Autonomous decision-making against induced seismicity in deep fluid injections

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Abstract

The rise in the frequency of anthropogenic earthquakes due to deep fluid injections is posing serious economic, societal, and legal challenges to geo-energy and waste-disposal projects. We propose an actuarial approach to mitigate this risk, first by defining an autonomous decision-making process based on an adaptive traffic light system (ATLS) to stop risky injections, and second by quantifying a "cost of public safety" based on the probability of an injection-well being abandoned. The ATLS underlying statistical model is first confirmed to be representative of injection-induced seismicity, with examples taken from past reservoir stimulation experiments (mostly from Enhanced Geothermal Systems, EGS). Then the decision strategy is formalized: Being integrable, the model yields a closed-form ATLS solution that maps a risk-based safety standard or norm to an earthquake magnitude not to exceed during stimulation. Finally, the EGS levelized cost of electricity (LCOE) is reformulated in terms of null expectation, with the cost of abandoned injection-well implemented. We find that the price increase to mitigate the increased seismic risk in populated areas can counterbalance the heat credit. However this "public safety cost" disappears if buildings are based on earthquake-resistant designs or if a more relaxed risk safety standard or norm is chosen.