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Science for Environment Policy

Screening tool developed to assess seismic risks from geothermal energy projects

A new screening tool to assess the potential seismic risks (earthquake activity) from deep geothermal energy projects has been outlined in a recent study. The tool provides categories of seismicity risk for projects, which are dependent on factors including geological aspects, as well as social concern and location in relation to urban areas.

The development of a range of low-carbon technologies is necessary to mitigate climate change. Deep geothermal energy — using the Earth's heat for electricity and heat generation — has great potential as a low-carbon energy source. Compared to solar or wind energy, geothermal energy also has the advantage of being unaffected by weather variations. However, geothermal energy can cause potentially damaging seismicity, as it involves developing underground reservoirs, which can trigger existing stresses below the Earth's surface. Known as 'induced seismicity', this effect is also a concern for other sectors including oil and gas exploration, hydraulic fracturing, mining and geological carbon storage.

For example, in 2006 the Basel Enhanced Geothermal System (EGS) project in Switzerland induced 'mini-earthquakes' (with a maximum magnitude of 3.4) during the creation of a reservoir, which were felt by the local population. Insurance claims as a result of this event (mostly fine cracks in plaster) reached around $9 million USD (€8.2 million approx.) and an updated risk assessment led to the project being cancelled. Induced seismicity is, therefore, a major threat to geothermal and geoenergy projects globally due to the potential damage and public concern raised.

This study outlines a screening tool for geothermal seismicity termed the Geothermal Risk of Induced Seismicity Diagnosis (GRID), which estimates to what extent induced seismicity is a concern for a project. GRID is designed to be used during project planning and develops four categories for induced seismicity risk from very low or no concern (Category 0) to a high level of concern, where induced seismicity is likely (Category III). The framework was tested on three geothermal projects in Switzerland — Basel, St. Gallen, and Riehen — as well as a hypothetical Basel-type project located in a low-risk area with high social concern.

As the level of seismic risk is not definitively known when GRID is carried out, the framework instead reflects level of concern; a higher GRID score means more measures are required to govern the risk. Seismic concern is assessed using several indicators such as the depth of the geothermal system, rock type, the volume of rock affected, level of fluid injected or extracted and fluid injection pressure during operation, and distance from known active underground fault lines. It also considers the exposed local population, industrial and commercial activity and buildings, and infrastructure within the vicinity of the project. The data required for GRID can be obtained from regional statistics or estimated by experts at an early stage of project development. The researchers recommended that the project operator, licensing or regulating authority, and independent experts are all involved in carrying out the assessment.

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GRID also comprises a framework for tailored risk governance of a project. The framework covers hazard and risk assessment, seismic monitoring, insurance for damage caused by induced seismicity, structural retrofitting of vulnerable building and infrastructure, traffic-light systems to manage the risk of seismicity, information and outreach, and public and stakeholder engagement.

For the four projects where GRID was tested, the Basel and St. Gallen projects were rated as Category III, which the researchers describe as a reasonable score because both projects led to induced seismicity and are both located close to large cities. The Riehen project was given a Category II, because, despite the fact that it was located close to a densely populated area with natural seismicity, the shallow depth, rock type and smaller scale of the project means that induced seismicity is unlikely. Similarly, the Basel type project would be a Category II if it were located in a lower risk area.

The researchers say the framework is the first developed for geothermal energy projects. They acknowledge that, as an emerging field of risk, the GRID scores and indicators will need updating as new evidence becomes available. However, they say the strength of GRID is in its simplicity, enabling fast, transparent, reproducible assessments, which can be adapted to other regions or geo-energy applications.

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