CROWDTHERMAL

SYNTHESIS OF ENVIRONMENTAL FACTORS

Geothermal energy is an environmentally friendly and sustainable form of energy, yet a major obstacle to geothermal development is social acceptability, with perceived environmental factors being a cause for public concern.

This CROWDTHERMAL report on the environmental issues associated with geothermal energy explains how they influence public support on the development and deployment of the technology; some are based on facts, whilst others are associated perceptions which operate as socio-environmental and psychological processes (Figure 1).

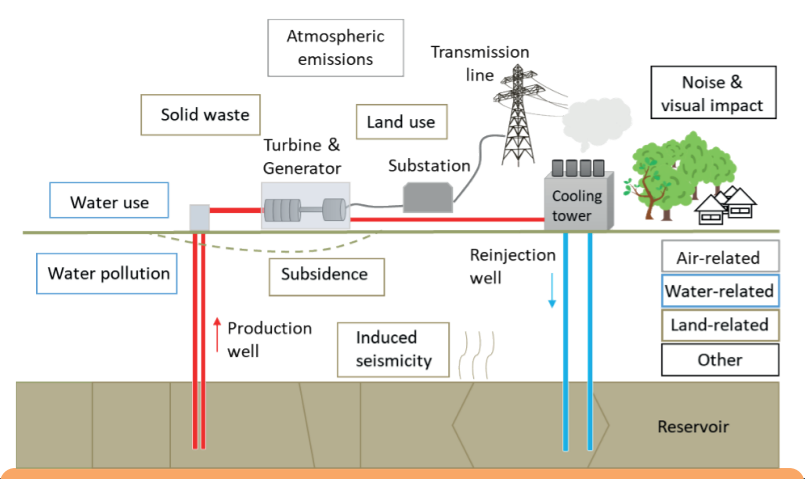

Figure 1: Environmental risks of geothermal energy projects.

This state-of-the-art review of the risks of these environmental factors classifies these factors in terms of environmental matrices, namely:

1. **Air risks** - emissions to the atmosphere from geothermal energy plants and direct use geothermal heat are much lower than conventional fossil fuel-based energy plants, but still need to be monitored and reduced.
2. **Water risks** - pollution and consumption are issues with geothermal power plants which use considerable amounts of water throughout their lifetime depending on size, technology type, working temperatures, and cooling mechanism. As spent geothermal fluids are neither potable nor suitable for agriculture, they need careful disposal. In high-enthalpy projects, losses of geo-fluid and steam during operations mean make-up water is required.
3. **Land risks** – as geothermal operations are concentrated in seismic active zones, energy production by extraction or circulation of geofluids can lead to induced seismicity. Land subsidence can occur from the extraction of fluid and steam from geothermal reservoirs. Land use during the different project phases of a geothermal power plant can be temporal (construction and reclamation) or permanent (operation) and includes changes to landscape and to natural features. Solid waste is created during drilling and operation phases and waste from geothermal energy production includes activated carbon from abatement systems and chemical deposition in pipes, vessels and in cooling towers.
4. **Noise and visual pollution and radioactivity risks** – Throughout the life of a geothermal energy system, noise is created during the plant operations. Visual disturbances caused by geothermal plants include deforestation, land occupation, and increased road traffic and dust emissions. Radioactivity from leached uranium and thorium can reach the surface in geothermal fluid and radioactive tracers have been used in doublet well testing.

Illustration: Leonnidas - Text: University of Glasgow

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The review covers the environmental risks of both deep and shallow geothermal systems and considers each factor's criticality in terms of its influence on public perception and approval.

The assessment not only considers the risk of the selected technology used to exploit geothermal energy (Figure 2), but also its temporal nature as environmental factors can change in different stages of a geothermal development.

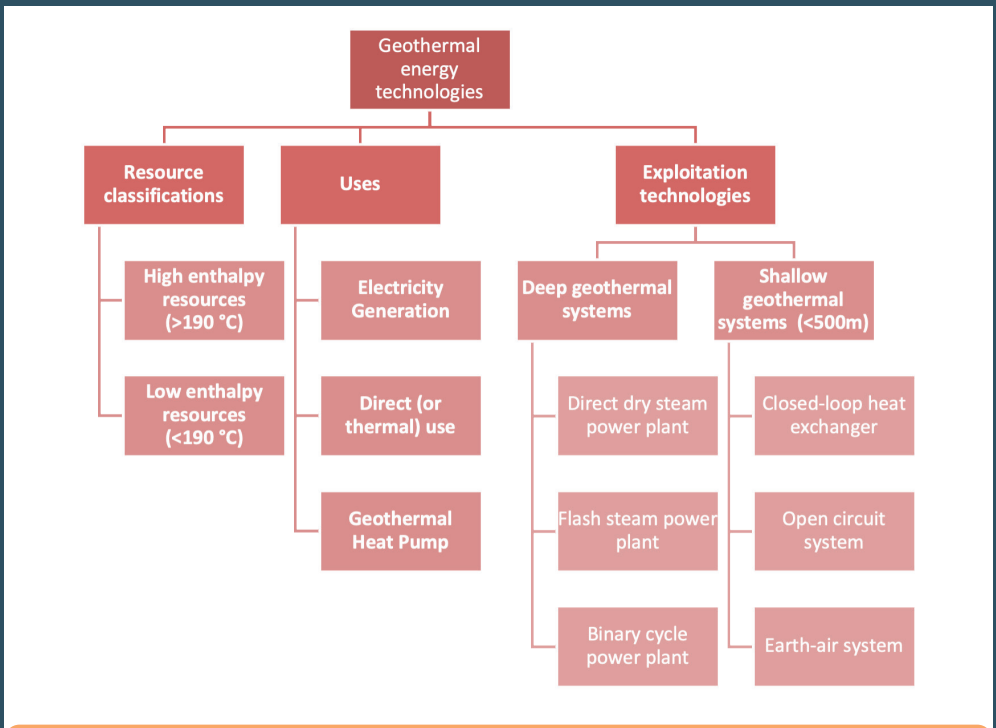

Figure 2: Classification of geothermal energy projects.

The social acceptability of many geothermal projects depends on the potential environmental risks of the implemented technology, which in turn depends on the geothermal energy system being developed. When classifying projects in terms of their geothermal energy use, three main categories have been distinguished: thermo-electrical production, direct use, and ground-sourced geothermal heat pumps.

- **Thermo-electrical power**, which uses hot liquid and steam supplied to the power plant by geothermal wells drilled into the subsurface reservoir, uses steam expansion to rotate a turbine and so generate electricity. The technology selected depends on the reservoir's temperature, pressure, and steam-to-liquid ratio. Geothermal reservoirs are located at depths of 500m to 5000m and are petro-thermal or hydro-thermal in nature. The former system (often called Enhanced Geothermal Systems or EGS) requires hydraulic stimulation to reactivate the naturally occurring fractures to increase reservoir permeability and create an artificial subsurface heat exchanger. The latter system uses hot geothermal fluid pumped from existing aquifers for electricity generation.

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- **Direct use** comprises pumping hot water from the geothermal resource to deliver heat directly to the end user for heating buildings, industrial applications, greenhouses, crop drying, and ice melting.
- **Geothermal heat pumps** utilise the constant temperature near the surface to transfer heat from the ground during winter and dispose of heat for cooling during summer.

The review considers the evolving environmental risk of a geothermal energy project over its lifetime, which can be divided into six distinct phases:

i. **Project definition** - assessing existing data and previous studies, and analysing conditions considered favourable for the presence of geothermal resources to become a commercially viable project securing the exploration license.
ii. **Exploration** - acquiring new geoscientific data to integrate with existing information, well path planning, transmission development, and securing drilling and testing permits.
iii. **Drilling** – constructing and testing the production/injection wells.
iv. **Construction** - building the geothermal plant, facilities and wells, considering all health, safety and environmental aspects, possibly connecting to a local grid/heating network, and securing permits to operate.
v. **Operations** - commissioning and operating the geothermal energy plant, including maintenance and monitoring.
vi. **Decommissioning and post-closure** - field restoration to its original status, site closure, well plugging, and monitoring for potential releases from abandoned wells.

More information:

CROWDTHERMAL Deliverable 1.2 Synthesis of environmental factors

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