Application of Probabilistic Seismic Hazard Analysis (PSHA) for the Safety and Environmental Assessment of CO_2 Storage

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Abstract

Objectives
The rapid development of carbon capture and storage (CCS) facilities around the world has introduced a new set of challenges related to induced seismicity (IS). Probabilistic seismic hazard analysis (PSHA), which combines rates of probable future earthquake with estimates of resulting ground motions, is an essential tool of the safety and environmental assessment process when planning and operating CCS projects for the long-term integrity and safety of facilities and also minimizing the social safety concerns.

Process
PSHA for induced seismicity employs a multidisciplinary approach that begins with geological assessment to identify potential fault systems and stress conditions in the project and surrounding areas. Data from available public seismic networks can inform on larger events with longer recurrence intervals but requires complementary stations to be installed to record baseline seismicity (natural or induced) at smaller magnitudes for each storage site. Following analysis of the collected data, utilizing PSHA techniques, the potential impact of CCS operations on nearby infrastructure and the surrounding environment is assessed. Mitigation strategies that minimize induced seismic risks, such as pressure management and injection rate control, can then be developed and implemented.

Results
We present an example case study from wastewater injection in North America to demonstrate how ground motion hazard can be used to inform risk mitigation strategies for induced seismicity both before, and during operations. To this end, we carried out an assessment to understand the seismic hazard posed by induced seismicity generated at disposal wells on nearby oil and gas facilities. We calculated the exceedance probability of critical ground motion levels at the facilities and presented distinct seismicity scenarios to enhance an operator's ability to plan risk mitigation protocols and invoke them during operations. Considering the ground motion hazard posed by future induced seismicity from project planning stages and throughout the project life is a proactive approach an operator may utilize to further de-risk operations.

Significance
This study provides practical recommendations for assessment of induced seismicity in CCS projects and illustrates the approach using a wastewater disposal case study. Both likelihood and consequence of future events are addressed. The proposed best practices offer a standardized, rigorous methodology for induced seismicity risk assessment, grounded in engineering seismology practice.