Pathway to Transformative Change
Shale Gas – Geothermal

Shale Gas: Technology Innovations
Spawned Sector Transformation

Potential for similar impact in Geothermal using broadly comparable technologies

Barnett: High-rate slick-water fracs 2.4% OGIP recovery
Barnett: Horizontal well 2-4 stimulations per well 5-8% OGIP recovery
Barnett: Horizontal well 6-8 stimulations per well 8-12% OGIP recovery

Barnett: Improved Petrophysics 16 stimulations per well 12-30% OGIP recovery

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

Geothermal Development Potential

The Future
Solving the EGS Puzzle
Innovative Exploration
Discovery and Technology Successes

Wildcat Manufacturing
# Geothermal Program Balance

## Transition from Near to Long Term

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

**GTO Operational Space**
Geothermal Program: Key 2013-2014 Objectives

Creating Impact

- **Establish EGS Field Observatory**
  - Temporary, collaborative subsurface lab
  - New techniques and technologies

- **Identify new hydrothermal opportunities**
  - Lowered risk and cost through “play fairway mapping”
  - New prospecting workflow

- **Reduce Risk Through Project Synergies**
  - Co-Production and Distributed Power
  - Strategic Resources

- **Address Non-Technical Barriers**
  - Regulatory Roadmaps and Optimization
  - Data Access- NGDS
## Technology as the Pathway to Growth

### Accomplishments in 2011-2012

#### Low Temp

- **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
- **O&G**: Deploying two binary systems in operating O&G fields.

#### Blind Hydrothermal

- ~100+ MW of new hydrothermal capacity
- 26 wells drilled to date

#### In-Field EGS

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

#### Greenfield EGS

- **Desert Peak, NV**
- **Potter Drilling**
- **Polycrystalline Diamond Compact Drill Bit**
- **CSI Technologies /AltaRock- DivERTers**
- **Baker Hughes – Ultrasonic Fracture Imager**
- **Sandia National Lab – PDC Bits**
EGS Field Observatory
Vision and Objectives

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

Energy Efficiency & Renewable Energy
Position all major initiatives for initiation and execution over next 2 years

- **EGS Field Observatory:**
  - Competitive Solicitation early FY14

- **Play Fairway mapping**
  - 1st go-by completed 2013

- **Oil and Gas Co-Production deployment**
  - Equipment in the field Q3, first data by year end

- **Regulatory Roadmap**
  - Completion Q2 and support optimization
  - 5 of 10 white papers on key topics

- **Interagency Collaboration:**
  - **DOE-DOD collaboration**
    - Identify and pursue activities where missions align
  - **Strategic Materials**
    - Project kickoff with key agency stakeholders