Emissions, earthquakes, economics: Benefits of super fracking questioned

The piece "Super fracking" by Donald Turcotte, Eldridge Moores, and John Rundle (PHYSICS TODAY, August 2014, page 34) was quite informative.

The authors state that "carbon dioxide emissions from power plants have been reduced by about a factor of two." That may be true if one only takes the US into consideration, but it does not account for the displacement of US coal production to Europe,[1] where it is now a low-cost fuel that is producing, one imagines, a similar amount of CO_2 as it did in the US.

Another statement that requires some caution concerns the likelihood of an earthquake occurring during hydraulic fracturing. The authors suggest that the probability of a magnitude 4 earthquake is extremely low. Although, again, that may be true, the analysis does not cover water-disposal activity: The effects of long-term pressure buildup in disposal wells can produce earthquakes of greater magnitude than hydraulic fracking per se. One such quake in Oklahoma was reported[2] at magnitude 5.6.

The authors then state that fracking is a "successful tool for *economically* extracting oil and gas" (my italics). That is quite a bold claim and one that in the US is quite contentious, at least for gas production. Witness the 2012 remark from ExxonMobil CEO Rex Tillerson that the company and others were "losing our shirts" on shale gas.[3]

References

1. G. Chazan, G. Wiesmann, "Shale gas boom sparks EU coal revival," *Financial Times*, 3 February 2013.
2. StateImpact Oklahoma, "Exploring the Link Between Earthquakes and Oil and Gas Disposal Wells," http://stateimpact.npr.org/oklahoma/tag/earthquakes.
3. J. A. Dicolo, T. Fowler, "Exxon: 'Losing our shirts' on natural gas," *Wall Street Journal*, 27 June 2012.

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A building's effect on gravity experiments

Amidst the descriptions by Clive Speake and Terry Quinn ("The search for Newton's constant," PHYSICS TODAY, July 2014, page 27) of eliminating effects of the planet's pull and handling a plethora of electronic and mechanical problems in order to measure gravity, one issue seems missing: the effects of the mass of the building in which the experiments were performed. Buildings are massive compared with the test and source masses, and the distances from walls and ceilings are small enough to make their effects noticeable in, say, the fourth decimal place of the measurement. Wouldn't you need to use a massive spherical chamber devoid of other mass so that the effects would cancel each other?

Perhaps I've misunderstood or failed to notice any discussion of this in the article. Could the experiments be done outdoors above a flat plain with no mountains or buildings within miles? The problem seems way too simple a thing to have been overlooked by so many diligent people; perhaps it was considered and compensation made. I would be interested in how, if the authors could take time to explain.

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■ **Speake and Quinn reply:** The effects of local gravity gradients in G experiments are almost always negligible because the experiments are designed so that only changes in the gravity gradients that are in phase with the experiment's sequence of operations would have any effect. Thus, unless the lab walls, nearby elevators, heavy vehicles, or any other large mass is moving in phase with the experiment, there will be no effect. Changes that aren't precisely in phase with the experiment would increase gravitational noise but would not alter the measured signal. (Because our torsion balance was carefully designed, even that gravitational noise falls off as the fifth power of the distance.)

There could be an effect, however, if the source masses—the repositionable masses that couple with the smaller, test masses on a torsion balance or pendulum—were sufficiently large to move the torsion balance or pendulum enough to place it in a significantly different part of the local background gravitational field. In laboratory-sized experiments, however, the movements in torsion balances and pendulums are many orders of magnitude below the level at which such effects could be significant. In our experiment, for example, the rotation of the torsion balance was, at most, only some 150 microradians, with the test masses on the balance moving only about 15 micrometers. The change in local gravity field over that distance is negligible.

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Schrödinger's radial equation

The August 2014 issue of PHYSICS TODAY contains a letter (page 8) in which M. Y. Amusia comments on the article "Bohr's molecular model, a century later" by Anatoly Svidzinsky, Marlan Scully, and Dudley Herschbach (PHYSICS TODAY, January 2014, page 33). Amusia points out that the radial part of the article's D-dimensional Schrödinger equation in Hartree units is

$$\left\{-\frac{1}{2}\frac{\partial^2}{\partial r^2}+\frac{[l+(D-3)/2][l+(D-1)/2]}{2r^2}-\frac{Z}{r}\right\}\phi=E\phi,$$

and he criticizes the implication that the Coulomb potential does not depend on D, which it surely does. Half a century

Letters and commentary are encouraged and should be sent by email to ptletters@aip.org (using your surname as the Subject line), or by standard mail to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842. Please include your name, work affiliation, mailing address, email address, and daytime phone number on your letter and attachments. You can also contact us online at http://contact.physicstoday.org. We reserve the right to edit submissions.