Geothermal Drilling vs. Oil & gas Drilling

• Hard Rock
  – Volcanic top to bottom
• Temperature
• Low Reservoir Pressures
• Completion Techniques
• High Production Rates
Developing the Drilling Program

• Pertinent data is required to adequately design and ultimately drill the well.
• Our goal is to develop a drilling program then a cost estimate for budgeting purposes.
• Questions that we need answered to develop a drilling program and cost estimate:
  – Location of the well
  – Governmental regulations for the area to be drilled
  – Proposed depth of well
  – Proposed zones of interest
  – Final hole and casing diameters (final hole size)
  – Purpose of the well (What will the hole be used for and what are the size of the instruments to be installed)
  – Nature of the resource (vapor, liquid or mixture)
  – Elevation of the well
  – Proposed lithology, location of faults and earthquake centers
  – As much information as possible from nearby wells
  – Expected temperature profile of the well

The Drilling Program

Drilling Procedure - Operations in sequence:
• Prepare Location and set 30’ Conductor
• Move in Rig and rig up on well.
• Make up 26” BHA and spud through 30” conductor to 500’
• Pick up and run in the hole with 20” casing and cement same.
• Cut off 30” conductor and 20” surface casing and attach Blowout equipment.
• Drill 17 ½” hole to 4,000’
• Set and cement 13 3/8” casing to Total Depth
• Install well head and BOP
• Drill 12 ¾” hole to 8,000’
• Test and Complete
Understanding Equipment and Technology

Casing

- Design detailed casing program:
  - Based on hole size, casing size (O.D.) and approximate setting depth, we then design to casing string.
  - Establish casing grade, weight per foot and connection type
  - Design casing based on manufactured properties of the casing weight and grades, API (American Petroleum Institute) established manufactured properties for:
    - Collapse (ability to resist external pressure – that is a crushing action)
    - Tensile strength – suspension ability of the pipe
    - Burst – ability to resist internal pressures.
Wellhead and Valving

Other Drilling Considerations

Drilling System Design

Each section of the well must be drilled with the best systems to allow casing to be set and cemented. Various systems are available:

- **Mud Systems** have many purposes; cool bit and drill strings, lubricates, carry’s out cuttings, holds back and balance wellbore and resource pressures and helps to keep poorly or unconsolidated formations in place.

- **Aerated System** is a mixture of mud or water and air injected within. Used in areas of low reservoir pressures and poorly consolidated formations.

- **Air Drilling** uses compressed air in areas of very low reservoir pressures.
Other Drilling Considerations

Cementing

A cement slurry and procedure is designed to completely fill all annular spaces between the casing and the wellbore:

- Good cementing is the key to success in well completions:
  - It reduces expansion due to temperature
  - Reduces casing problems due to trapped voids of mud or water between casings
  - Withstand excessive pressures that may be encountered within casing

- Cement is designed to:
  - Give adequate pumping time
  - Produce adequate compressive strengths once it is hard and set
  - Develop good bonding between casing and wellbore & casing and casing

The Bid Process

- The most important factors are:
  - Derrick capacity
  - Draw works horsepower well pulling capacity
  - Substructure height
  - Pumping output
  - Power needs
  - Space requirements
  - Drill pipe size and grades
  - Mud system capacity and mud cleaning equipment
  - Rotary table size
  - Fuel consumption
  - Day rate
  - Mobilization/Demobilization costs
  - Extra provided equipment
    - Forklift
    - BOPE

Bids are received and evaluated. A cost estimate is developed based on bids and days vs. depth curve.
## Major Drilling Risks

- Lost circulation
- Poor Cement Jobs
- Corrosion and presence of H2S
- Poorly consolidated formations
Drilling Contingencies

- Slotted liners
- Option to run and cement additional casing strings as required
- Special handling needs
  - Hot liners
  - Welded pipe and casing
- Additional blow out preventer needs and rotating heads
- Sumpless operations
- Abatement of emissions during drilling
- Air compressors
- Air, steam and cuttings separators. Discharge re-circulating systems
- Handling poorly consolidated formations
- Corrosion
- Mud Coolers

Thank you