



Geothermal Technologies Program Annual Peer Review May 7, 2012

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Geothermal Technologies Program Mission

Vision: Geothermal will be a major contributor to the nation's baseload energy supply

Accelerate Near Term Hydrothermal Growth

- Decrease exploration risks and costs.
- Lower cost of electricity to 6 cents/kWh by 2020.
- Development of 30 GWe of undiscovered resources.

Secure the Future with Enhanced Geothermal Systems (EGS)

- Demonstrate that EGS is technically feasible by 2020.
- Lower EGS cost of electricity to 9 cents/ kWh by 2020 and 6 cents/kWh by 2030.
- Accelerate the development of 100 GWe by 2050 (MIT).



Industry Current Activity

Steady Growth

- **Total installed capacity of 3,187 MW**
 - 97% in California and Nevada
 - Five new plants came online in 2011-12 (91 MW)
- **147 confirmed projects under development in the US**
 - Development capacity 4,116-4,525 MW
 - Additional 16 exploration prospects underway
 - Activity in 13 additional states besides NV and CA

Source: Geothermal Energy Assoc. (2012)

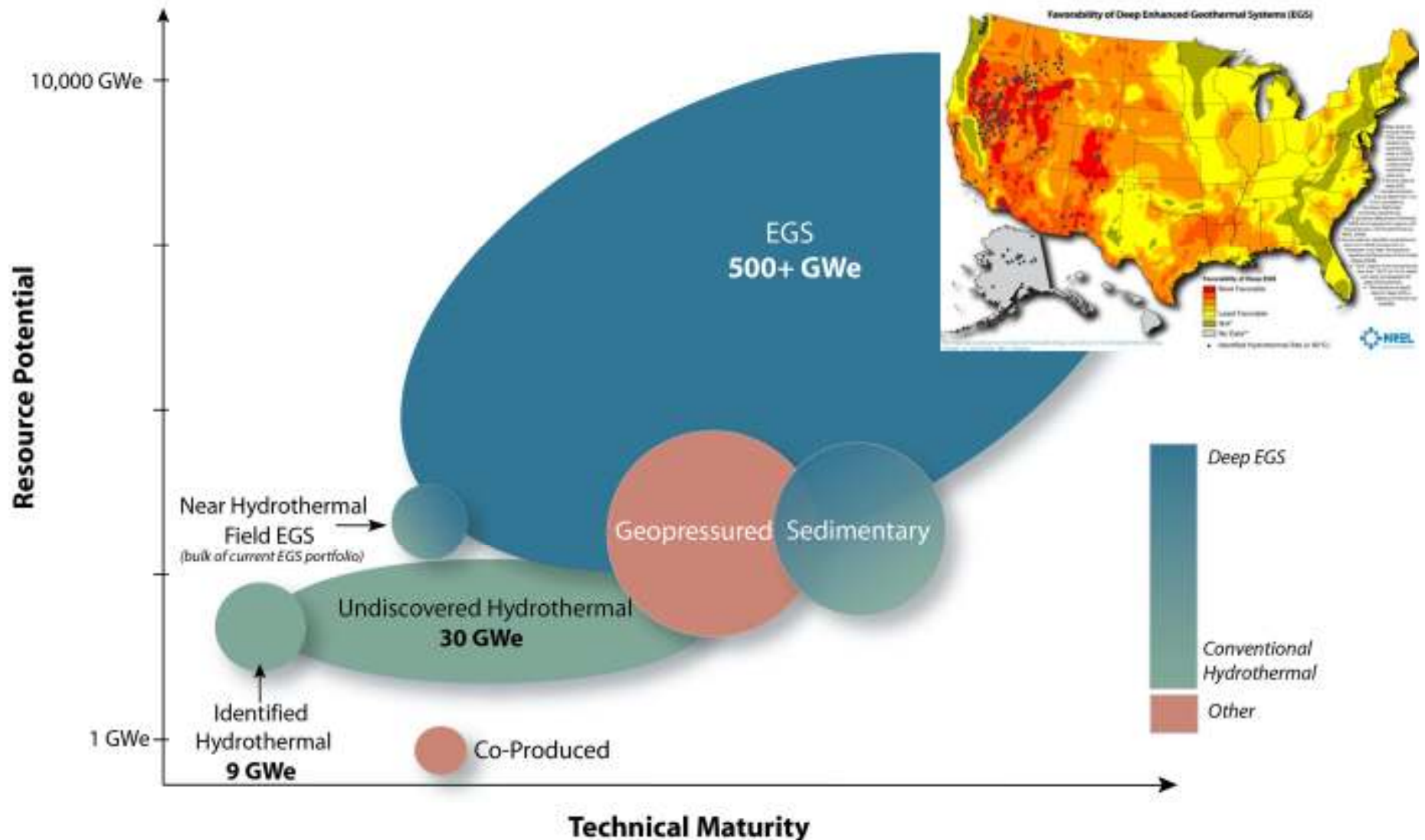
- **There are 6-10 geothermal rigs operating in the US at any time**
 - Compare to +1900 for onshore oil and gas (+50% horizontal)



Realizing the Full Potential of Geothermal

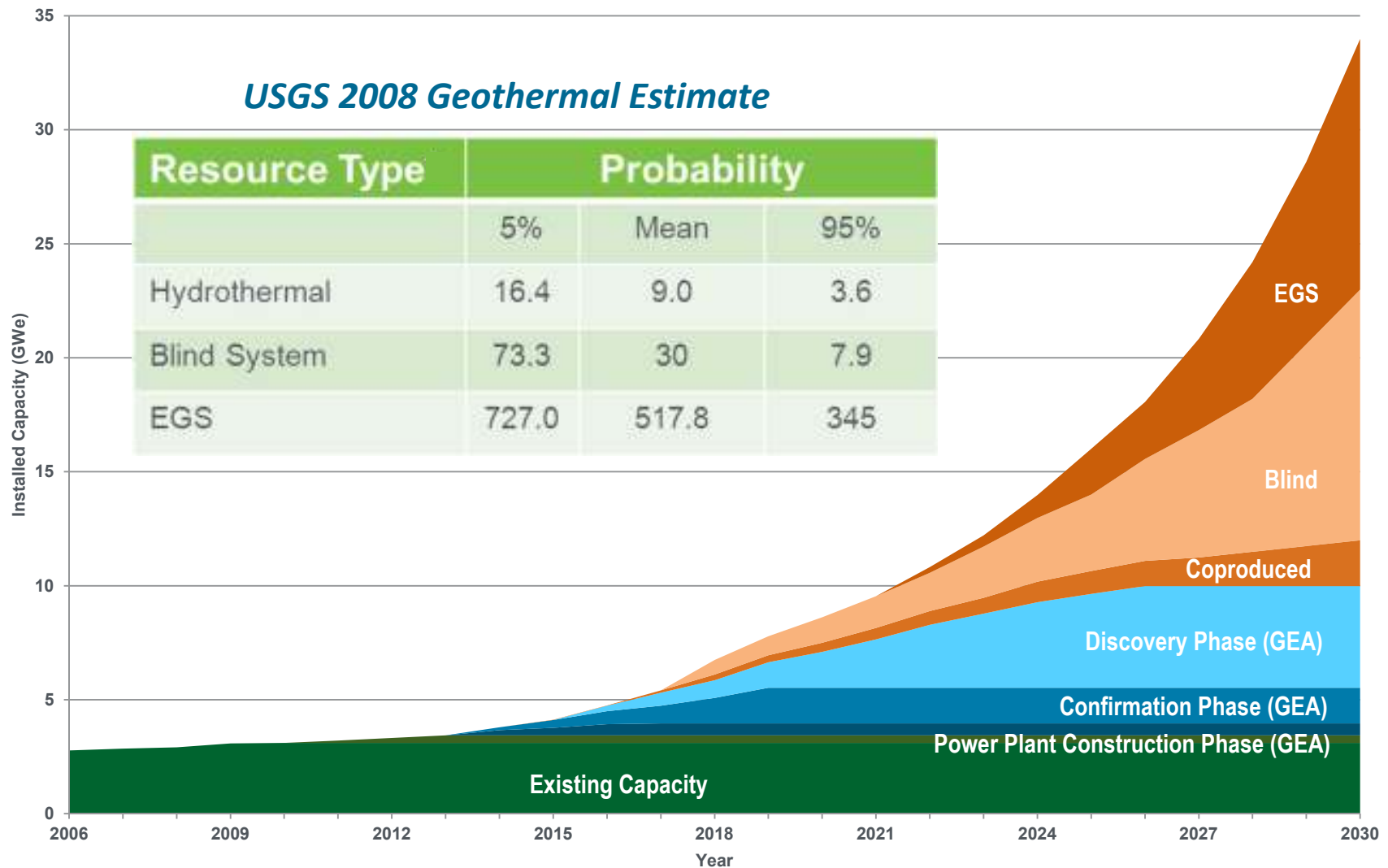
Exploring the upside

Geothermal Resource Potential



Geothermal Potential by 2030

Program Support Critical to Growth



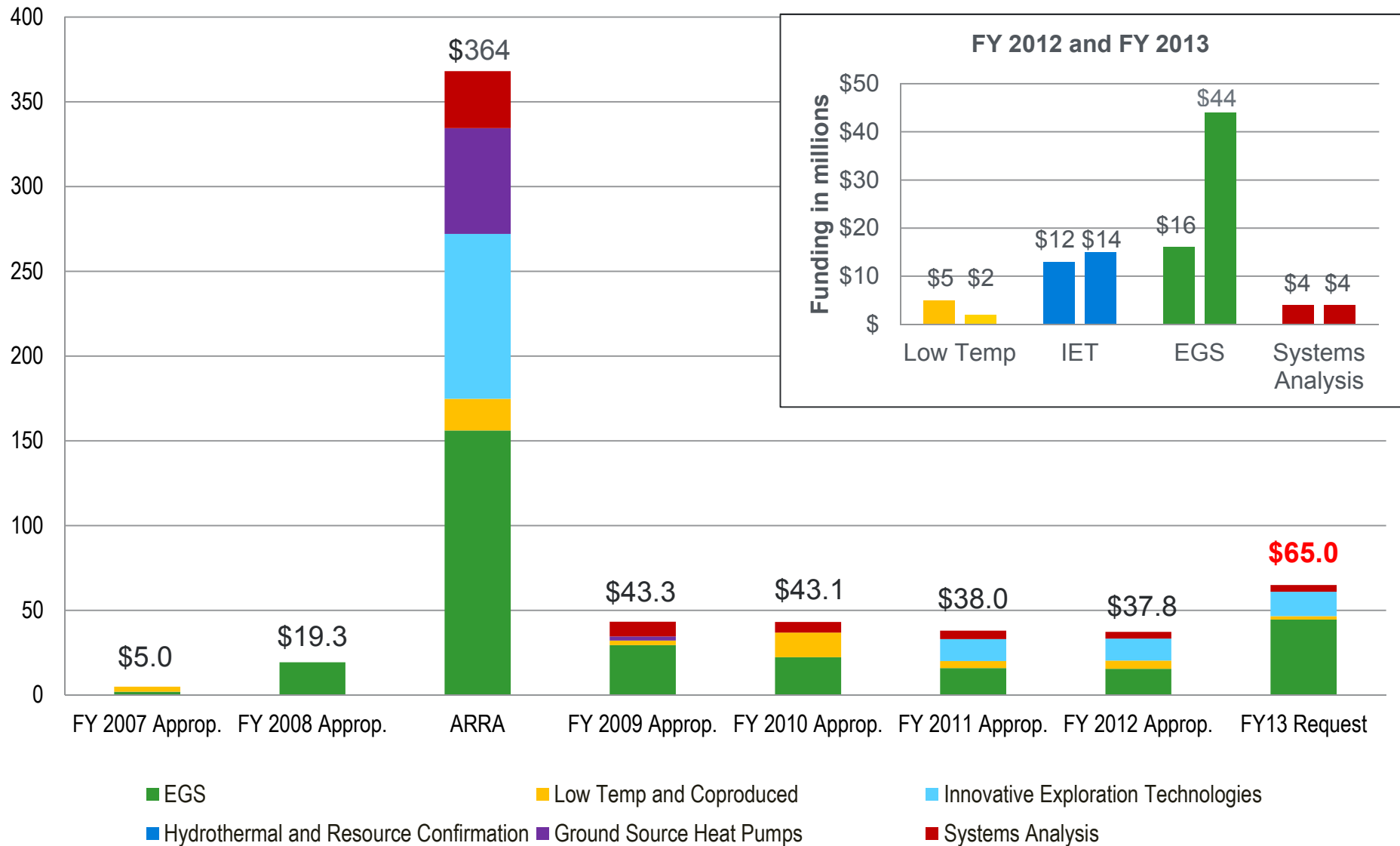
Increased Focus

- **Identification of New Geothermal Prospects**
 - Lowering risk and cost
- **Regulatory Roadmaps and Streamlining**
 - Programmatic Environmental Impact Assessment
- **EGS Test Sites**
 - Advancing new techniques and technologies
- **Strategic Mineral Assessment**
- **Increased Funding Leverage**

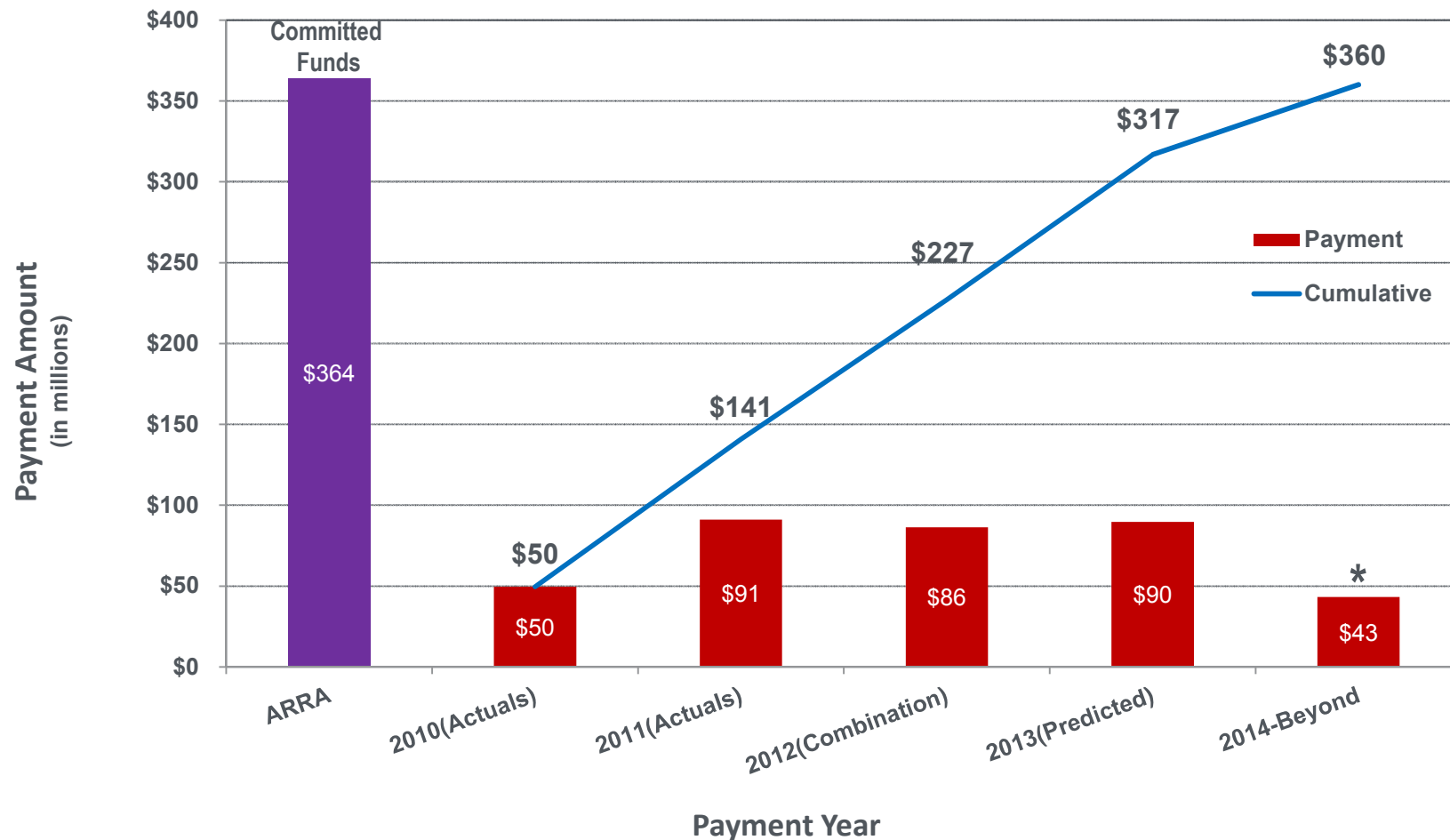


GTP Budget History

FY13 increase in EGS



American Recovery and Reinvestment Act Payments

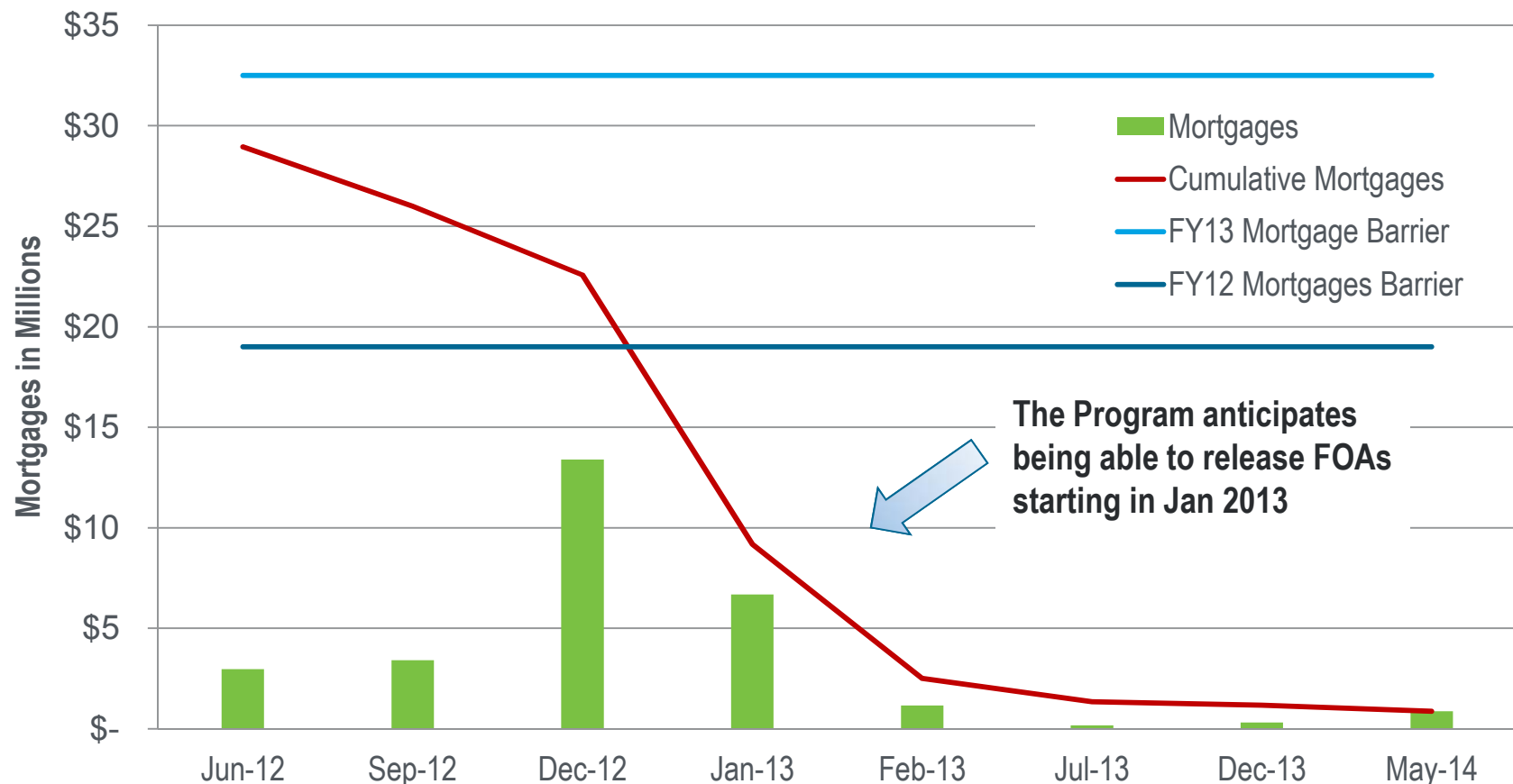


* Currently reviewing projects that extend beyond 2013 to identify ways to accelerate costing to meet the new OMB Guidance on ARRA spending

Mortgage Forecast

The reason behind no FY12 FOA's

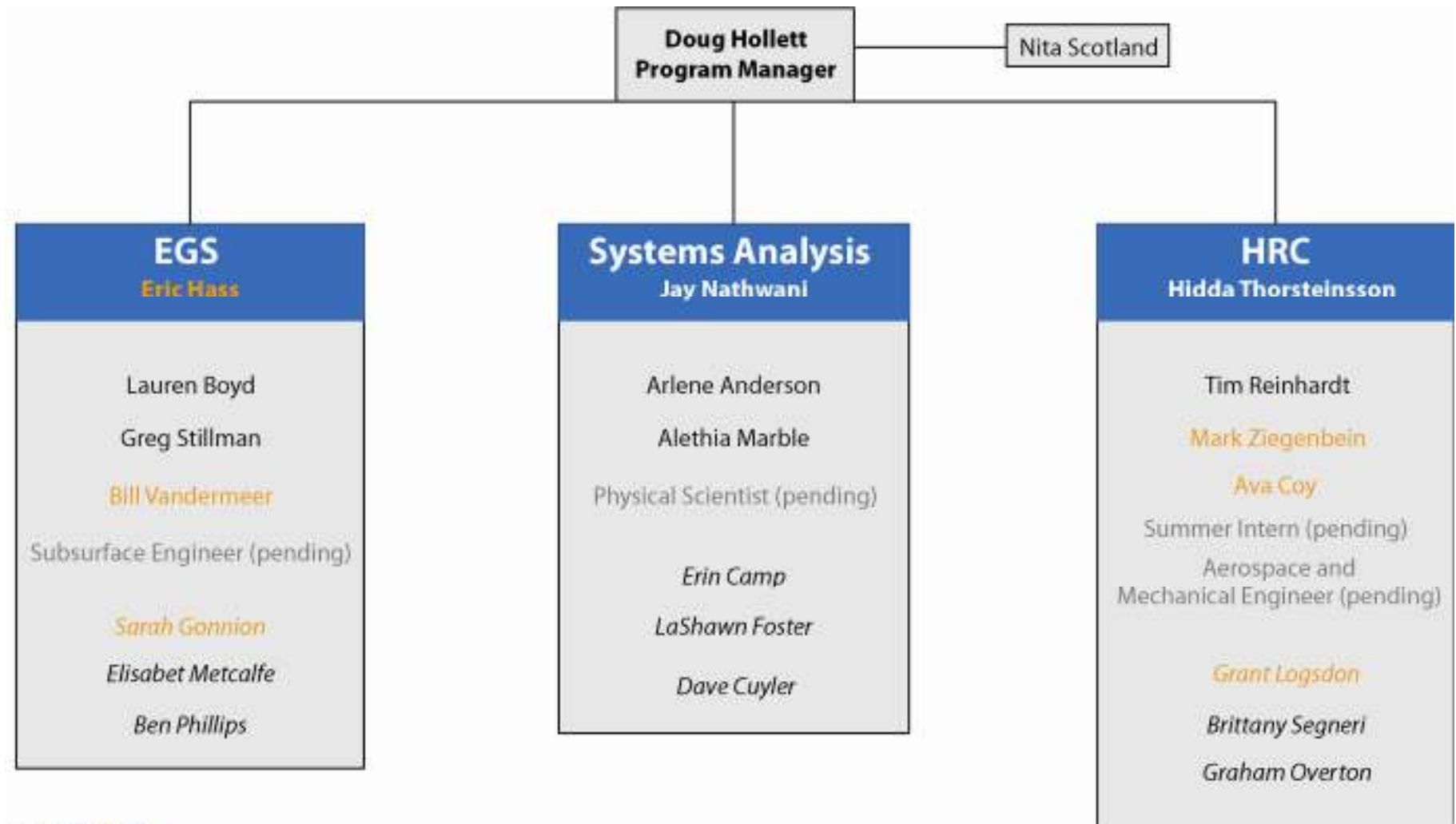
- The FY12 Conference Report stated “GTP may not announce new funding opportunities that result in total mortgages on future fiscal years in excess of half of the program's fiscal year 2012 appropriation”
- In FY12 the **mortgage barrier is \$19M**
- In **FY13 the barrier is \$32.5M** (based on the EERE request & assuming the conference report language persists)



The Program anticipates being able to release FOAs starting in Jan 2013

Geothermal Program

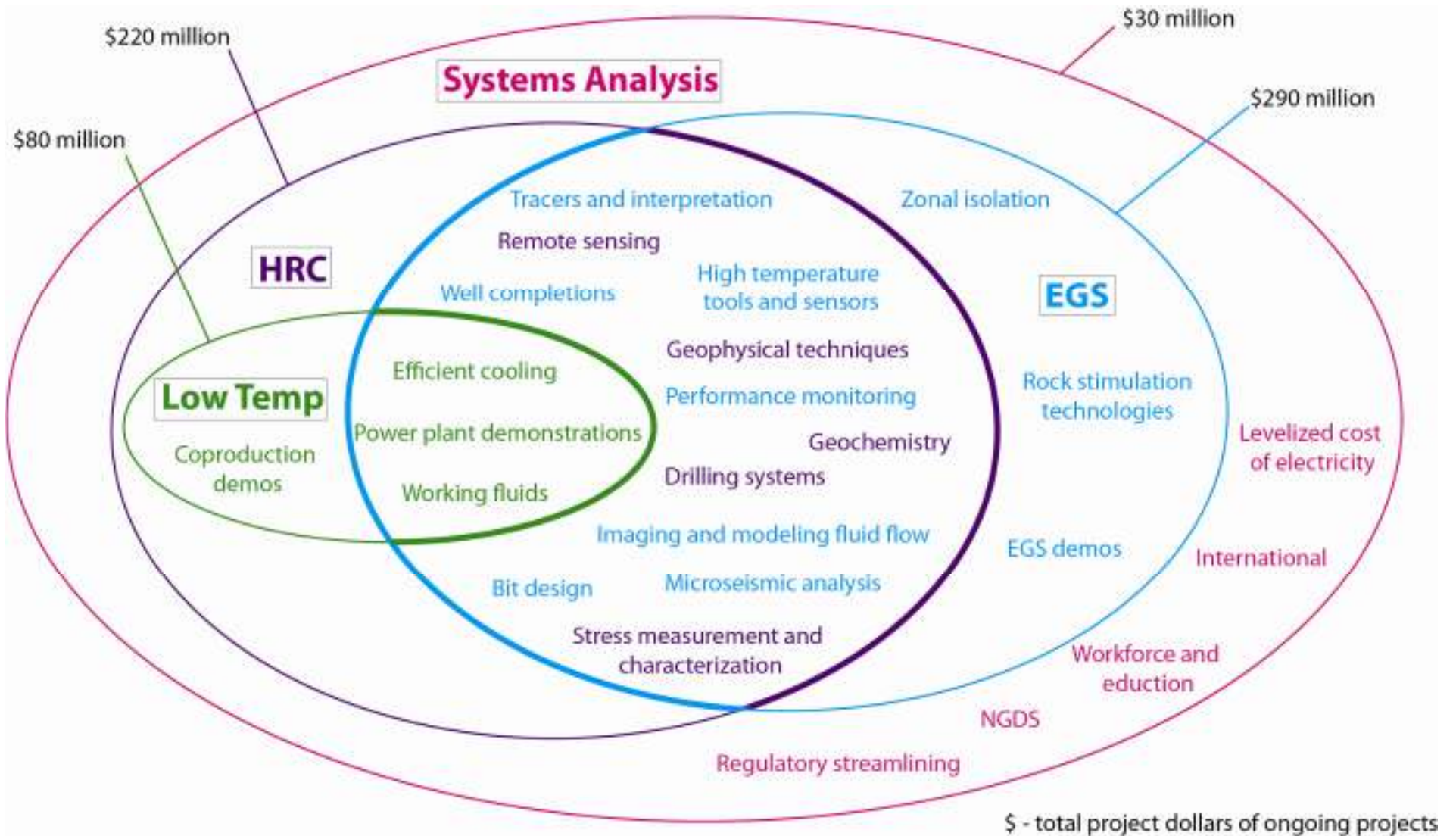
Staff and organization



Golden Office
Contractor

R&D Integrates Across Subprograms

2008-Present



Hydrothermal and Resource Characterization

Innovative Exploration Technologies – FY13 Request \$13.5M

Current Portfolio

- **20 ARRA projects to validate innovative exploration technologies and confirm 400 MW of new hydrothermal resources by 2014**
 - Projects in Nevada, California, New Mexico, Alaska, Colorado, Hawaii, and Oregon
 - About 30-60 new MW's already identified
- **19 R&D projects focused on increasing exploration success through**
 - Advanced geophysical surveys and processing
 - New geochemical signals and improved analysis
 - Innovative drilling systems
- **USGS resource assessment efforts**

FY13

- **Continued research and development to lower exploration risk and costs**
 - Phase II funding for successful R&D projects that accomplish technical milestones
- **Regional Data Gathering and Analysis to identify new opportunities**

Project Highlight – Lithium Extraction from Geothermal Brine



- \$3M ARRA award
- Successfully scaled up laboratory process for making a lithium extraction material
- Currently running a pilot plant that filters 20 gallons/minute
- A commercial plant, near Salton Sea, CA, will begin construction in late 2012

Subprogram goal: Lower LCOE to 6 cents/kWh by 2020

Hydrothermal and Resource Characterization

Technology Readiness Level (TRL) Context

TRL 2-3

TRL 4-6

TRL 7-9

Reservoir
Characterization

- Resource Assessment
- Geophysical techniques
- Geochemical methods
- Remote sensing



Access
Reservoir

- Drilling systems
- Advanced drilling tools



Energy
Conversion

- Co-production demonstrations
- Thermodynamic cycles
- Operations and maintenance
- Low temperature demonstrations



HRC: Technical Challenges

Program Investment Matrix

CHARACTERIZATION

Effective and low cost subsurface characterization

ACCESS

Low cost drilling

ENERGY CONVERSION

Low cost O&M and high efficiency energy conversion

Geophysical- joint inversion and seismic

Metric: Reduce non-uniqueness of gravity models from millions of solutions to hundreds; 17 Projects / \$72,598,943

Geophysical- self potential, resistivity and shallow temperature

Metric: 400MW by 2016; 6 Projects / \$10,646,794

Geophysical- remote sensing

Metric: Decrease processing efficiency from months to weeks, increase depth of penetration of airborne surveys from 400m to 2 km ; 8 Projects / \$64,830,793

Geology

Metric: Categorize geothermal settings in US; 3 Projects / \$30,664,757

Geochemistry- thermochronometric, chronostratigraphy, geothermometers

Metric: Add at 1+ geophysical signature to reaction transport models ; 3 Projects / \$13,163,010

Geochemistry- soil gas/fluid inclusion and isotopes

Metric: Identify 1+ new geothermal signature, 20% increase in # of mineral phases in database; 3 Projects / \$15,721,199

Drilling Systems

Metric: crystalline rock, 30 ft/hr for 1000 ft; 8 Projects / \$19,350,308

Surface equipment- working fluids

Metric: >20% thermal conversion efficiency; 4 Projects / \$6,168,145

Surface equipment- mineral recovery

Metric: 15,000 tonnes per year of lithium carbonate at >99.5% purity ; 1 Project / \$9,633,543

Surface equipment- cooling

Metric: obtain 85% of powerplant maximum theoretical efficiency; 3 Projects / \$3,174,022

Surface equipment- power conversion

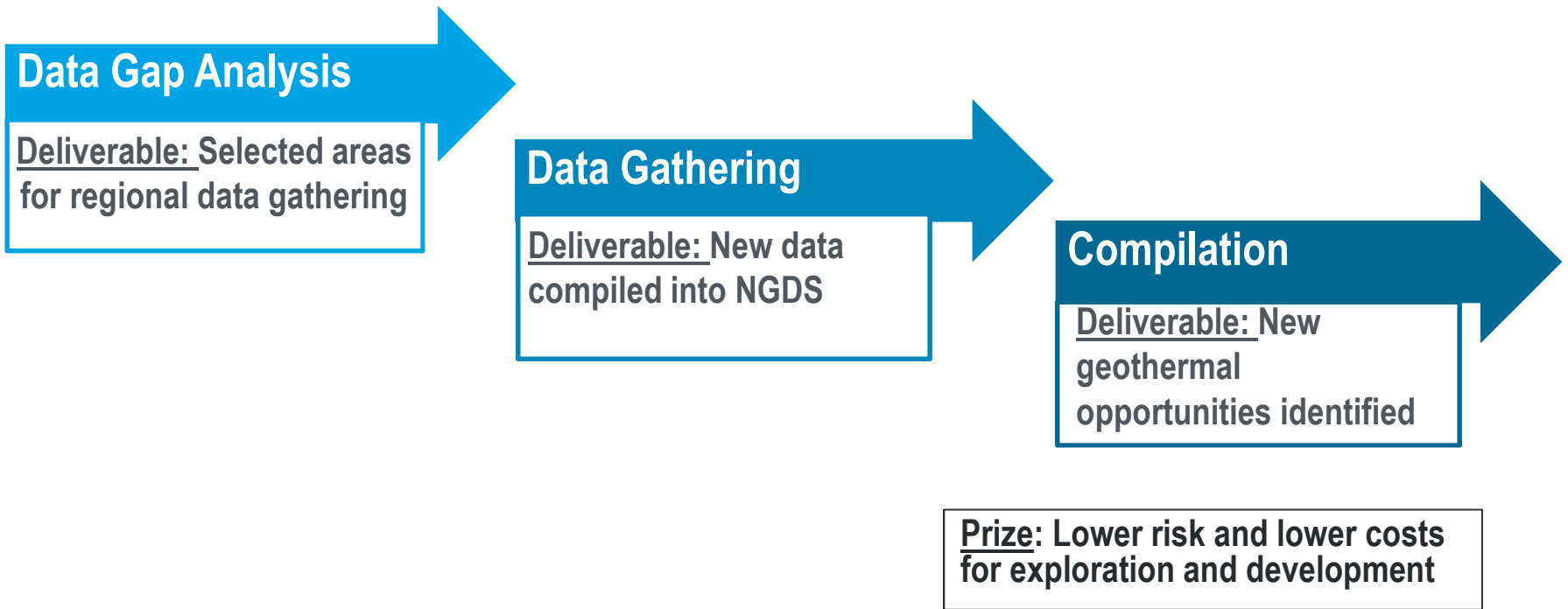
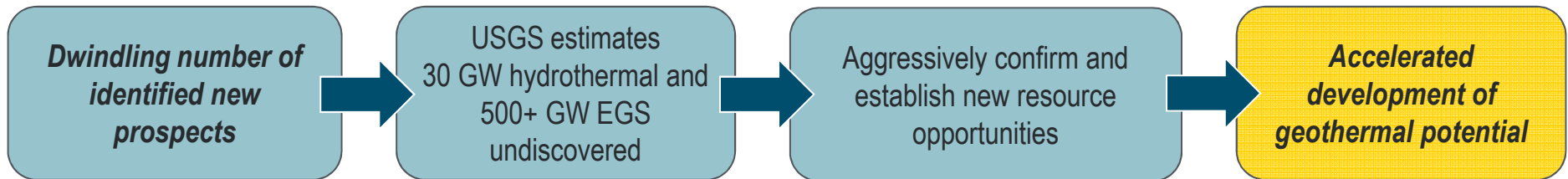
Metric: <200 F, >10% thermal conversion efficiency ; 5 Project / \$8,615,093

Power production demo- low temperature and coproduction

Metric: Install 20 MW by 2016; 10 Projects / \$68,221,841

Geothermal Resource Opportunities

Critical Tool for Industry Growth



Hydrothermal and Resource Characterization

Low Temperature and Coproduced – FY13 Request \$2M

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Current Portfolio

- **17 demonstration projects in progress including low temperature and co-produced resources**
 - Projects in Nevada, North Dakota, Oregon, California, Texas, Colorado, Massachusetts, and Idaho
- **Testing sites at Rocky Mountain Oilfield Testing Center (RMOTC)**
 - Providing lessons learned and preliminary cost data.
 - Demonstrations in commercial fields in planning stages
- **ARRA R&D projects focused on working fluids and efficient cooling**

FY13

- **Demonstration projects**
 - Phase II funding of demonstration projects that successfully complete phase I.

Project Highlight –

Rural Cooperative Developing Geothermal Power



- \$2 million ARRA investment
- Increasing electricity costs from the Bonneville Power Administration have incentivized rural coops in the NW to go out looking for other sources of power.
- Model for other remote settings

Subprogram goal: Lower LCOE to 6 cents/kWh by 2020

Enhanced Geothermal Systems

FY13 Request \$43.6M

Current Portfolio

- **Six EGS demonstrations** to validate reservoir creation in different geologic conditions
- **110 R&D projects** related to fracture characterization, coupled modeling, high temperature tools and sensors, etc.

Performer	Project Site	Site Information	Funding
Ormat Technologies Inc.	Desert Peak, NV	<i>Adjacent to existing hydrothermal sites</i>	\$ 4.3 M
Geysers Power Company, LLC	The Geysers, CA	<i>Two existing wells will be reopened and deepened for injection and stimulation</i>	\$ 6.2 M
University of Utah	Raft River, ID	<i>Improve the performance of the existing Raft River geothermal field</i>	\$ 8.9 M
Ormat Technologies Inc.	Bradys Hot Springs, NV	<i>Improve the performance of the existing geothermal field</i>	\$ 3.4 M
AltaRock Energy Inc.	Newberry Volcano, OR	<i>High potential in an area without existing geothermal development</i>	\$ 21.4 M
NakNek Electric Association	NakNek, AK	<i>Located in remote location in Alaska without existing geothermal development</i>	\$ 12.4 M

FY13 Efforts

- **EGS field test sites effort initiated**
 - Multi-user pre-competitive R&D environment for **EGS testing and validation**
 - **Up to three geologically unique sites**



Targets: Demonstrate technical feasibility of EGS at commercial scale by 2020 and lower LCOE to 6 cents/kWh by 2030

Current EGS Demo Schedule

March 2012



Enhanced Geothermal Systems

Technology Readiness Level (TRL) Context

TRL 2-3

TRL 4-6

TRL 7-8



Note: not all entities listed

EGS: Technical Challenges

Program Investment Matrix

ACCESS HOT FORMATION

CREATE RESERVOIR

SUSTAIN RESERVOIR

Low Cost Drilling & Subsurface
Characterization

Establish Inter-well connectivity and sufficient
Reservoir Volume

Maintaining Production & Long Term In-situ
Monitoring

Fracture characterization (pre- and post-stimulation)

Metric: location (+/- 10m), azimuth (+/- 15); 9 Projects / \$9,899,992

Long Term in-situ sensors

Metric: 300 C, 3200 psi (10 km), 8760 hrs; 2 Projects / \$5,192,000

In-situ stress diagnostics and inventory

Metric: +/- 10% true value; 1 Project / \$5,696,835

Temporary sealing of fractures

Metric: Self degrading after 60 days, 300 C, ΔP of 500 psi ; 4 Projects/ \$1,879,000

Seismic imaging tools and analysis

Metric: 500 SPS, 24 bit dynamic range, 3-C, 0.5 km between stations, 1 Hz – 1000 Hz sensors, 250 C, 60 dB SNR; 4 Projects /\$9,986,158

Zonal Isolation

Metric: Self degrading after 14 days, 300 C, ΔP of 5800 psi; 2 Projects / \$2,532,144

High temperature tools & sensors

Metric: 300 C, 3200 psi (10 km); 20 Projects / \$29,513,833

Drilling Systems

Metric: crystalline rock, 30 ft/hr for 1000 ft; 9 Projects / \$37,720,577

Coupled Models (THMQC)

Metric: +/- 10% validation with laboratory experiments; 5 Projects / \$5,048,620

Stimulation Prediction Models

Metric: Location, azimuth and total fractured volume +/- 10% compared to MEQ data; 6 Projects / \$6,152,848

Pumping Technology

Metric: 300 bar dynamic head, 43,500 BPD, 3 years operational life, 300 C; 3 Projects / \$8,705,713

Smart Tracers and Tracer Interpretation

Metric: fracture surface area (m2), reservoir volume, hydraulic conductivity (m/sec), T; 10 Projects / \$8,686,307

Imaging and Modeling Fluid Flow

Metric: Ability to locate and estimate flow rates +/- 10% of true value; 6 Projects / \$2,640,297

Stimulation Technologies

Metric: >60 kg/sec production rate; 1 Project / \$950,000

EGS Test Sites

Key initiative which requires Federal leadership

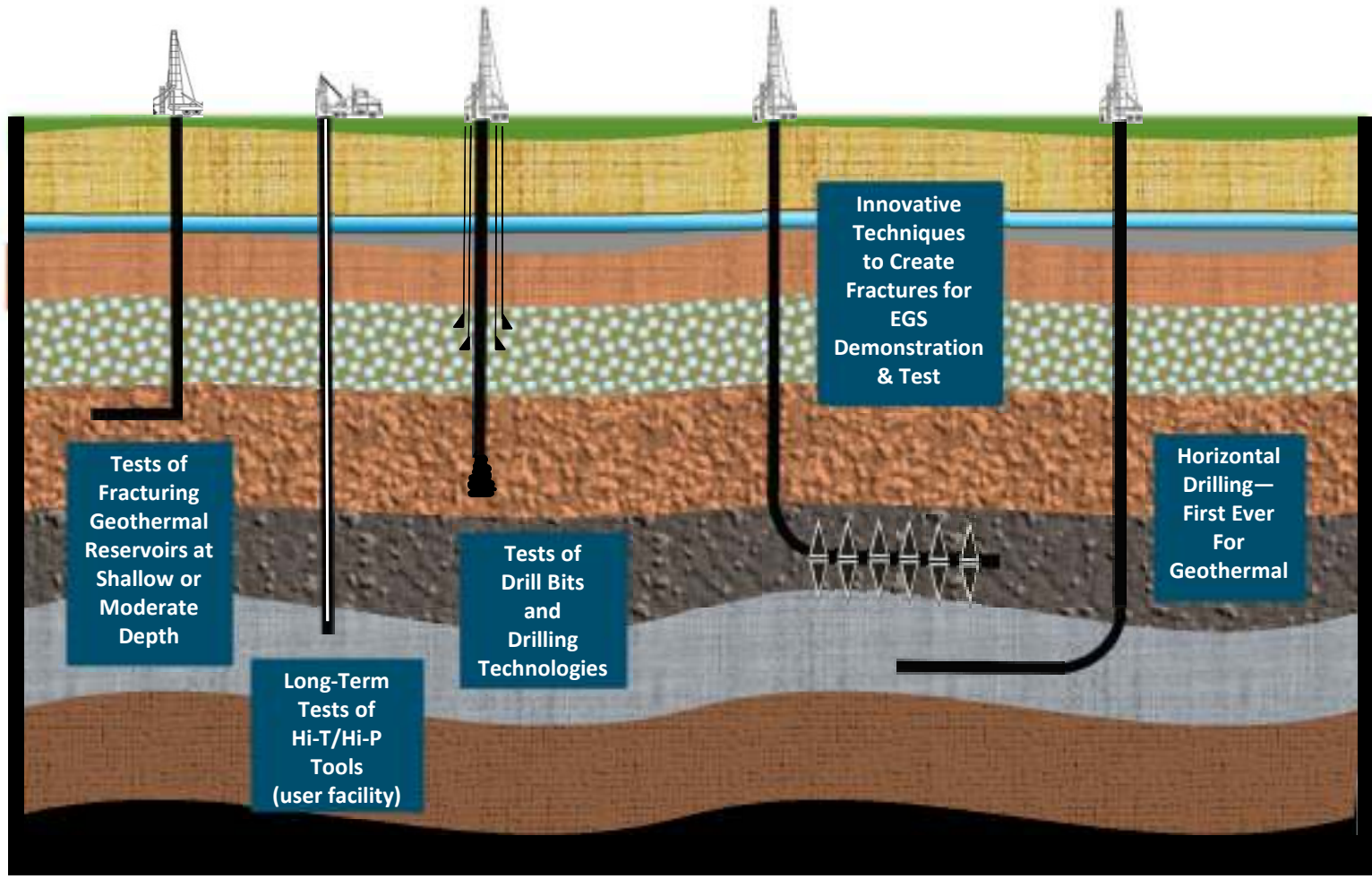
- **Federal Role:** Ability to test technologies and take technical risks not possible in the private sector
- **Timing:** Need to achieve EGS success more rapidly than possible with our current demonstration portfolio
- **Results:** Well-run test sites focusing on strategic innovation, will quickly optimize the best pathway for EGS success
- **Clarity:** Near-term EGS success will lower risk of this vital resource... allows the private sector to more easily obtain funding and positions EGS as a nationwide resource



EGS Test Site(s)

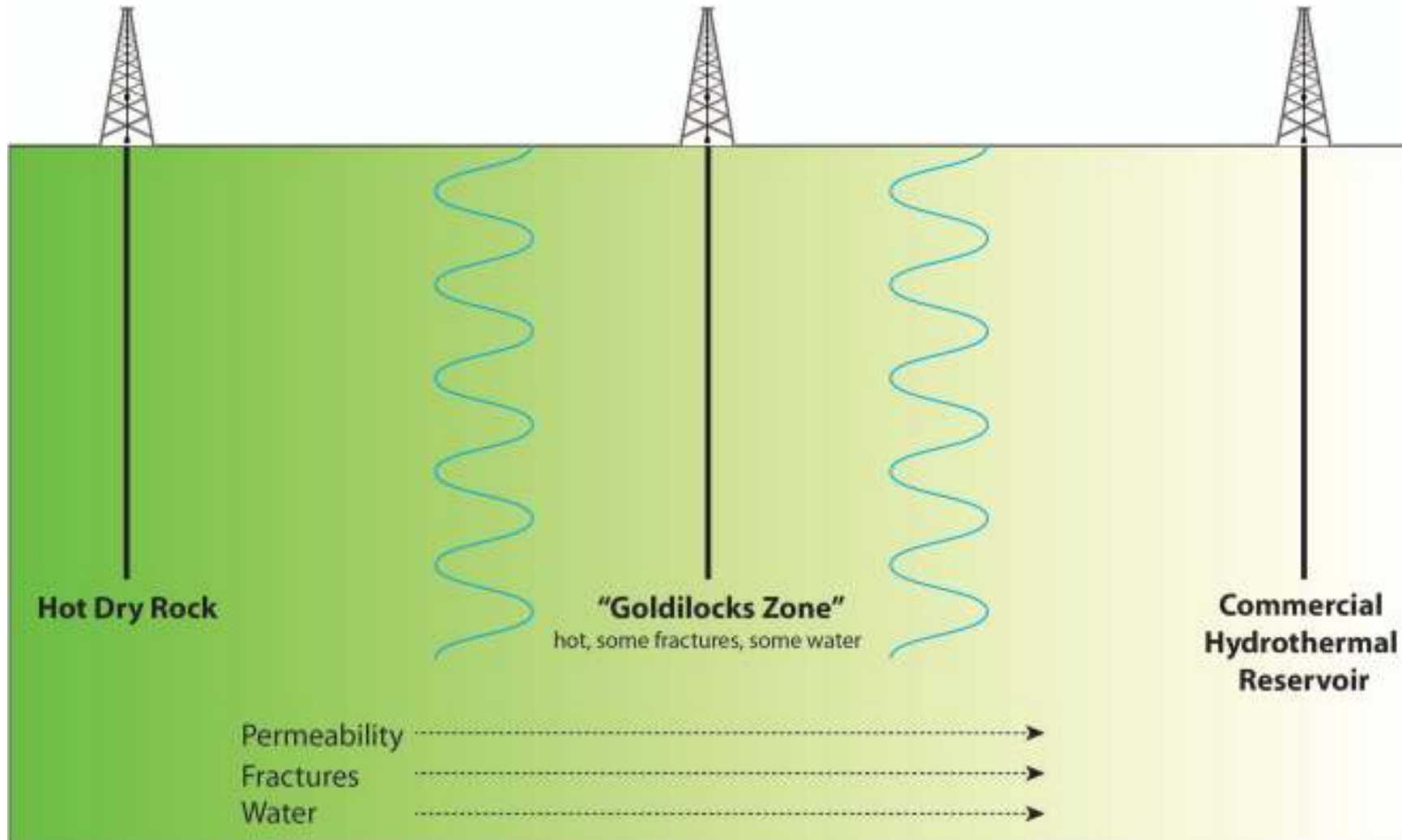
Example activities

Highly likely to be a site with an existing well or well control, subsurface data, permitting etc.



EGS Test Sites

Candidate Considerations



Systems Analysis

Request \$4M

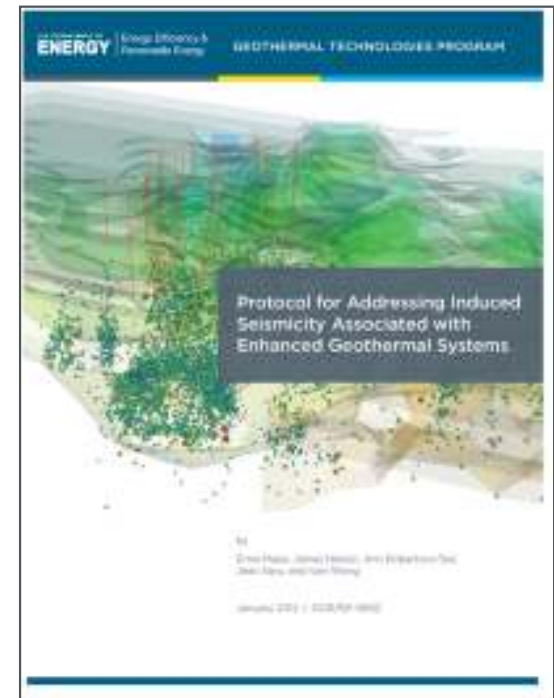
Systems Analysis assesses geothermal resources, cost drivers, barriers, the impact of policy, and progress toward goals.

Current Portfolio

- Regulatory Roadmap Initiative
- Programmatic Environmental Assessment (EA)
- National Geothermal Data System design, testing and population
- EGS field test site planning, analysis and initial scoping

FY13

- Techno-economic, environmental and financial analysis
- Geothermal data provision
- Intergovernmental and international coordination



New U.S. based Protocol
2012

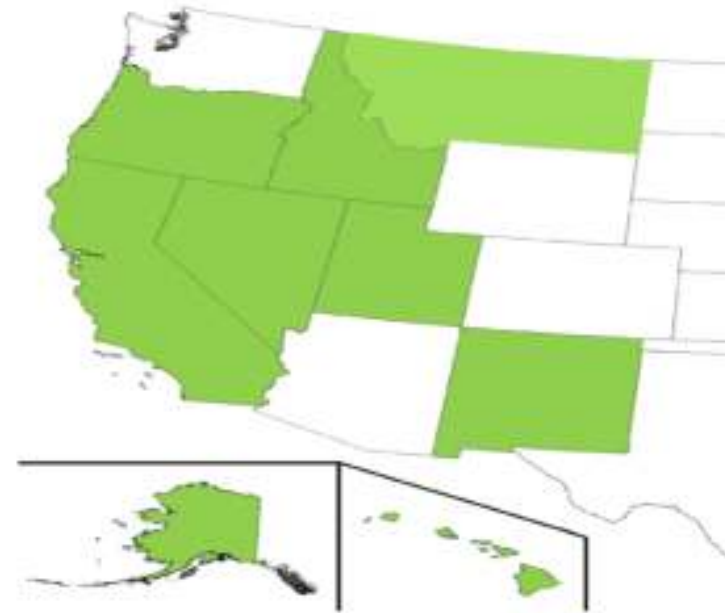
Solutions that increase deployment and decrease risk.

Regulatory Roadmap Project

Initiated Spring 2012

Scope:

- Document the regulatory process for geothermal development for:
- **8 states:** California, Nevada, Hawaii, Oregon, Utah, Idaho, Alaska, Montana.
- **3 levels:** Federal, State, County

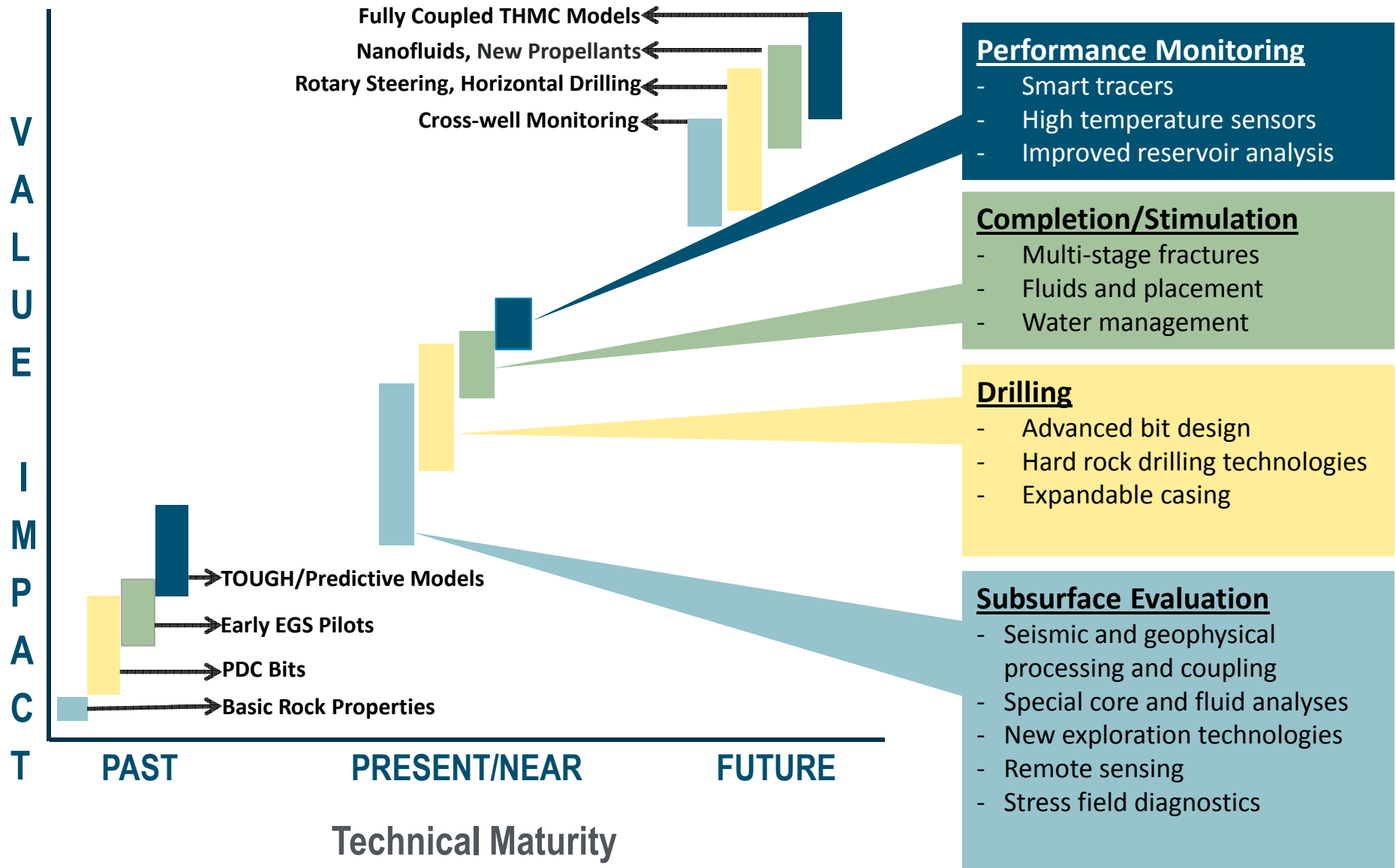


Approach:

- Research **permitting regulations** - develop first draft of flowcharts and supporting documents
- Convene **key agency officials** to review and comment
- Integrate into regulatory roadmap draft. *Deadline: 9/30/2012*
- Convene key agency representatives (at all levels) and stakeholders to identify areas of concern, bottlenecks, overlaps, differences in implementation, and difficulties in the permitting process. *Deadline: October 2012*

Geothermal Portfolio

Technology Drives Value



Geothermal

Hydrothermal and EGS Path Forward

- ***Potential is huge and remains highly attractive***
 - Opportunity for broad-based implementation of baseload power
- ***Balanced Investment Portfolio***
 - Hydrothermal/Exploration Technologies R&D near-term
 - EGS RD&D and demonstrations
 - EGS test sites for long-term goals
- ***Reduction of Non-Technical Risks is critical***
 - Carry many of the siting challenges of other energy sources
- ***Success is:***
 - ID of more prospects and opportunities
 - Decreased and predictable risk profile
 - Reliable and sustainable business case

“A key mechanism for gaining rigorous, formal and documented evaluation of Geothermal Technologies Program Activities”

- Project evaluations and guidance
- Feedback to principal investigators
- Forum for collaboration and tech transfer
- Complements stage-gate and in-depth project reviews
- Influences operational practices and processes of the Program
- Influences and guides future R&D directions

“Your guidance and feedback are critical to making geothermal a key component of the nation’s energy solutions”

Questions?