Geothermal project development
Outline

- Phases of geothermal development
  - Development time
  - Key decision points
  - Cost, Risk and Financing
- Development models – role of public vs private sector
- Risk management strategies
- Focus on resource risk
- Procurement and contracts
Phases of geothermal development – Risk and cost profile

Development time in years

1  2  3  4  5  6  7

Risk

Cost

Go/no go decision

Surface exploration

Exploration drilling

Conf drilling

Preliminary design

Feasibility study – Plant capacity fully decided

Capacity drilling

Final design

Power plant construction

ESIA

Operation

Go/no go decision – Prefeasibility study

Plant capacity fully decided

Phases of geothermal development

Preliminary study

Power plant construction

Operations
Phases of geothermal development – Financing*

- **Preliminary study**
  - $1-2 million
  - Typically funded by owner

- **Surface exploration**
  - $20-30 million
  - Owner’s equity, venture capital, concessional funding

- **Exploration drilling**

- **Conf drilling**

- **Capacity drilling**

- **Preliminary design**

- **Power plant construction**
  - Final design
  - $40-60 million
  - Owner’s equity, venture capital, concessional financing

- **Commercial financing generally available**
  - $70-100 million

* Numbers refer to typical costs for a 50MW power plant
Roles of public and private sector in geothermal development

**WIDE RANGE OF APPROACHES INVOLVING DIFFERENT LEVELS OF PUBLIC VS PRIVATE PARTICIPATION**

<table>
<thead>
<tr>
<th>Resource Assessment</th>
<th>Preliminary survey</th>
<th>Detailed surface exploration</th>
<th>Exploration drilling and well testing</th>
<th>Appraisal drilling and testing/Wellhead unit</th>
<th>Flow testing/well head</th>
<th>Feasibility study</th>
<th>Production drilling</th>
<th>Steam gathering system</th>
<th>Power Plant Construction</th>
<th>Power Plant O&amp;M</th>
<th>Reservoir Management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Public/ Private</td>
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| Implementation      | Greenfield         | Sale after explor. drilling   | Sale after feasibility             | Energy Conversion/ Steam Sales           | Joint Venture        | Public Model     |                   |                      |                        |                |                     |

**International Application**

| USA, Turkey, Indonesia | Turkey, USA, Kenya* | Philippines, Guatemala, Indonesia | Kenya, Italy, Mexico, Japan, Iceland, |
Comparative Analysis of Approaches to Geothermal Resource Risk Mitigation

Published by ESMAP in April 2016

- Authored by sector experts and World Bank specialists
  - Subir Sanyal, Ann Robertson-Tait, Migara Jayawardena, Jerry Huttner, and Laura Berman

- Historical review of geothermal risk mitigation approaches around the world
  - Analysis includes the global portfolio of geothermal power projects commissioned before 2014 – about 12 GW
  - Support mechanisms for geothermal development analyzed for each project
  - Focus on upstream support

- Four main approaches to upstream support emerge
  - Fully Public Development
  - Public-Private Cost Sharing
  - Geothermal Resource Risk Insurance
  - Early Fiscal Incentives

- Other modes of public support include
  - Feed-in tariffs, Renewable Portfolio Standards, tax credits, public investment in infrastructure
Fully Public Development

- This approach has been used in 12 countries
  - Most capacity in Mexico, Iceland, Kenya, El Salvador and Costa Rica has been developed by public sector
  - Originally the main approach but most countries have now opened up for private developers
- Over 3.6 GW developed by Public Model
- Requires a strong commitment from Government
  - Human and technical capacity
  - Financial resources
- Not easily scalable
Cost Sharing

- Cost Sharing has been used in 11 countries
  - Most capacity in Philippines, Japan and Turkey developed through this approach
- 3.0 GW developed through Cost Sharing
- Two main approaches
  - Public exploration drilling
  - Private exploration drilling with public financial support
- Allows more rapid development under right conditions
  - Government committed to rapid geothermal development
  - Qualified and committed developers
  - Transparent selection of developers key to success
  - If government carries out exploration drilling quality is critical
## Cost Sharing Modalities

<table>
<thead>
<tr>
<th>Development Stage</th>
<th>I Surface exploration</th>
<th>II Exploration drilling</th>
<th>III Production drilling</th>
<th>IV SAGS Power plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of financing</td>
<td>Public funding</td>
<td>Public funding</td>
<td>Private funding</td>
<td>Private funding</td>
</tr>
<tr>
<td>Developer</td>
<td>Public</td>
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- **GDC steam sales model**
  - ICE Costa Rica
- **Turkey, Nicaragua, Kenya (Olkaria III)**
- **USA, Japan, GRMF, GDF-LAC**

### Multilateral Development Banks’ Financing of Exploration Drilling and De-Risking versus Downstream Developments over Time

- **1978 – 2012**: 7%
- **2013 – 2017**: 29%
- **2017 – today**: 93%
Risks in geothermal projects

Risk Management Strategies

- **Avoid**
  - Select approaches that circumvent problems
  - Go by the book

- **Mitigate**
  - Reduce likelihood of negative/harmful events
  - Take actions to reduce negative impact

- **Transfer**
  - Contract agreements such as EPC and PPA
  - Comes at a cost but gives comfort

- **Accept**
  - Realistic contingency plans are essential
## Risks in geothermal projects, continued

<table>
<thead>
<tr>
<th>Risk category</th>
<th>Description</th>
<th>Example of risk handling</th>
<th>Related risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market risk</td>
<td>Revenue will not be as expected because the developer does not get paid for the production as originally planned.</td>
<td>Transfer risk to an off-taker by signing a Power Purchase Agreement (PPA). The market risk is then converted to off-taker default risk.</td>
<td>• Off-taker credit risk; • Price risk;</td>
</tr>
<tr>
<td>Geological resource risk</td>
<td>Risk that the production drilling campaign fails to reach the required capacity, or it does so with cost overruns. Also risk of decline in the resource due to unsustainable exploitation. In this case the resource is smaller than originally considered and the reservoir cannot sustain production to the power plant to produce according to planned capacity.</td>
<td>Reduce the likelihood of occurrence by investing in good surface exploration and experienced consultants. Transfer the risk through risk mitigation facilities if available. Develop the resource in phases with partial exploitation in the first phase and then stepwise increase in exploitation.</td>
<td>• Reservoir decline risk • Reservoir size risk • Drilling exploration risk • Reservoir sustainability risk</td>
</tr>
<tr>
<td>Location and site risks</td>
<td>Risk associated with the location such as natural hazards (earthquakes, hurricanes and volcanos). Risks associated with the site such as landslides and floods. Risks connected to the location such as security risks.</td>
<td>Select site to avoid natural hazards. Design infrastructure to withstand natural hazards.</td>
<td>• Natural hazard risk • Security risk</td>
</tr>
<tr>
<td>Legal risk</td>
<td>Risk related to the business transactions and contractual relationships in the project.</td>
<td>Mitigate the risk by engaging experienced legal counsel. Identify pertinent stakeholders</td>
<td>• Contract risk • Credit risk</td>
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# Risks in geothermal projects, continued

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<td><strong>Technical risk</strong></td>
<td>Risk associated with technical problems, be it during drilling, plant construction or plant operation. This can include quality problems, abandonment and non-completion. The impact can be increased cost, delays or revenue loss due to lower generation of energy.</td>
<td>Investing further in the engineering of the project. Transfer risk to equipment suppliers and EPC companies. Contracts with these companies can include guarantees and penalties for delays.</td>
<td>• Construction risk; • Technical drilling risk;</td>
</tr>
</tbody>
</table>
| **Project execution risk** | Risk due to delays in project execution.  
Risks due to management problems.  
Risks due to poor planning and inadequate budget not considering cost uncertainties.  
Risk due to difficulties in the procurement process. | Follow scheduling classification systems. Increase efforts in project planning. Follow procurement plans. Advanced engineering. | • Company risk • Procurement risk;                                                                |
| **Financial risk**    | Risk of cost increase.  
Risk of delays,  
Risk of revenue loss,  
Risk of changes in financing conditions such as interest rate change or currency changes. | Financial planning should be based on proper financial analysis, including sensitivity analysis. | • Credit risk                                                                                     |
## Risks in geothermal projects, continued

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</table>
| Legal risk                    | Risk related to the business transactions and contractual relationships in the project. | Mitigate the risk by engaging experienced legal counsel. Identify pertinent stakeholders                                                                                                                                 | • Contract risk  
• Credit risk |
| Social and environmental risk | Risk of environmental damage caused by the geothermal power plant including any liability following such damage.  
Risk of delays and even project cancellation due to adverse social impact of power plant. | Carry out investigations according to internationally available guidelines regarding environmental and social impact assessment.  
Apply inclusive and comprehensive communication strategies  
Identify employment and economic development opportunities to reduce the risk of local community opposition | |
**Exploration Drilling Strategy**

- Surface exploration results in **Conceptual Model**
- Conceptual Model used to define drilling targets for exploration drilling
  - Conceptual model is updated as data is collected through drilling
- Exploration Drilling Strategy aims at **maximizing** information about the nature of the resource and **minimizing** cost
  - Goal to collect good information about size, temperature, productivity, chemistry
  - Decision tree based on whether wells are successful or not
  - Abandonment of the project a possible outcome
Drilling – Success Rates and Well Capacities

- Productivity of new wells uncertain
  - Well productivity ranges between and within geothermal systems
  - Uncertainty largest for first wells
  - Decreases as more wells are drilled into a given system but does not disappear

- Significant implications for project development cost
  - Drilling cost is in the range $3-8 million per well
  - Total number of wells (production and reinjection) for a 50 MW project may range between 10 and 20
  - Can result in a cost difference of $30-80 million

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Sanyal and Morrow, 2011
IFC, 2013

Average Drilling Success Rate vs Number of Wells Drilled in Kamojang, Indonesia

Distribution of well capacities
Contracts

- Preliminary survey
- Surface exploration
- Exploration, confirmation, and capacity drilling
  - Owner’s engineer
  - Access roads and infrastructure
  - Drilling Contractor
    - Drilling
    - Consumables
    - Staff facilities
    - Directional drilling
    - Logging
    - Cementing
    - Testing
    - Etc...
- ESIA
- Feasibility study
- Power plant design and construction
  - Owner’s engineer
  - Civil works
  - Steam gathering system
  - Power plant
- Operation
  - Services
  - Supply of consumables
Procurement

- Procurement takes time – particularly public procurement
- Unforeseen events come up in geothermal projects – delays are costly
  - Plan for contingencies
  - Include funds for short notice costs in contracts with drilling contractors
- Failed tenders can cause significant project delays
  - Drilling activities particularly sensitive due to small size of sector
  - Drilling contractors do not like small, “unusual” and “complex” projects
  - Prepare bidding documents carefully
  - Informing bidders about any unusual requirements is key to success

World Bank Procurement Framework
Core Principles
## Procurement and Contracts

### OPPORTUNITIES FOR GENDER EQUALITY AND LOCAL COMMUNITY BENEFITS

<table>
<thead>
<tr>
<th>Modify regulatory frameworks to allow application of Sustainable Procurement Strategies</th>
<th>Support bid readiness for women-majority owned firms and small businesses</th>
<th>Providing insight into products and services in demand to inform businesses of potential opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small firms may offer nonprice advantages over larger firms in terms of quality, customization, service, short-order delivery, and reliability</td>
<td>Support general business development services, such as implementing accounting and invoicing systems</td>
<td>Informing first-time businesses about what to expect post-award can help them plan accordingly</td>
</tr>
<tr>
<td>Higher-priced bids may offer a greater value proposition in terms of development outcomes and decreased social risks (WB value-for-money principle)</td>
<td>Workshops on the mechanics of finding, scoping, costing, and responding to tenders</td>
<td>Reach out to potential suppliers through workshop sessions and women’s business associations and word-of-mouth networks)</td>
</tr>
<tr>
<td>Sustainable Procurement Strategy can be applied in WB projects but requires prior approval</td>
<td>Assistance in connecting with financial institutions capable of providing needed financial guarantees could</td>
<td>Include language in tender documents encouraging women and women owned business to participate</td>
</tr>
</tbody>
</table>
## Procurement and Contracts

### Opportunities for Gender Equality and Local Community Benefits

<table>
<thead>
<tr>
<th>Encourage participation of smaller firms by breaking larger solicitations into smaller ones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaking up procurement lots for protective gear can offer opportunities for local tailors and seamstresses</td>
</tr>
<tr>
<td>Separate snacks or meal components from a larger catering contract</td>
</tr>
<tr>
<td>Large-award holders can be encouraged to form consortia with designated small or women owned businesses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific gender equality requirements imposed on contractors and service providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific fraction of women in the workforce</td>
</tr>
<tr>
<td>Realistic requirements are key</td>
</tr>
<tr>
<td>Capacity building</td>
</tr>
<tr>
<td>Equal pay</td>
</tr>
<tr>
<td>Inclusive HSE protocols and open and transparent Grievance Redress Mechanisms</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Implement Codes of Conduct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workers sign Codes of Conduct, vowing not to engage in specific behavior and to intercede and report such behavior if they witness it</td>
</tr>
<tr>
<td>Provide sensitization training on a regular basis, especially during on-boarding</td>
</tr>
<tr>
<td>Training cost can be included in contract cost</td>
</tr>
<tr>
<td>Transparent tracking and reporting of incidents</td>
</tr>
</tbody>
</table>
Thank You.

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