Induced Seismicity Potential in Energy Technologies

Witnesses:
Murray Hitzman
Chairman, Committee on Induced Seismicity Potential in Energy Technologies, National Research Council
Professor of Economic Geology, Colorado School of Mines
Bill Leith
Senior Science Advisor for Earthquake & Geologic Hazards, U.S. Geological Survey
Susan Petty
President and Chief Technology Officer, Altarock Energy, Inc.
Mark Zoback
Professor of Geophysics, Stanford University

Committee Members Present:
Jeff Bingaman (D-NM), Chairman
Lisa Murkowski (R-AK), Ranking Member
Mary Landrieu (D-LA)
Joe Manchin (D-WV)

On June 19, the Senate Committee on Energy and Natural Resources held a hearing to discuss the findings of a recently released National Research Council (NRC) report on induced seismicity. The report, titled Induced Seismicity Potential in Energy Technologies, was released on June 15. In 2010, Chairman Jeff Bingaman (D-NM) requested that Steven Chu, Secretary of the Department of Energy (DOE), conduct a study to assess energy technologies' potentials to cause earthquakes. DOE then requested NRC's Board on Earth Sciences and Resources (BESR) to complete the report. Bingaman's original request came shortly after a group of seismic events near a waste water disposal site in Guy and Greenbrier, Arkansas. Earthquakes occurred in Basel, Switzerland in 2006 and 2007 that have been linked to a nearby geothermal plant. Several other moderately sized seismic events have recently occurred in Youngstown, Ohio and Texas that may be linked to waste water injection wells.

Geoscientists have suspected since the 1920s that injecting fluid into the Earth can causefaults to slip. Earthquakes as high as magnitude 3.7 near geothermal plants like The Geysers in California during the 1970s and 1980s made more Americans aware of this potential hazard. The NRC report confirmed that certain energy development technologies do have the potential to cause earthquakes, though they can rarely be felt by humans. Fluid injection and extraction is cited as the main cause of induced seismicity from energy technologies.

Bingaman began his opening statement by outlining the different energy production methods which were assessed for their seismic potential. The report covered geothermal energy, carbon sequestration and storage, waste water disposal from hydraulic fracturing and enhanced oil recovery. All of these methods involve pumping liquid or gas deep into rock formations. He reported the findings of the report saying the potential for seismicity is there but, "only a small percentage [of energy-related injection and extraction activities] have created earthquakes at levels noticeable to humans."

The chairman said that methods such as hydraulic fracturing, which inject a relatively small volume of fluid over a short period are very unlikely to cause earthquakes. Much higher volumes of waste water from drilling or hydraulic fracturing are injected into the ground over a longer period for storage and this is much more likely to induce seismic activity. Carbon capture and sequestration (CCS) is the process of capturing carbon dioxide emissions from fossil fuel-fired power plants and injecting it as a supercritical

fluid into permeable formations or depleted oil and gas reservoirs. This method is thought to have seismic potential, but there are few sites actively sequestering large amounts of carbon dioxide to acquire data from.

Bingaman emphasized that the "risk for earthquakes … is minimal" and that no technology-induced seismic event has "caused significant damage to life or property." He echoed the report's claim that with "appropriate proactive measures" the risk from induced seismic events can be managed.

Ranking Member Lisa Murkowski (R-AK) agreed with Bingaman and the report on the relatively low levels of risk posed by induced seismic events. She reproached members of the media for "sensational" headlines on induced seismicity and thanked the witnesses and those who wrote the report for the "reality check." Though the risk is "remote," Murkowski was quick to point out that no one "should be dismissive of this discussion."

The ranking member emphasized that "drilling is perhaps not the issue," instead risk comes from "injection of water or carbon … where pressures have become destabilized." She said she is thankful that with so many methods of energy production involving the deep earth the hazards are "barely noticeable to humans." Murkowski stressed the importance of deciding "whether that sort of seismicity is avoidable and manageable."

Murray Hitzman, a professor at Colorado School of Mines and chairman of BESR's Committee on Induced Seismicity Potential in Energy Technologies, testified that energy development, like underground nuclear testing, mining and dam reservoirs, can be a source of induced seismicity. The report found that induced seismicity from injection and extraction of fluid "is caused in most cases by change in pore fluid pressure and/or change in stress in the subsurface in the presence of faults." This knowledge is important but he added it does not aid in predicting the magnitude or occurrence of induced seismic events.

Hitzman explained that the risk of inducing seismicity is governed by fluid balance. The volume of fluid injected should be as close as possible to the volume of fluid removed. The report found that induced earthquakes with the largest magnitude did not maintain this fluid balance, though Hitzman clarified this as a statistical observation. He suggested the relationship could serve as an important meter to measure the risk of induced seismicity from a project.

Hitzman then outlined the findings for the major energy technologies assessed in the report. He said geothermal energy production usually maintains a constant fluid balance within the Earth. "Vapor-dominated" and "fluid-dominated" geothermal production usually results in quick cooling of subsurface rocks, which Hitzman said could cause induced seismicity. Enhanced Geothermal Systems (EGS) have caused low magnitude induced seismicity in all EGS projects in development.

Hitzman testified to the low risk of induced seismicity for conventional oil and gas sources and shale gas recovery. He stressed that the possibility of induced seismicity for these methods comes from the disposal of waste water. Though the majority of waste water wells do not result in induced seismicity, Hitzman said there is a "causal [link] between the injection zones and previously unrecognized faults in the subsurface." He explained many of the well-documented seismic events near waste water wells occurred over a long period of time and involved a large volume of fluid.

The potential for CCS sites to induce seismicity was "difficult to accurately assess" with a limited amount of large scale sites in production. Hitzman testified that because large amounts of fluid are injected but nothing is extracted, the fluid balance relationship would suggest large-scale CCS sites could carry a high risk of induced seismicity.

Bill Leith, an advisor of geological hazards for the U.S. Geological Survey (USGS), explained in his testimony that the greater number of earthquakes in the Eastern and Central U.S. could be a result of induced seismicity. Leith said the August 2011 5.8 magnitude Mineral, Virginia earthquake was naturally caused, but other events do not have a known cause and induced seismicity should be considered.

To understand induced seismicity, Leith recommended research focus on the differences between injection procedures which cause earthquakes and those that do not and how those procedures can be altered; if injection or an induced seismic event can increase the likelihood of a larger, natural earthquake; the distribution and maximum magnitude of an induced earthquake; and the possible damage from an induced earthquake. Leith stressed industry cooperation in research.

He expanded on the "data gap" and echoed the report's recommendation that "data related to fluid injection... should be collected by state and federal regulatory authorities in a common format and made publicly available (through a coordinating body such as the USGS)." Leith explained "To meet these increasing demands, we have increased research efforts within our current budget" and said the Obama Administration asked the USGS "to address potential environmental, health, and safety issues associated with hydraulic fracturing."

Susan Petty, President and Chief Technology Officer of Altarock Energy, testified that induced seismicity has become a major concern for scientists in the geothermal, mining and oil and gas industry. She cited a Massachusetts Institute of Technology (MIT) study which found 2 million megawatts of energy can be recovered from 2 percent of domestic geothermal resources. She explained that industry knows more about operation and selection of sites from past problems with induced seismicity related to geothermal energy production. EGS "relies on controlled induced seismicity," according to Petty, to create fractures where heat can be extracted.

She explained that the magnitude of an earthquake determined by the Richter scale only partly influences whether the event can be felt on the surface. Depth of the slip, types of rock above the event and structural integrity of buildings on the surface contribute to the "ground shaking" people will feel on the surface. She said, "It would be better to talk about the risk of ground shaking" than the energy released by the actual event.

She noted that the mining industry has "long had regulations to address induced seismicity." Petty emphasized the importance of the industry educating the public on the dangers of induced seismicity. She said it has been "difficult … communicating the information it [the NAS report and others on induced seismicity] contains to the public." Petty said that public outreach has shown that groundwater contamination is a much larger concern for most people.

She stressed the need for scientists with effective communication skills to properly brief the public and regulators on the complex tectonic nature of any site. Petty said much of the misunderstanding regarding this issue comes from miscommunication between scientists from industry and the press.

Mark Zoback, a professor at Stanford University, focused on induced seismicity hazards from waste water injection and carbon capture and storage in his testimony. He began by agreeing with Leith's assessments that recent earthquakes in the Eastern and Central U.S. could be linked to induced seismicity from energy technologies and that these practices could contribute to the advancement of faults at critical stress.

When discussing waste water injection, Zoback explained that fault identification is not required by the Environmental Protection Agency (EPA) in site characterization. He outlined steps to reducing the risk of induced seismicity. He cautioned that fluids should not be injected into areas with brittle rock and the injection site and injection rate should be selected to minimize the change in pore pressure of the target formation. Seismic monitoring arrays should be in place at a site, and procedure should be in place to reduce injection or shut down a site if induced seismicity could become problematic. Another method is to simply reuse waste water for other hydraulic fracturing projects, rather than disposing of it. He said this method was a "welcome development."

Zoback referenced one of his recent papers published on June 18 in *Proceedings of the National Academies of Science* titled "Earthquake Triggering and Large-Scale Geologic Storage of Carbon Dioxide" and discussed the difficulty in implementing enough CCS sites around the world large enough to properly combat greenhouse gas emissions. A large site injection site greatly upsets the fluid balance because large volumes of fluid are injected while essentially none is extracted. He clarified that the concern is not a large destructive earthquake, rather a breach of the reservoir's seals in a CCS site leading to a release of the stored carbon dioxide. Zoback said a CCS site would have to leak less than 1 percent of its carbon per thousand years "to achieve the same climate benefits as switching to renewable energy sources." Natural earthquakes could cause this leak just as easily as induced earthquakes.

Zoback raised concerns that the large amounts of sequestered carbon necessary to "have a beneficial affect on climate change" would likely result in induced seismicity which could cause a leak in the site. He questions if a large enough site could even be found for the 3.5 billion tons of carbon dioxide per year needed to be stored to reduce atmospheric greenhouse gases.

Bingaman asked the panel who would define the practices necessary to avoid sites where induced seismicity could occur. Hitzman responded that the committee did not make a recommendation but it would be most beneficial to bring together members of industry, academia and the government to define safe procedure. Murkowski asked Leith about the specific changes needed to ensure greater seismic monitoring at the USGS. Leith explained that in addition to the hundreds of additional portable monitoring systems needed, many more geoscientists and analysts would be required to make sense of the data. The ranking member further qualified that because waste water injection is a low cost operation, not much mapping is done. Zoback agreed, clarifying that most injection wells do not cause earthquakes, but agreed that more monitoring was necessary.

The Department of Energy Carbon Capture and Sequestration Program Amendments Act of 2011 (S.699) was a main focus of questioning. This bill would provide liability insurance for groups attempting CCS projects if the site was approved by the DOE and there is no carbon leakage. Murkowski and Bingaman both asked if it was "premature" to provide this kind of support if the method would not sufficiently reduce carbon dioxide. Hitzman explained that more would have to be known about the size of the site, and Zoback argued that a large site could be affected by induced or natural earthquakes of any size. According to Zoback, CCS should not be relied upon to completely reduce greenhouse gases, but could be a minor source of reduction.

Witness testimonies, opening statements, and a webcast of the hearing can be found on the committee web site.