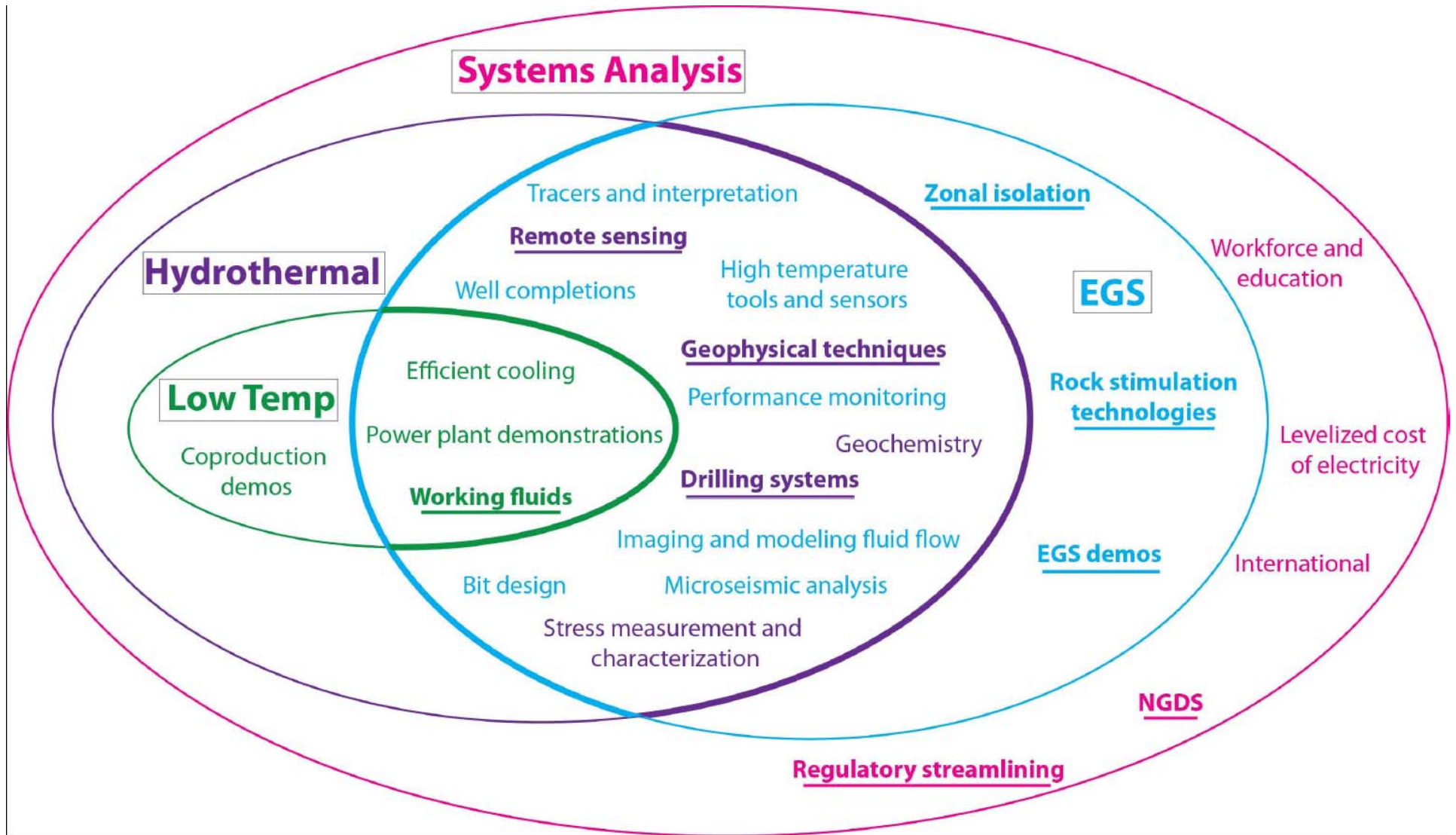
Grid Integration

Solutions to supply geothermal electricity to the grid

A Clearer Pathway for Geothermal Development

Subprograms support one another

Crosscutting Research



Select Program Accomplishments

2011-2012

EGS Demonstrations

- Geysers project - 5 MW
- Additional potential at this site.

Exploration:

- ~100+ MW of new hydrothermal capacity
- 17 wells drilled in four states.

Mineral Extraction:

- Simbol Materials: Lithium extraction plant groundbreaking expected 2013

Co-Production:

- Deploying binary systems in new operating O&G fields.



Select Program Accomplishments (ctd)

2011-2012

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

National Geothermal Data System (NGDS):

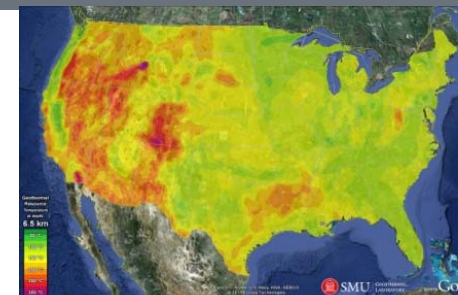
- An interoperable network of data from across all 50 states
- Fully operational by FY 2014

Regulatory Roadmap:

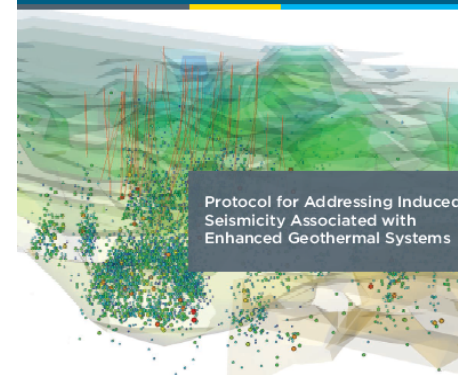
- Documenting regulatory process for eight states at the federal, state, and county level.
- Optimize permitting time, benefit to all stakeholders
- Improves project costs, lessens investor risk

Induced Seismicity Protocol

- Updated Induced Seismicity Protocol
- Best Practices Document underway
- National Academy of Sciences: *The geothermal community is a model to other subsurface energy industries for induced seismicity monitoring and mitigation*



U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy | **GEO THERMAL TECHNOLOGIES PROGRAM**



by
Ernie Major, James Nelson, Ann Robertson-Tait,
Jean Savoy, and Ivan Wong

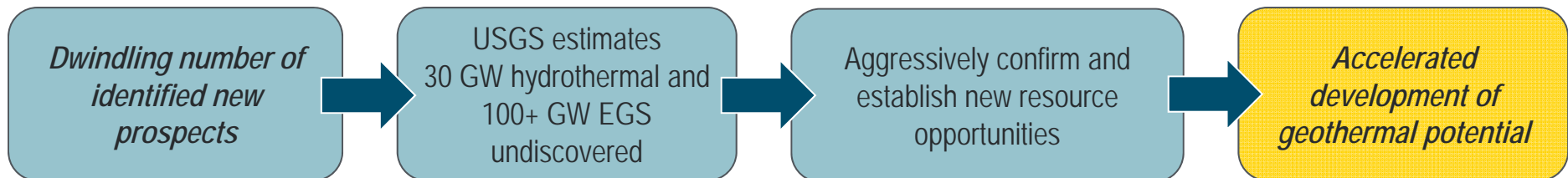
January 2012 | DOE/EE-0662

New Resource Opportunities

Facilitate Industry Growth 2012-2014

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Goal

- Lower risk and lower costs for exploration through early play and prospect analysis

Barriers

- Lack of comprehensive geothermal occurrence models
- Lacking exploration data in key areas

Progress to date

- NREL completing an exploration data gap analysis (October, 2012)
 - Based on current and incoming data to the NGDS and outreach to industry

Next steps

- Assess data gathering needs
- Perform prospect analysis akin to O&G play fairway analysis
- Communicate results

EGS Field Lab

Creating and Optimizing Reservoirs

Targeting:

- Horizontal geothermal wells
- Multi-stage stimulations
- Long term Hi-T/Hi-P tool and technique testing
- Highly controlled modern R&D and data collection

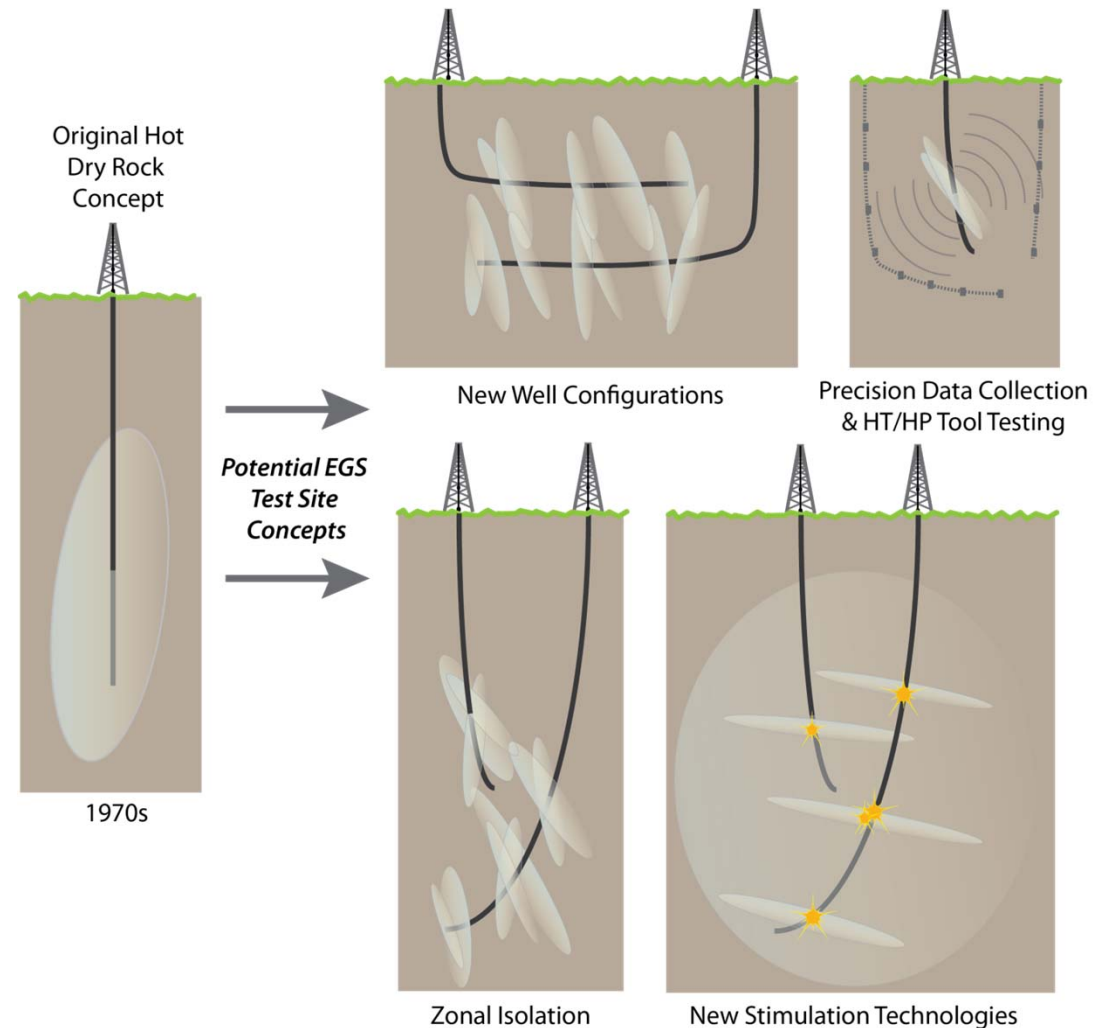
Ideal Characteristics:

Technical

- Well characterized: 1-2 prior wells
- Hi T, some fractures, moderate permeability and porosity
- Not too deep

Logistics

- Existing or nearby infrastructure/assets
- Permitting pathway
- Minimal on-site facilities
 - NOT a long-term, permanent facility



2012 GTP Peer Review


May 7-11, Denver

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

- 154 projects
- 59 reviewers
 - industry, academia, national lab, government and int'l
- New industry chair
- \$299.7M in DOE investment (includes ARRA)
- \$486.1M in total combined investment
- Final report by end 2012

...and a job well done!



2012
PEER REVIEW
EXCELLENCE AWARD
U.S. Department of Energy
Geothermal Technologies
Office

[And the Winner Is...]

2012 PEER REVIEW EXCELLENCE AWARD

U.S. Department of Energy

Geothermal Technologies Office

James Faulds, University of Nevada, Reno

***"Characterizing Structural Controls of EGS
and Conventional Geothermal Reservoirs"***