

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

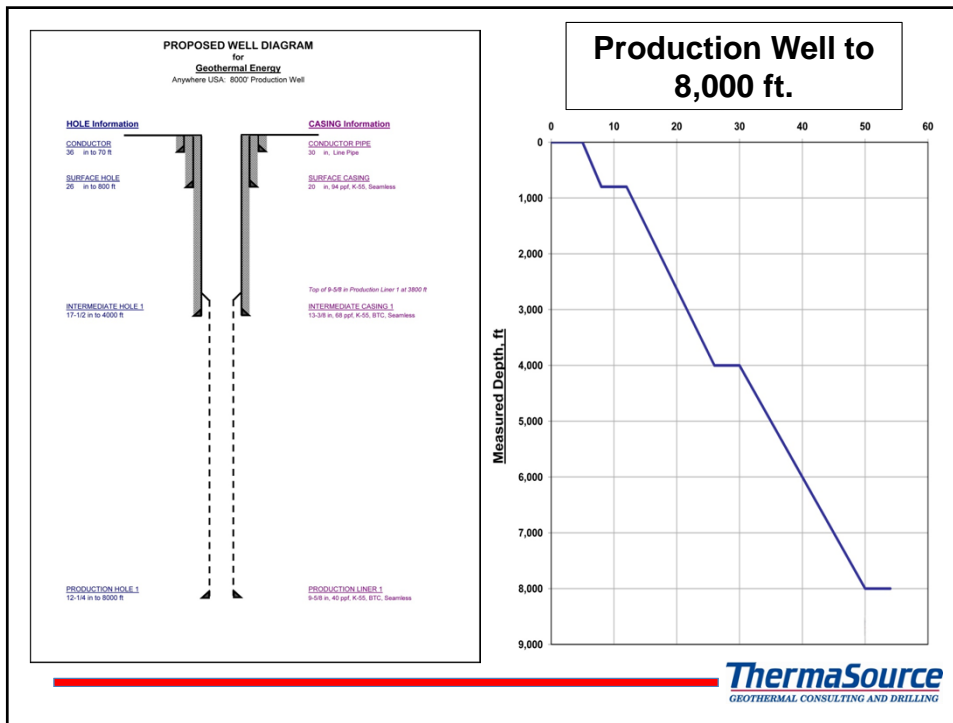
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The Drilling Program

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 ¼" hole to 8,000'
- Test and Complete

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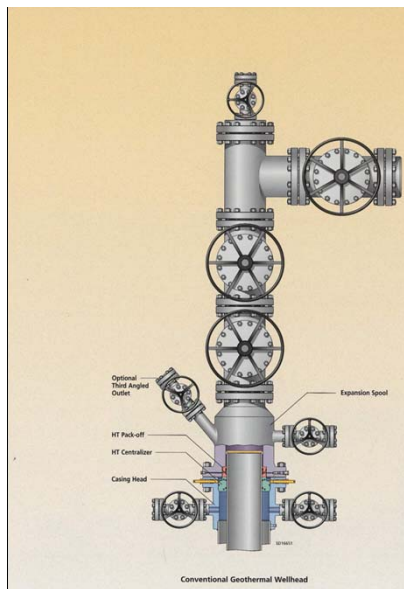


Understanding Equipment and Technology

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



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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.

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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

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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.

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WELL COST ESTIMATE		
NAME OF OPERATOR: Geothermal Energy		
FIELD NAME: Anywhere USA		
Well Name: 8000' Production Well		
Estimated Number of Days: 54		
SUMMARY OF ESTIMATED COSTS		
EQUIPMENT RENTAL AND SERVICES	\$	2,769,950
MATERIALS, CONSUMABLES AND RELATED SERVICES	\$	836,450
TOTAL DRILLING COST	\$	3,606,400
Code	COST CATEGORIES	Total Cost
EQUIPMENT RENTAL AND SERVICES		
\$ 2,769,950		
0100	RIG MOBILIZATION and DEMOBILIZATION	85,000
0200	CONTRACT DRILLING RIG	1,300,250
0300	PLANNING, ENGINEERING AND PROJECT MANAGEMENT	155,700
0400	DRILLING FLUIDS AND SOLIDS CONTROL	207,450
0500	DIRECTIONAL DRILLING SERVICES	11,700
0600	CEMENT and SERVICES	380,000
0700	AIR DRILLING SERVICES	98,050
0800	GEOLOGIC EVALUATION AND RESERVOIR ENGINEERING	152,800
0900	DRILLING TOOLS RENTAL AND REPAIR	90,100
1000	WELL CONTROL EQUIPMENT RENTAL AND SERVICES	107,200
1100	RIG SITE LOGISTICS	72,800
1200	ROAD AND LOCATION CONSTRUCTION	18,000
1300	TRUCKING AND TRANSPORTATION	90,800
1400	COMPLETION SERVICES	-
1500	FISHING TOOLS AND SERVICES	-
MATERIALS, CONSUMABLES AND RELATED SERVICES		
\$ 836,450		
1600	BITS	186,000
1700	CASING, TUBING AND SERVICES	520,800
1800	CASING ACCESSORIES	44,150
1900	WELLHEAD EQUIPMENT	85,500
		-


**Cost Estimate
for
Production
Wells to
8,000 ft.**



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Major Drilling Risks

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



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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

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Thank you

