How O&G know-how can leverage the geothermal industry

GeoEnergi2017, Bergen 22.05.2017
Shaping the future of energy

Competitive at all times  |  Transforming the oil and gas industry  |  Providing energy for a low carbon future
Building a profitable new energy business

**Industrial approach**
- Leverage core competence
- Scale & technology reduce costs
- Access to long-term projects

**Value driven**
- From subsidies to markets
- 9-11% return range (real)
- Cash flow resilience

**Growth opportunities**
- 15-20% of capex in 2030
- Offshore wind and other options
- Low-carbon solutions

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1. Relative share of project value
2. Capex potential per year USD million
3. © Statoil ASA
OUTLINE

• THE GEOTHERMAL OPPORTUNITY
• STATOIL RESEARCH PRIORITIES
• NEEDS & OPPORTUNITIES
**GLOBAL POTENTIAL GEOTHERMAL POWER GENERATION POTENTIAL**

<table>
<thead>
<tr>
<th>Region</th>
<th>Installed Capacity</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North America</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4,447</td>
<td>32,200</td>
</tr>
<tr>
<td><strong>Cent. America &amp; Caribbean</strong></td>
<td>522</td>
<td>27,400</td>
</tr>
<tr>
<td></td>
<td>2,260</td>
<td>5,130</td>
</tr>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,642</td>
<td>3,400</td>
</tr>
<tr>
<td><strong>Middle East</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>858</td>
<td>2,550</td>
</tr>
<tr>
<td><strong>Africa</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>684</td>
<td>11,600</td>
</tr>
<tr>
<td><strong>South America</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>30,800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>730</td>
</tr>
<tr>
<td><strong>Aus., NZ &amp; Pacific</strong></td>
<td>1,037</td>
<td>7,700</td>
</tr>
</tbody>
</table>

Sources: ThinkGeoEnergy, Geothermal Energy Association, IGA, Chevron
Note: Installed Capacity of 2017 [2015], resource estimates combined (1999-2012) – IGA estimates a conservative total potential of 70,000 MW and with technology improvements (extended use of low heat and EGS resources) at around 140,000 MW in power generation capacity.
Geothermal energy

The geothermal opportunity

- Geothermal provides **base-load power**
- **Cost competitive** with the right resources
- Vast global **resource potential** in mature and emerging markets
- Technology barriers matches the **core competencies** of the O&G industry

From: “Geothermal Development: Mission impossible? or possibly possible.”
*Arni Magnusson*, Mannvit, IGC 2016
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![Bar graph showing dispatchable and non-dispatchable technologies](chart)

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From: IEA Technology Roadmap, 2011
Geothermal energy

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What did NOT happen to geothermal the last 15 years?

• Limited development even with competitive LCOE
• Cost reductions for other renewables threaten geothermal energy as a future attractive source for power production
• Cost efficiency measures are required!

CAN THE O&G INDUSTRY LEVERAGE?

Risk picture similar to O&G industry

Project cost and risk profile for geothermal development stages

Project characteristics are familiar to the O&G industry

Total installed cost breakdown for two proposed 110 MW geothermal plants in Indonesia (source: IRENA)

*Project break-down (*)

<table>
<thead>
<tr>
<th>Project Breakdown</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Survey</td>
<td>42%</td>
</tr>
<tr>
<td>Exploration</td>
<td>7%</td>
</tr>
<tr>
<td>Test Drilling</td>
<td>15%</td>
</tr>
<tr>
<td>Feasibility/Planning</td>
<td>14%</td>
</tr>
<tr>
<td>Drilling</td>
<td>14%</td>
</tr>
<tr>
<td>Construction</td>
<td>9%</td>
</tr>
<tr>
<td>Start-up</td>
<td>7%</td>
</tr>
<tr>
<td>O&amp;M (*)</td>
<td>3%</td>
</tr>
</tbody>
</table>

(*) World Bank / ESMAP

Source: IRENA
Building a technology position for Statoil

**Build on core O&G competence**

- Exploration excellence
- «The perfect well» concept
- «Geothermal toolbox»

**Ultra-high temperature geothermal**

- 400-500°C
- 5-10 times more energy per well
- IDDP2 – field testing

**SUCCESS FACTORS**

- Partnering with world leading industry players
- Active engagement in IDDP2
# Geothermal technology development program

## Partnering for success

<table>
<thead>
<tr>
<th>IDDP2</th>
<th>DeepEGS / GeoWell</th>
<th>Technology projects</th>
<th>HotCaSe (IPN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="DeepVision" /></td>
<td><img src="image2" alt="DeepEGS" /></td>
<td><img src="image3" alt="MIT Energy Initiative" /></td>
<td><img src="image4" alt="NFR ENERGIX" /></td>
</tr>
</tbody>
</table>

- **DeepVision**
- **EU Horizon 2020**
- **MIT Energy Initiative**
- **NFR ENERGIX**
IDDP2 – our key enabler

- Partners: HS Orka, Landsvirkjun, Reykjavik Energy, Orkustofnun, Statoil
- Financial support from H2020 DEEPEGS and ICDP
- Drilling IDDP2 at Reykjanes -> Key enabler for qualifying Geomagma technology!
- Drilling operation completed January 2017:
  - Drilled to 4650 meters MD
  - Reached supercritical reservoir conditions
  - Successful core sampling
- Next phase – harnessing the high-enthalpy energy resource
  - Stimulation
  - Flow test

SUCCES CRITERIA
- Proof-of-concept
- Successful test period
- No HSE incidents
Conventional geothermal energy

Customizing O&G technologies for geothermal

"GEOTHERMAL TECHNOLOGY TOOL BOX"

- Regional mapping
- Reservoir characterization
- Geochemical characterization
- Concept modeling
- Temperature prediction
- «The perfect geothermal well»
- and others...
Temperature prediction by multi-geophysical approach
The «Perfect Well» concept from US unconventionals

CONTINUOUS IMPROVEMENTS:
• Delete
• Execute in parallel
• Shorten

IDDP2 workshop: Applied methodology to standard geothermal wells

Identified >100 possibilities for improvement

Hypothesis: Drilling and completion time can potentially be reduced by 2/3
• increasing the ROP
• address well cleaning
• using improved cement slurry designs (shorten WOC)
• optimizing connections
• BOP installation

-> Reducing Well costs by up to 40%?
Offshore GEOMAGMA
Sci-fi or for real?

• Huge energy potential in offshore ridges
• 280 sites of geothermal vents have been discovered
• Depth from shallow to 2500 m
• Large Black Smokers have been stable for decades
• Large power plants – platform or subsea
• Major advances in HVDC technology - onshore and offshore markets
How O&G know-how can leverage the geothermal industry

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