Steamfield Management and Challenges: Kenya Case
Outline

• Introduction
• Geothermal generation status
• Challenges and solutions
• Conclusions
• Currently steamfield supports;
  □ Four conventional power plants
    • Olkaria I
    • Olkaria II
    • Olkaria IV
    • Olkaria IAU
  □ 16 wellhead power plants
    • KWG-01 to KWG-15
    • Eburru

Installed capacity is being added via ongoing projects; Olkaria V, Olkaria IAU6, Modular wellhead units
## Steam supply and demand status all the plants

<table>
<thead>
<tr>
<th>Plant</th>
<th>Plant Capacity - MW</th>
<th>No of Connected Production Wells</th>
<th>Av. Total Steam Flow t/h</th>
<th>Plant consumption t/h</th>
<th>Av. Total Brine Flow t/h</th>
<th>Av. Enthalpy kJ/kg</th>
<th>No of Hot Reinjection Wells</th>
<th>No of Cold Reinjection Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olkaria I</td>
<td>45</td>
<td>19</td>
<td>561</td>
<td>450</td>
<td>258</td>
<td>2166</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Olkaria II</td>
<td>105</td>
<td>18</td>
<td>890</td>
<td>810</td>
<td>504.9</td>
<td>1840</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Olkaria IAU</td>
<td>150</td>
<td>23</td>
<td>1384</td>
<td>1056</td>
<td>684</td>
<td>2314</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Olkaria IV</td>
<td>150</td>
<td>21</td>
<td>1409.9</td>
<td>1041</td>
<td>864.6</td>
<td>1980.2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Wellheads</td>
<td>83.4</td>
<td>14</td>
<td>756</td>
<td>689</td>
<td>402</td>
<td>2013</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>533.4</strong></td>
<td><strong>95</strong></td>
<td><strong>5000.9</strong></td>
<td><strong>4046</strong></td>
<td><strong>2713.4</strong></td>
<td></td>
<td><strong>19</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>
Steamfield system description

- System used is single flash steam cycle

- The geo fluid (2-phase) is flashed in a separator to produce;
  - Steam that goes to the plant for power generation
  - Brine that is reinjected

- Design is dictated by production and chemical properties of the wells
  - Olkaria I and II - Separator for each well operating at 6 bar
  - Olkaria IV and IAU - Central separator stations operating at 11 bar
  - Wellheads – One plant per well installation, separation done at 13 bar
Steamfield Management activities

• Steamfield Management involves;
  - Operation and maintenance of steam and brine systems
  - Delivery of quality and adequate steam to power plants
• Operation activities – Wells start up, shut in, throttling, production and reinjection monitoring
• Maintenance done according to schedules
• O&M activities done according to standard OP and WI
• Modifications/replacements and design & construction works
Steamfield Management challenges

- Encountered right from development stage;
  - Well production characteristics and fluids chemistry
  - Environment and community issues
  - Injection well permeability
- Operational challenges
  - Silica scaling
  - Corrosion and leakages
  - Decline of well outputs
<table>
<thead>
<tr>
<th>Plant 🏙️</th>
<th>Installed capacity (MW)</th>
<th>Sustained Gross Load (MW)</th>
<th>Measured steam (T/HR)</th>
<th>Required Steam (T/HR)</th>
<th>Turbine inlet pressure (Bara)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellhead 914 KWG-08</td>
<td>5.5</td>
<td>4.2</td>
<td>34.07</td>
<td>42.5</td>
<td>11.1</td>
</tr>
<tr>
<td>Wellhead 919 KWG-11</td>
<td>5.5</td>
<td>3</td>
<td>24.98</td>
<td>42.5</td>
<td>12.7</td>
</tr>
<tr>
<td>Wellhead 905 KWG-14</td>
<td>5.5</td>
<td>3.45</td>
<td>30.21</td>
<td>42.5</td>
<td>11.7</td>
</tr>
<tr>
<td>Wellhead 39 KWG-15</td>
<td>5.5</td>
<td>1.5</td>
<td>15.75</td>
<td>42.5</td>
<td>11.6</td>
</tr>
<tr>
<td>Wellhead 39 KWG-15 (Connected to make-up Well)</td>
<td>5.5</td>
<td>5.0</td>
<td>40.57</td>
<td>42.5</td>
<td>13.0</td>
</tr>
</tbody>
</table>
Design process

- Route selection
- Pressure drop calculation
- Pipe thickness calculation
- Flange rating – class 150, 300, 600, 900 etc
- Material selection ASTM A106 GR B or API 5L GR B
- Stress modelling for various load conditions (Gravity, Thermal, Wind, Earthquake, Ice etc)
Autopipe model deliverables

- Spacing for pipe supports, anchors and spring loads
- X,Y,Z forces on each support (used by civil for pipe foundation design)
- Pipe shoe movement due to thermal expansion (gaps right, left, forward and backward)
QC, commissioning & Test results

- 100% radiographic inspection of all the welded joints
- Flushing the line to clean welding mill
- Target bar test for quality of steam
- Plant output up to 5.0MW up from 1.5MW
- Zero accidents throughout the project
<table>
<thead>
<tr>
<th>Materials</th>
<th>Cost (KSHS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes, fittings, flanges, bolts and nuts</td>
<td>5,000,000.00</td>
</tr>
<tr>
<td>Insulation</td>
<td>1,000,000.00</td>
</tr>
<tr>
<td>Sand</td>
<td>500,000.00</td>
</tr>
<tr>
<td>Reinforcement bars</td>
<td>2,000,000.00</td>
</tr>
<tr>
<td>Cement</td>
<td>550,000</td>
</tr>
<tr>
<td>Timber</td>
<td>500,000.00</td>
</tr>
<tr>
<td>Staff variable allowances</td>
<td>1,500,000.00</td>
</tr>
<tr>
<td>Civil works</td>
<td>2,000,000.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13,050,000.00</strong></td>
</tr>
</tbody>
</table>
Conclusions

• Challenges are part of Steamfield management
• Increased revenue losses due to maintenance stops
• Increased O & M cost
• Essential to continue building internal capacity
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Thank you