Phases of geothermal development

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Total cost per energy unit





Project development

- Step 1: Gathering and evaluation of existing data
- Step 2A: Surface exploration
- Step 2B: Exploration drilling
- Step 3: Pre-feasibility report
- Step 4: Environmental assessment
- Step 5: Drilling and testing of confirmation wells
- Step 6: Feasibility report
- Step 7: Design, construction, production drilling.
- Step 8: Testing, commissioning, training
- Step 9: Operation



Project Development - Time frame: Geothermal Power Plant

Step	Step/Year	1	2	2		3	2	1	۳,	5	e	5	7	3	3
1	Reconissance - licensing														
2A	Surface exploration														
2B	Exploration drilling														
3	Prefeasibiliy report				X										
4	Environmental assessment														
5	Drilling of confirmation/production wells														
6	Feasibility report							X							
7	Design and construction of power plant														
8	Testing, commissioning, training														
9	Operation														



Geothermal Power Plant Exploration and Construction Cost



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Step 1: Reconnaissance Gather and evaluate existing data

- Information on geothermal field & possible market for energy
- Chemical analyses
- Gathering of maps, reports and literature
- Outline which data are missing
- Site visit for first estimate
- Recommendations for further exploration
- Licenses, environmental, social and legal aspects







After Step 1:

- We have generated a broad picture of the existing data.
- We have an idea about the possible type and size of the reservoir.
- We know who are the possible customers.
- We have some ideas about financial matters.
- We know the legal and regulatory framework.
- We have idea of the environmental and social impact.
- In view of our knowledge we decide if to proceed to step 2 or abandon the project.



Step 2A: Surface exploration

- Geological- geothermal and structural mapping.
- Chemical analyses and interpretation.
- Geophysical surface exploration.
- Prepare and collect data for environmental impact assessment.
- Prepare, design, site and finance exploration wells.







After step 2A:

- We have a conceptual model of the field, including estimate of possible reservoir temperature, flow of geothermal fluid, chemical composition of the fluid and rough estimate of the possible size of the system.
- We might use volumetric methods to roughly assess the possible energy output.
- Based on the results we either go for step 2B or stop the project.





Step 2B: Exploration drilling

Drilling of 1 -3 wells to testing the results of the surface exploration.

Might be slim or relatively shallow wells.

Revision of the results of the surface exploration and possibly additional geophysical exploration.





Step 3: Pre-feasibility report

A conceptual model based on surface data and drilling

- Evaluation of field capacity
- Basic process design
- Treatment of the geothermal fluid
- Preliminary cost estimate
- Environmental & social evaluation
- Recommendations for next step
 - EIA
 - Financing
 - Exploitation license



Environmental Impact and Conceptual design of the Power Plant

- Environmental and Social Impact Study for the Power Plant
- Design of production- and reinjection wells.
- Update evaluation of field capacity

- Update on basic process design
- o Update on the fluid treatment
- o Recommended field operation









Drilling and testing of confirmation wells

- Location of additional wells, are based on pre-feasibility report
- Design of confirmation wells a test procedure for each well
- o Drilling, testing and evaluation of test results



Feasibility report (bankable) - Exploitation license

- Update on field capacity
- Process design
- All main equipment specified
- Investment and Operational cost
- Environmental Impact for the project
- Recommendations for next step
- Process of licenses completed



Volumetric assessment, using the Monte Carlo method

Statistical sizes	Values [MWe] (30 y.)	Values [MWe] (50 y.)	Values [MWe] (100 y.)
Most probable value (with 7% probability)	275-290	165-175	85-90
90% confidence interval	170-460	100-270	50-140
Mean	300	180	90
Median	300	180	90
Standard deviation	80	50	20



Detailed design, construction, drilling, supervision

- Detail design based on concept design
- Supervision of detail design
- Tender documents for civil construction
- Production Drilling
- Supervision of drilling

- Manufacturing, delivery and installation of equipment
- Civil construction
- Supervision of construction



Operation



Financing of Geothermal Projects Geothermal Project Cost estimate for a 70 MW_e Power Plant in Kenya

Project Identification, Desktop review, inception Report	
and Licensing	\$50,000
Detailed Surface Exploration	\$500,000
Pre-feasibility Study	\$10,000
Exploration Drilling well testing pads and roads (3Wells)	\$9,120,000
Appraisal Drilling and testing (6 WELLS)	\$17,400,000
Feasibility Study	\$100,000
Design and tender documents	\$1,300,000
Environmental Impact Assessment (EIA)	\$100,000
Production Drilling and Testing	\$40,600,000
Power station & Transmission Construction and	
supervision	\$100,000,000
TOTALS	\$169 180 000
TUTALS	\$105,100,000
COST PER MWe	\$2,416,857

Notice that by far most of the cost is for production drilling and plant construction



The end