Upstream Geothermal Development

Narendra Widjajanto

Netherlands, November 19, 2013
Outline

Overview of Indonesia Geothermal Potential

Overview of Geothermal Cycles

Exploration and Resource Confirmation

Key Factor for Geothermal Development

Next Step
Indonesia has the highest potential for geothermal energy in the world, which remains largely untapped.

<table>
<thead>
<tr>
<th>Country</th>
<th>Conventional geothermal 2010 capacity</th>
<th>Total potential capacity</th>
<th>Resource Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>1 27</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>U.S.</td>
<td>3 20</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>Japan</td>
<td>1 19</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>Others¹</td>
<td>2 18</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Philippines</td>
<td>2 4 6</td>
<td>11</td>
<td>33</td>
</tr>
<tr>
<td>Mexico</td>
<td>1 5 6</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>Iceland</td>
<td>1 5 6</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1 3 4</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>11 102</td>
<td>113</td>
<td>10</td>
</tr>
</tbody>
</table>

In spite of having the world’s largest geothermal resource, utilization remains low at only 4%.

- Geothermal resource in Indonesia is high temperature resource, which enables more economical geothermal project development.

Source: Indonesia’s Geothermal Reserve and Utilization Status, Compared to Other Countries (PT. Pertamina Geothermal Energy, PIT API XII November 2012)
GoI is making a strong push for renewable energy, with plans to significantly increase geothermal power generation.

Target energy mix in Indonesia

- Coal
- Oil
- Geothermal
- Gas
- Hydro

100% = 146 TWh

2010

- Coal: 5
- Oil: 7
- Geothermal: 25
- Gas: 17
- Hydro: 1

2025

- Coal: 12
- Oil: 6
- Geothermal: 64
- Gas: 17
- Hydro: 1

Target geothermal capacity

GW

Government plans to have 8~9 GW of geothermal energy capacity by 2025

- 2013 capacity
- Planned additions
- New required
- 2025 target

- 1.3
- 2.3
- 4.9
- 8.6

- ~7 GW of additional geothermal capacity is needed by 2025, to reach RUPTL’s projected 12% share of power generation
- Current capacity expansion plans will only cover 1/3 of the gap

1 2025 proposition is assumed to be the same as shown in RUPTL 2020

SOURCE: PGE annual report, Press reports, Team analysis
Geothermal Resources Map of Indonesia

SUMATRA 4,520 MW
- Iboi-Jabob 10 MW
- Seulawah Agam 275 MW
- Lau Debuk-Debuk / Sibuyak 2 MW, 38 MW
- Sipaholon – Tarutung 50 MW
- Sarula – Sibual Bual 630 MW
- S. Merapi – Sampuraga 100 MW
- G. Talang 30 MW
- Muaraalubuh 240 MW
- Sungel Penuh 355 MW
- Lempur / Kerinci 20 MW

JAVA-BALI 3,635 MW
- Lumut Balai 620 MW
- Marga Bayur 170 MW
- Ulubelu 440 MW
- Wai Ratai 120 MW
- Citaman – G. Karang 20 MW
- Cosolok – Cisukaram 180 MW
- G. Salak 375 MW, 120 MW
- G. Patuna 500 MW
- G. Wayang - Windu 110 MW, 290 MW
- Darajat 155 MW, 110 MW
- Kamojang 200 MW, 120 MW
- G. Karaha – G. Telagabodas 400 MW

SULAWESI 755 MW
- Suwawa – Gorontalo 55 MW
- Kotamobagu 140 MW
- Lahendung – Tompas 2 MW, 320 MW
- Merana 200 MW

MOLUCCA 40 MW
- Jailolo 20 MW
- Tulehu 20 MW

NUSA TENGGARA 146 MW
- Atautei 10 MW
- Oka – Larantuka 20 MW
- Sokoria – Mutubusa 20 MW
- Bena – Mataloko 20 MW
PGE’s Working Areas

Concession Area = 14 (MEMR Decree No 2067K/30/MEM/2012
Total Installed Capacity PGE = 402 MW

Legend:
- Production
- Exploration/pengembangan
- JOC : Joint Operating Contract
- @ : Installed Capacity

02 Desember 2013
PGE projects are in different stages of project development

<table>
<thead>
<tr>
<th>Exploration</th>
<th>Development</th>
<th>Operations and reservoir management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop study</td>
<td>Feasibility study</td>
<td>Production drilling</td>
</tr>
<tr>
<td>Geoscientific analysis</td>
<td>Infrastructure and exploration drilling</td>
<td>Power plant FEED</td>
</tr>
<tr>
<td>Delineation drilling</td>
<td>Power plant EPC</td>
<td>Power plant operation</td>
</tr>
</tbody>
</table>

Projects will progress through different stages of the pipeline

- Future projects:
  - Ulubelu 1&2
  - Sibayak
  - Kamojang 1-4
  - Lahendong 1-4

- PGE own projects:
  - Iyang Argapuro
  - Semurup
  - Margabayur
  - Tambang Sawah
  - Masigit Guntur
  - Ciharus
  - Waypanas
  - Lumut Balai 3&4
  - Hululais
  - Sungai Penuh
  - Kotamobagu
  - Kamojang 5
  - Karaha
  - Lahendong 5&6
  - Lumut Balai 1&2
  - Ulubelu 3&4

SOURCE: PGE
A typical Geothermal Project has 3 Phases Upstream

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<thead>
<tr>
<th>Exploration</th>
<th>Development</th>
<th>Operation</th>
</tr>
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<tbody>
<tr>
<td>Desktop study</td>
<td>Norc</td>
<td>Sgs construction</td>
</tr>
<tr>
<td>Geology &amp; Geo-chemistry</td>
<td>NOID</td>
<td>Operations and maintenance</td>
</tr>
<tr>
<td>Geophysics</td>
<td></td>
<td>Reservoir management</td>
</tr>
<tr>
<td>Infrastructure &amp; exploration drilling</td>
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### Major milestones
- Internal go/no-go milestones
- Norc
- NoID
- Commissioning

### Key activities
- **Exploration**
  - MT survey
  - Drill up to 3 discovery wells
- **Development**
  - Drill 4-7 production and injection wells
  - Construct steam gathering systems and piping
  - In parallel with production drilling
- **Operation**
  - Regular operations

### Approx duration (months)
- **Exploration**
  - 1
  - 3-4
  - 6-9
  - 12-15
  - 2-3
  - 0-6
- **Development**
  - Up to 15 months
- **Operation**
  - N/A

### Approx cost ($)
- **Exploration**
  - $5k
  - $30-50k
  - $300-500k
  - $15-25m
  - $300k
  - (If needed)
- **Development**
  - $25-50m
- **Operation**
  - $10-15m
  - N/A
  - N/A

**SOURCE:** Expert inputs
# Exploration & Resource Confirmation Phase

<table>
<thead>
<tr>
<th>No</th>
<th>Phase</th>
<th>Activities</th>
<th>Potential Risk</th>
</tr>
</thead>
</table>
| 1  | Geology & Geochemistry  
• Geophysics  
• Infrastructure & exploration drilling | • Prepare exploration program  
• Process project approval for Environment  
• Process local and regional permit for land and forest usage  
• Procurement process and execution  
• Bridges dan roadways preparation  
• Land clearance with locals | • Geological Hazards (Landslide Subsidence vs “Cut & Fill”)  
• Civil Works (Technology & Competency)  
• Uncertainty for various permit approvals |
| 2  | Drilling (exploration & production) | • Prepare detailed drilling program  
• Rig Mobilization & Logistics  
• Rig review  
• Dilling process execution | • Drilling execution risk  
• Geological risk (hard rocks, fracture, permeability)  
• Gas / steam leakages |
| 3  | Production Testing | • Prepare testing facilities  
• Heating up period  
• Final testing | • Steam result confirmation delay due to long heating up period.  
• Resource risk leads to steam availability/reinjection well below target |
Key Barriers For Developing Indonesia’s Geothermal Potential

Key Barrier

- Resource Risks: Resources can only be proven following expensive on-site exploration.
- Land Permits & Concession Rights: Mostly geothermal area is located in conservation areas, need regulation to exclude geothermal activity in forest regulation.
- Domestic Capacity: To date, no geothermal IPP tender has reached financial closure.
- Price Regulation: Need government support to have favorable pricing mechanism for green energy.
- High Exploration Cost and Investment: Financial cost of geothermal higher than base-load substitute (i.e. coal), when environmental impacts not considered.

*Barriers make it challenge to mobilize significant investments for achieving GoI target*
Resource Risk Make it More Challenging To Mobilize Investment

- Uncertainties associated with geothermal field conditions and resource characteristics during the initial stages of field development will cause developers to require a price premium for taking on this risk.

Geothermal Project Cost Structure

For 50 MW Flashed Steam Geothermal Plant, % of total
Source: SBC Summary

- Cost ranges can vary depending a variety of factors such as: depth of the resource, geologic characteristics and temperature

- **Upstream Cost** less than **Dowstream Cost** but having the **most riskiest part**.

- The upstream phases, (drilling phase), can be considered the riskiest parts of geothermal project development.
## Next Steps for Managing Geothermal Barriers

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<tr>
<th>No</th>
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<th>Explanation</th>
<th>Next Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project delayed due to Various Permits uncertainty</td>
<td>• Uncertainty for acquiring approvals from local and national government agency</td>
<td>• Project socialization&lt;br&gt;• Revised related procedures / regulation to support green energy development especially for geothermal activities</td>
</tr>
<tr>
<td>2</td>
<td>Resource and Upstream Risks</td>
<td>• Steam availability below target&lt;br&gt;• Difficulties in getting injection wells</td>
<td>• Expert and technology enhancement&lt;br&gt;• Operational excellence&lt;br&gt;• Prepare sufficient time to develop geothermal fields properly (5-7 years)&lt;br&gt;• Increase risk mitigation in developing upstream projects in parallel&lt;br&gt;• Upstream Risk beared by Government</td>
</tr>
</tbody>
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<tr>
<td>3</td>
<td>Offtake uncertainty and financial risk</td>
<td>• Adequate pricing for steam and electricity</td>
<td>• Propose more attractive new tariff to the government to increase certainty in geothermal investment projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Includes environment cost in coal tariff in order gain comparability with geothermal tariff</td>
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