Technical Requirements of Geothermal Exploration in the RSM

DADI THORBJORNSON, RSM CONSULTANT

WORKSHOP SWISS HOTEL IZMIR 5 JULY 2018

JV Partners

Engineering firm with hundred twenty years of experience in engineering - 10,000 employees

Fields of Expertise:

- Project management and economics
- Feasibility studies and strategic investigations
- Design
- Construction management
- Operations and maintenance

ÍSOR
ICELAND GEOSURVEY

Geoscience firm with sixty years of experience in geothermal investigation – 75 employees

Fields of Expertise:

- Geothermal Exploration
- Drilling Consultancy
- Drilling Engineering
- Resource assessment
- Resource management
- Geothermal Training

VERKÍS

Engineering firm with fifty years of experience in geothermal engineering - 300 employees

Fields of Expertise:

- Project Management
- Geothermal power plant engineering
- Power System Engineering
- District Heating

Phases of Geothermal Development

- Surface exploration/Reconnaissance
- Exploration drilling
- Project Design (concept design)
- Construction and field development
- Operation
  - Monitoring, modelling, management
- Shut-down and abandonment

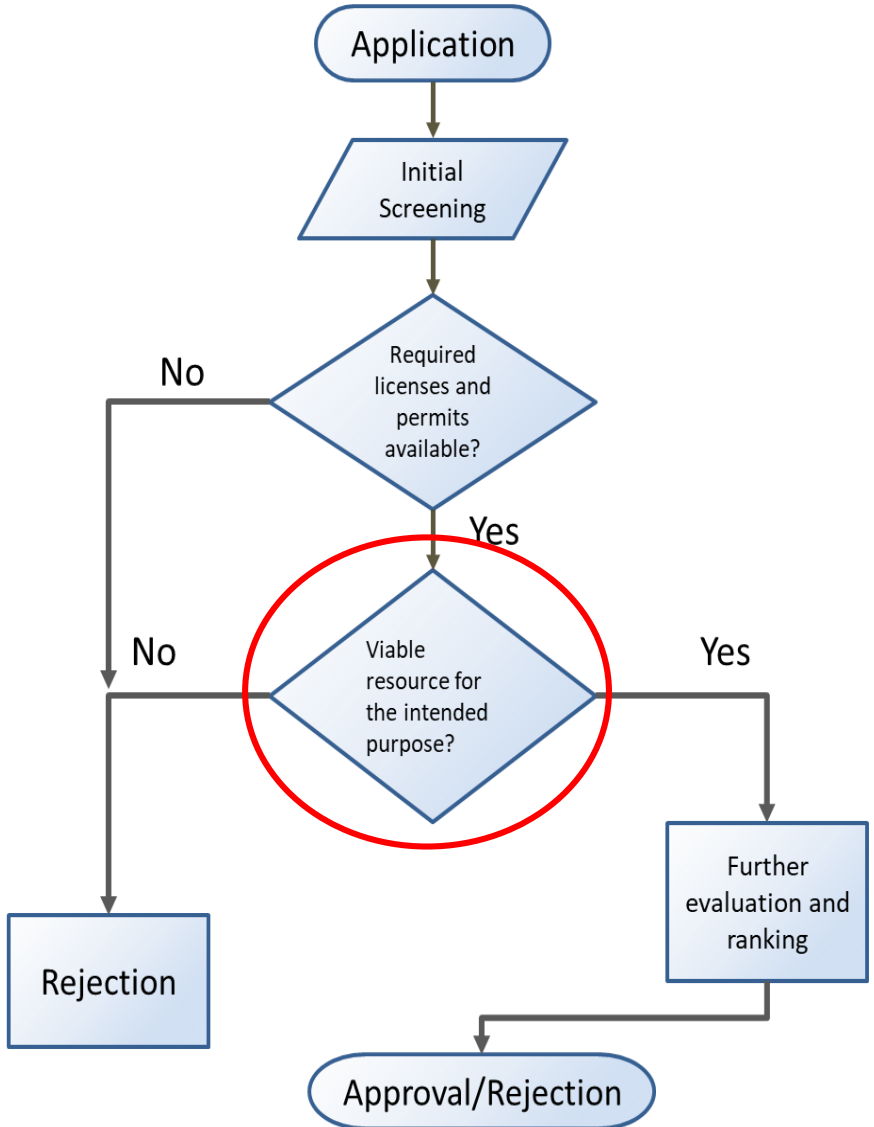
Steps in geothermal exploration

1. Review and study of existing data
2. Studies of surface manifestations and Geochemical studies
3. Geological Exploration
4. Geophysical Exploration
5. Exploration Drilling and flow testing
6. Preliminary Resources Estimate

Contents of Applications

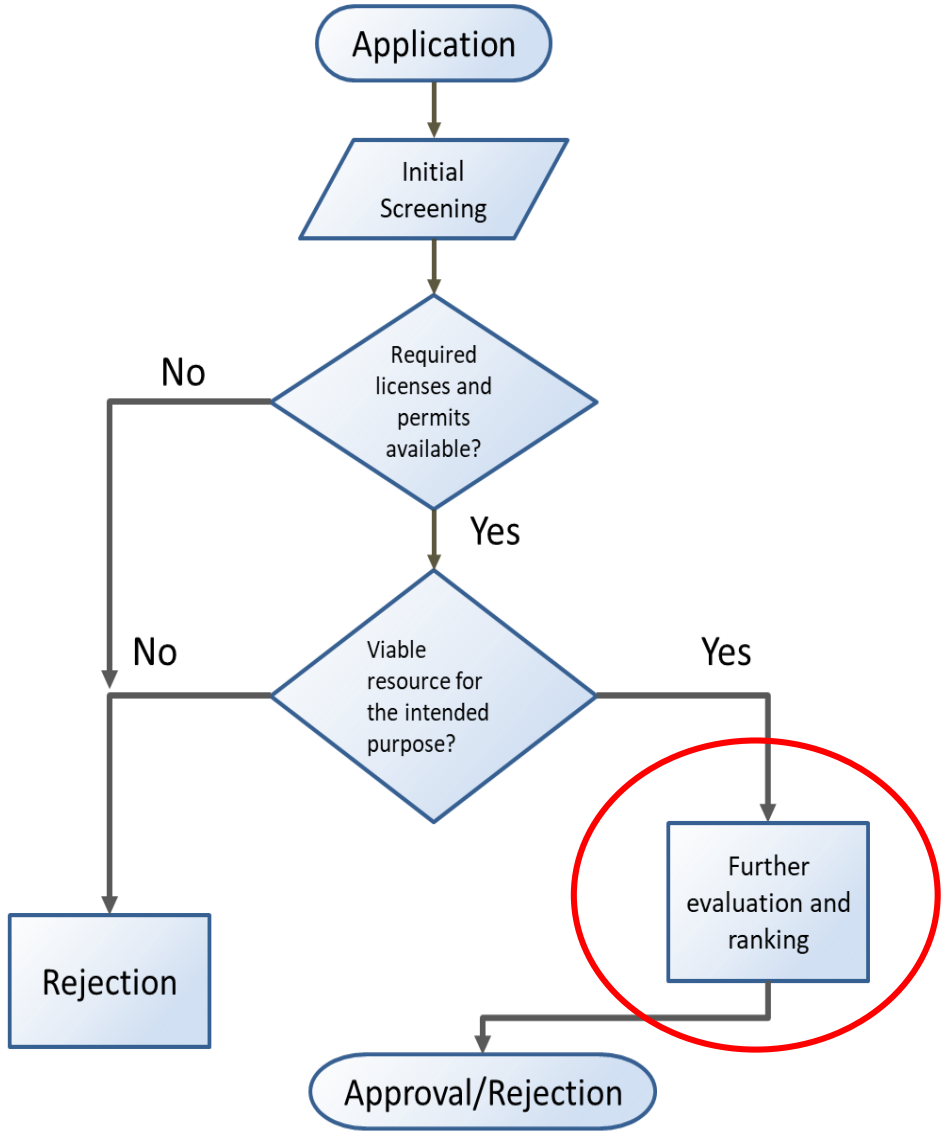
- Surface exploration information and data that meet RSM requirement for participation in the program (see Appendix 2 for details).
- Conceptual model and resource capacity evaluation (see details in Appendix 3).
- A professionally prepared business plan showing how the geothermal energy will be utilized and geothermal resource energy requirements necessary to meet such plan (see Section 3).
- A professionally prepared drilling and testing program for the exploration wells, including cost estimates, and technical specifications for drill rigs to be used (see Section 5).
- Applicable environmental and social impact studies and management plans (see Appendix 9)
    - Points 3-6 and 8 from Table 1, Chapter. 2.1

Evaluation process (3.2)



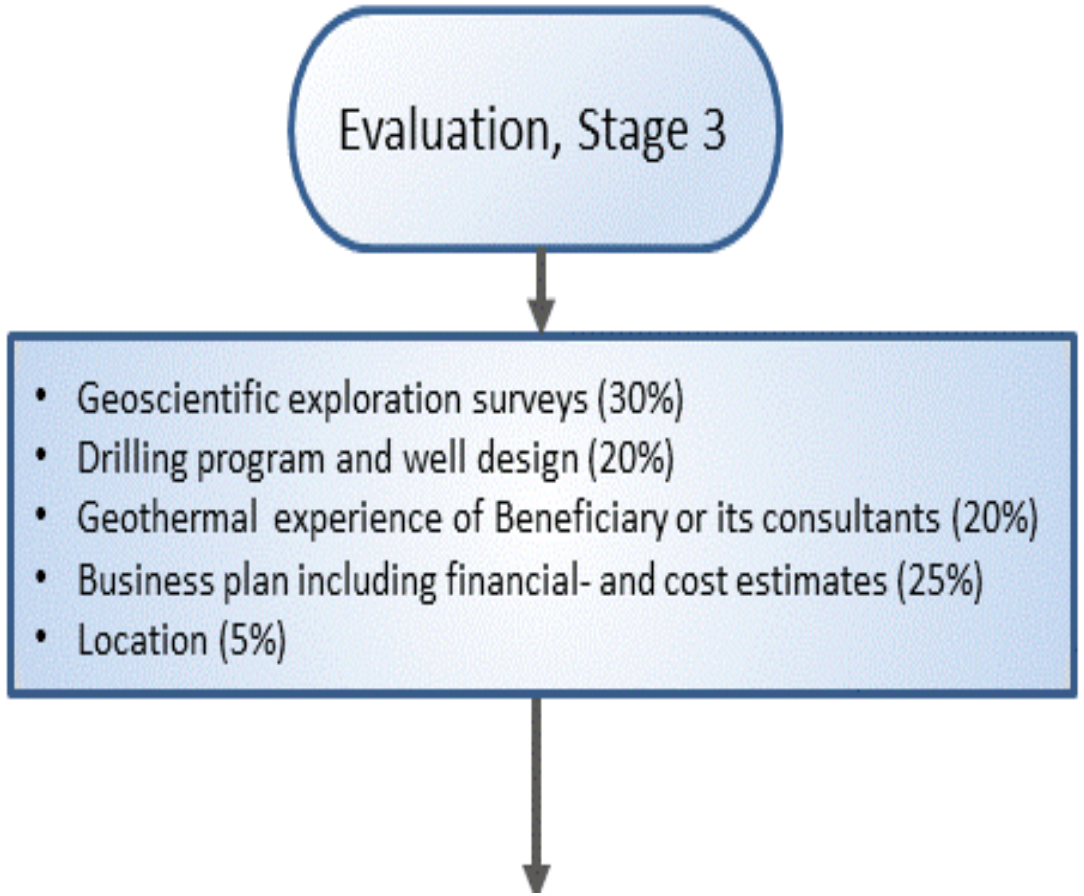
- The second stage of the evaluation process will be used to assess the surface exploration and conceptual modelling included in the application based on the probability of finding a viable resource to support the needs of the applicant's business plan (items 3 and 4 in Table 1).
- This step of the evaluation process will concentrate on two main aspects of the applicant's program which include: a) the credibility of the conceptual models based on the surface exploration data and b) the intended use of the geothermal energy as described in the business model.

Evaluation process (3.2)



- In stage 3 applications will be evaluated using the scoring and ranking protocol described for each of the following categories of information:
  - Geoscientific exploration data and the resulting conceptual model
  - Drilling programs and well designs
  - Geothermal experience of the Beneficiaries or its consultants
  - Business plan, including financial- and cost estimates
  - Location

Evaluation process (3.2)



Evaluation Stage 3: Scoring and Ranking of Viable Projects

Evaluation process (3.3)

- As the RSM is eligible for developers holding licenses for different resources and different utilization approach, relevant exploration data may vary between projects. Thus, appropriateness of the methods used will be evaluated in each case.

No.	Items to be evaluated	Points
1	Appropriateness of exploration methods used	20
2	Completeness of surface exploration studies	20
3	Data quality	20
4	Quality of conceptual models and applicability of drilling targets	30
5	Preliminary resource assessments	10

Evaluation process (3.3)

- Item 2 in the table, “Completeness of surface exploration” will be used to evaluate if important methods in one or more geoscientific disciplines is missing (see Appendix 2).
- Data quality (item 3) will be evaluated where possible.
- Quality of conceptual models (item 4) will be evaluated based on data interpretation and completeness of the models.

Information on geology, hydrology and topography

- → Geological maps
- → Structural maps (tectonic maps)
- → Geothermal maps (surface manifestations)
- → Infrastructure maps (roads, licensing area, wells, other relevant infra-structure)
- → Hydrogeological information (groundwater level, flow directions, chemical composition, recharge, discharge, etc.)
- → Topographic maps
- Aerial photos, satellite photos, LiDAR data, infrared photos etc. for remote sensing
- Heat-flow maps (both remote sensing and direct soil measurements)

Essential items are marked with red arrows (→)

Information on geochemical surface exploration data

- chemical analyses from geothermal surface manifestations (solids)
- → chemical analyses from springs, both hot (water, steam, gas) and cold
- → Chemical data interpretation (including use of geothermometers)
- Isotope analyses
- soil gas-flux analyses (CO2, H2S, Radon, etc.)
- chemical information on rocks

Essential items are marked with red arrows (→)

Information on geophysical exploration

- resistivity (TEM, MT, Schlumberger etc.). Essential for high temperature fields
- reflection seismic (2D/3D)
- seismicity (macro- and micro natural seismicity)
- gravity
- magnetic data

Information on wells in the area (if available)

- list of wells
- location (map)
- design, including depth, diameter, casings, etc.
- temperature logs
- information on testing (flow- and injection testing); mass flow, pressure (water-level or well-head), temperature
- monitoring data (mass flow, pressure (water-level or well-head), temperature) if well has been utilized
- chemical content of fluid
- stratigraphic information
- drilling reports

Information on geothermal resource assessments

- heat-flow and natural output estimates
- → conceptual models
- → preliminary volumetric assessments (P90)
- → pre-feasibility studies
- assessments based on well-testing results
- other modelling studies (simple modelling, numerical modelling, etc.)

Essential items are marked with red arrows (→)

Delivery of data

- The data submitted to the RSM should be in digital form, such as PDF, Word, Power point, Excel format or as scanned figures and text. All documents shall be delivered through a link on the RSM website. Paper documents are not accepted, unless digitally scanned.
- Tentative English translation of key documents in Turkish is appreciated