Geothermal Drilling
Overview

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My Point of View

- No drilling engineer
- Developer and consultant for geothermal projects worldwide
  - Germany
  - Switzerland
  - Tanzania
  - Indonesia
- First well drilled in 2003
  - Upper Rhine Valley / Offenbach an der Queich
  - Depth: 2360 m
  - Deviated well
  - No major drilling problems
  - But: …dry well
- Research and development in drilling technology
  - Herrenknecht drill rig Terra Invader
  - Downhole tool: Seismic prediction while drilling
  - Hard rock drilling using electrical impulse method
Content

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I. Importance of Drilling

- Drilling cost vs. project cost
  - Heat project: up to 90% (excluding distribution system)
  - Electricity project: 50 – 70%

- Drilling risk
  - Lost in hole
  - Stuck pipe
  - Casing instability
  - Side-tracks
  - You can loose a well but you cannot loose a power plant!
II. Geothermal Plays and Drilling

- Plays / Resource Types
  - Definition
    - Temperature (low – moderate – high enthalpy)
    - Geothermal systems (closed – hydrothermal – EGS)
    - Geological setting (convective – conductive / plate tectonics / magmatic – non magmatic)
  - Differences in drilling concepts and technology
    - Magmatic
      - Large resources (> 10 MW, 100 MW, 300 MW)
      - High enthalpy
      - Slim-hole exploration wells
      - Many wells / power plant
      - Medium depth
      - High temperature equipment (BOP, testing, cement,…) and related procedures
      - Composition of gas and fluid may be dangerous (e.g. HCl gas)
    - Non Magmatic
      - Small resources < 10 MW
      - Low – medium enthalpy
      - Full size exploration production and injection wells
      - 2 – 4 wells / power plant
      - Medium to large depth (50-30 m TVD, 6500 m MD)
      - Standard equipment and procedures
III. Geothermal vs. Oil and Gas Drilling

- Differences
  - Low - medium enthalpy
  - Well size
  - Less horizontal drilling
  - Reservoir protecting drilling methods
  - EGS: Hard rock drilling
  - High enthalpy
    - All of above
    - High temperature equipment
    - High temperature safety procedures
    - Less electronics
IV. Drilling as a Team Effort

- Drilling and drilling service
  - Drilling rig
  - Services:
    - Mud
    - Logging
    - Directional drilling
    - Supervision
    - Coiled tubing
    - Stimulation
    - Cement
    - Casing
    - Geological sampling
    - Data acquisition
    - Drill bit
    - Drilling tools
V. Planning

- **Drilling program**
  - Drilling procedure (section by section)
  - Casing and cementing program
  - Drilling fluids program
  - Drill bit program
  - Directional program
  - Well logging
  - Geological sampling program / mud logging
  - Drilling data acquisition
  - Testing program
  - Procurement
  - Communication
  - Safety program
  - Waste disposal

- **Contracts**
  - Day rate
  - Turn key
  - Meter contract
  - Open books

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V. Planning
V. Planning

Well Path Data

Time Vertical Depth [m]

Time vs. depth

Cost vs. depth

Offenbach GT 1

Time- and Cost Estimate for the Drilling Project

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VI. Must Haves

- Quality
  - Rig and material
  - Experienced drilling crew
  - Planning and supervision
  - Team spirit
  - Kick-off meeting

- Interface Management
  - Services
  - Timing
  - Cost

- Risk management
  - A good drilling plan is risk mitigation.
  - There will always be something happening you do not expect!
VII. Present and Future

- **Wells**
  - Present
    - Deviated wells
    - Side-tracks
  - Future
    - Horizontal wells
    - Multilaterals

- **Technology**
  - Present
    - Mechanically cutting drilling bits
    - Hydraulic hammer
  - Future
    - Spallation drilling
    - Electro impulse drilling
    - But beware of:
      - Iron core drilling (melting)
      - Unrealistic speed-drilling 6000 m in 7 days
Thank you for your attention! Questions?

KILAMBO GEOETHERMAL PROSPECT
EXPLORATION HOLE DRILLING

"THINK AND ACT SAFETY" 1.5 KM