NREL Barriers Task Force Team

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Barriers Taskforce Goal

Quantitatively analyze barriers

- How do you quantify barriers?
- How do you analyze geospatially?
- How do you quantify impact?
- How do you analyze potential improvements?
Barriers Expert Team
The GeoRePORT System:

- Was developed to address the need of the GTO to track and measure the impact of research, development, and deployment funding for GTO-funded geothermal projects.
- Is particularly useful for describing early-stage exploration projects.
- Is unique in providing a detailed system for reporting both the resource grade and the project readiness level. The analysis conducted for GeoVision discusses only resource grade and not project readiness levels.
- Is comprised of three assessment tools: Geological, Technical, and Socio-Economic.
- Each of the assessment tool’s resource grades are divided into attributes and sub-attributes that describe the characteristics that contribute to feasibility of project development (see figure).
Using GeoRePORT for GeoVision

**STEP 1:** Identify market barriers (sub-attributes) and weight them according to impact

Barriers (Sub-Attributes)
1. Market demand
2. Price of electricity
3. Policies
4. Incentives

**STEP 2:** Develop grading system for the market attribute and each sub-attribute

**EXAMPLE:** Policy Sub-Attribute Grades

<table>
<thead>
<tr>
<th>Grades</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Feed-in tariff for geothermal (standard offer contracts)</td>
</tr>
<tr>
<td>B</td>
<td>Interconnection set-aside or RPS or state purchase requirement specific for geothermal</td>
</tr>
<tr>
<td>C</td>
<td>State renewable purchasing requirements or RPS - not preferential to a particular renewable</td>
</tr>
<tr>
<td>D</td>
<td>State purchasing requirements or RPS - with preferential consideration or set-asides for non-geothermal renewables</td>
</tr>
<tr>
<td>E</td>
<td>No policies beneficial to renewables (No RPS)</td>
</tr>
</tbody>
</table>

**EXAMPLES:** Figures 4-7

**STEP 3:** Collect and/or develop data to create maps of each sub-attribute

**EXAMPLES:** Figures 4-7

**STEP 4:** Combine all attributes into a single attribute summary map

**EXAMPLE:** Figure 8

**STEP 5:** Identify thresholds (unallowed, significant barrier) for each sub-attribute

**EXAMPLE:** Table 4

<table>
<thead>
<tr>
<th>Sub-Attribute</th>
<th>Unallowed Grade(s)</th>
<th>Significant Barrier Grade(s)</th>
<th>Flagged Grade(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Demand</td>
<td>--</td>
<td>--</td>
<td>D, E</td>
</tr>
<tr>
<td>Price of Electricity</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Policies</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Incentives</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**EXAMPLE:** Table 5

**SCENARIO 1:** Renewables
- Increased State renewable standards

**SCENARIO 2:** Baseload
- Baseload set-aside, or
- Baseload tax incentive, or
- Integration charge for VREs

**SCENARIO 3:** Geothermal
- Geothermal set-aside, or
- Geothermal tax incentive

**STEP 6:** Estimate potential geothermal deployment for various market scenarios

**EXAMPLE:** Table 5

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Potential improvement scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAU</td>
<td>- Deployment based on current market conditions (current policies/incentives).</td>
</tr>
<tr>
<td><strong>SCENARIO 1:</strong></td>
<td>Increased State renewable standards</td>
</tr>
<tr>
<td><strong>SCENARIO 2:</strong></td>
<td>Baseload set-aside, or Baseload tax incentive, or Integration charge for VREs</td>
</tr>
<tr>
<td><strong>SCENARIO 3:</strong> Geothermal</td>
<td>Geothermal set-aside, or Geothermal tax incentive</td>
</tr>
</tbody>
</table>
Land Access Sub-Attributes
Land Access Summary

Identified MW

Undiscovered MW

Near-Field EGS MW

EGS MW

- Unallowed
- Significant Barriers
- Developable
Figure 2-19. Example timeline of a geothermal project on federal lands, illustrating that a single location could trigger National Environmental Policy Act analysis six separate times

Source: Young et al. 2014

Figure Note: EA = Environmental Assessment, EIA = Environmental Impact Statement, CX = categorical exclusion, MT = magnetotelluric, and TGH = temperature-gradient hole.
Permitting

Federal Regulatory Framework

Environmental Review

State Regulatory Framework

Ancillary Permits
Permitting
Permitting – Impact on Deployment

Geothermal Capacity (MW)

- **SCENARIO 2b: Central Office + CX**
- **SCENARIO 2a: Central Office**
- **BAU Baseline**

**Timeline Options:**
- 4-year timeline
- 6-year timeline
- 8-year timeline
Market

![Graph showing Total Solar and Distributed Generation Carve Outs and Solar Median LCOE over time. The graph indicates a decrease in Total Generation (TWh) and an increase in LCOE ($/MWh) from 1999 to 2016.]
Market
### Market

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>2050 Deployment</th>
<th>Improvement over BAU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAU</strong></td>
<td>BAU Baseline</td>
<td>5,940 MW</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>SCENARIO 1:</strong> Renewable Benefits</td>
<td>1a: Increased Renewables (49% State RPS)</td>
<td>6,080 MW</td>
<td>140 MW (2%)</td>
</tr>
<tr>
<td>SCENARIO 2: Baseload-specific benefits</td>
<td>2a: Federal Baseload 30% Tax Credit</td>
<td>7,090 MW</td>
<td>1,150 MW (19%)</td>
</tr>
<tr>
<td></td>
<td>2b: RPS with 20% Baseload Set-aside</td>
<td>6,850 MW</td>
<td>900 MW (15%)</td>
</tr>
<tr>
<td></td>
<td>2c: 30% Transmission charge for VREs</td>
<td>6,440 MW</td>
<td>500 MW (8%)</td>
</tr>
<tr>
<td><strong>SCENARIO 3:</strong> Geothermal-specific benefits</td>
<td>3a: Federal Geothermal 30% Tax Credit</td>
<td>7,200 MW</td>
<td>1,260 MW (21%)</td>
</tr>
<tr>
<td></td>
<td>3b: State Geothermal Set-Aside</td>
<td>10,710 MW</td>
<td>4,770 (80%)</td>
</tr>
<tr>
<td><strong>SCENARIO 4:</strong> Changes in Market Conditions</td>
<td>4a: High Natural Gas Prices</td>
<td>6,870 MW</td>
<td>930 MW (16%)</td>
</tr>
<tr>
<td></td>
<td>4b: High Electrification</td>
<td>6,810 MW</td>
<td>870 (15%)</td>
</tr>
</tbody>
</table>
Boosts local economy

Causes little impact

Creates long-term jobs

Provides grid stability & reliability

Is always available
Transmission
Social Acceptance

Optimism About Technologies
"Which one of these technologies will have a positive, negative, or no effect on our way of life in the next 20 years?"

<table>
<thead>
<tr>
<th>Technology</th>
<th>Positive</th>
<th>Negative</th>
<th>No Effects</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Energy</td>
<td>54%</td>
<td>12%</td>
<td>28%</td>
<td>6%</td>
</tr>
<tr>
<td>Wind Energy</td>
<td>46%</td>
<td>16%</td>
<td>32%</td>
<td>6%</td>
</tr>
<tr>
<td>Biomass Energy</td>
<td>24%</td>
<td>21%</td>
<td>22%</td>
<td>33%</td>
</tr>
<tr>
<td>Nanotechnologies</td>
<td>22%</td>
<td>14%</td>
<td>14%</td>
<td>51%</td>
</tr>
<tr>
<td>Biotechnologies</td>
<td>20%</td>
<td>15%</td>
<td>24%</td>
<td>42%</td>
</tr>
<tr>
<td>GEOTHERMAL ENERGY</td>
<td>18%</td>
<td>18%</td>
<td>23%</td>
<td>42%</td>
</tr>
<tr>
<td>Nuclear Energy</td>
<td>8%</td>
<td>68%</td>
<td>18%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Pellizzone et al. (2015)

adapted from Wüstenhagen et al. 2007
Take Aways

• **Flat line** in geothermal **deployment** in recent years **may be due to institutional/soft-cost** (and not technical cost) barriers. Overcoming these barriers could lead to increased deployment slopes.

• The **geothermal resource supply curve is decreasing** due to growing environmental and land-use restrictions. Technology improvements and mitigation techniques may be able to reduce the impact these restrictions have on future geothermal development.

• **Permitting and land access challenges** can impact accessibility and development timeframes, **severely impacting deployment** potential. Modeling suggests these challenges reduce deployment by more than 50% in the BAU case and by 15% in the Barrier Technology Improvement (BTI) case.

• Well-designed policies and incentives can drive deployment:
  
  o **Set-asides** – Historical set-asides have allowed for deployment of non-economically competitive technologies (e.g., solar); the model demonstrates similar impact if geothermal set-asides were implemented.

  o **Tax credits** – Historical PTC has driven deployment of (cost-competitive) wind. Geothermal project timelines are too long to take advantage of this structure (as implemented). Historical oil and gas tax credits are exploration related and help to lower upfront risk.

  o **RD&D funding** – Historical (worldwide) government research funding in solar has helped drive reduction of solar LCOE, raise social acceptance of solar, and encourage policy/incentive development for increased solar deployment. Historical high geothermal budgets (e.g., 1980s) drove similar increases in geothermal deployment.
Take Aways

• Benefits of geothermal (e.g., economics, jobs, land use) relative to other technologies suggest states and communities would benefit from increased geothermal deployment.

• Local and federal economic paybacks are high compared to other renewables, so states that support development of geothermal will have greater economic benefit:
  o Local, full-time, living wage jobs Federal, state, and local annual royalties back into communities—if developed on state or federal land
  o High O&M spending into local communities Federal and state taxes, so geo generation produces more tax income for states and federal government.

• Environmentally friendly – low greenhouse gas emissions, small footprint, low water use, etc.

• The geothermal industry could benefit from improved, targeted marketing and advocacy to improve the community, market, and socio-political acceptance of geothermal development.
NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provides the knowledge to integrate and optimize energy systems.

Thank you

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