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Several of society's next grand challenges relate to the production of electrical energy.

In the United States, fossil fuels continue to be the largest production source of electricity. Over the past 30 years or so, the fossil fuels of natural gas, petroleum and coal have annually accounted for approximately 70 percent of our electricity production, nuclear power plants product about 20 percent, while renewable sources such as solar and wind contribute less than 10 percent. Although these renewable sources have steadily contributed more hours of electricity every year, we need more to power not just our computers, but also our new smart phones, tablets and Teslas.

I always enjoy seeing engineering topics receive widespread attention in the media, and it seems especially important to make right choices now with the recent focus on some energy sources that may have some negative environmental impacts.

One of the growing controversial aspects of energy production is the process of hydraulic fracturing, also known as hydrofracking or fracking, which is very much responsible for a surge in the production of oil and natural gas production in the United States. Energy companies can tap into oil and natural gas reserves that were previously inaccessible and stimulate production from older wells.

Lower fuel prices, job creation and domestic business growth are all viewed as economic benefits, but to better understand the costs, people need to know the mechanics of fracking that has been gradually developed since the 1940s.

Consider a solid structure that contains numerous tiny cracks that are in close proximity but not touching. Think of Swiss cheese with penny-shaped slits instead of spherical pores. If you could somehow apply enough mechanical loading to just one of those cracks, then the intensity of stress developed at the tip of that crack could very well be enough to create a fissure connecting the tip of one of the adjacent cracks. Apply more loading, and get to the next one. And so on until the network of initially disconnected pores are bridged.

In the case of fracking, however, the rock formations that drillers want to access are either shale or tight sandstones that have cracks filled with oil or natural gas. The network of cracks tends to be vertical or horizontal depending on the geological formation. To be able to open these underground cracks and get to the deposits, there are three principal steps: drilling, injecting and extracting.

The drilling process in fracking is similar to that used in conventional oil drilling. The borehole is about 20 inches in diameter and goes about 7,000 feet deep, well below the water table of many naturally occurring aquifers that sit at a 2,000 foot depth. New technology in the form of a steerable bit allows the bore to turn sideways and run horizontally for a little more than a mile within the relatively thin shale layer.

Approximately, 5 million gallons of fluid is delivered by powerful pumps at the surface. By volume, the fluid is a mixture containing 90 percent water, 9.5 percent fine sand, and the balance is various chemicals. The fluid is pressurized at roughly 15,000 pounds per square inch. The sand particles hold open the tiny cracks with enough spacing to allow the fossil fuels to escape to the borehole and travel up to the well for collection.

But the process is very contentious because of these issues:

1. **Water Resource Contamination** – Of the roughly 5 million gallons of water that can be pumped into a fracking well, about 15 percent escapes up the well shaft and can lead to a spill if not handled properly. If the bore is not constructed with enough strength, then the fracking fluid can be injected into the aquifer and contaminate water resources. This can especially be the case when the well has poor structural integrity.
2. **Methane Emissions** – Methane is more potent than carbon dioxide and has a great potential to escape to the atmosphere during fracking. This damaging greenhouse gas has been detected in ground water reserves near extraction wells. These gases can degrade the local air quality.
3. **Induced Seismicity** – Several studies have linked destructive seismic activity – earthquakes – to the subsurface stresses induced by fracking in the vicinity of ground faults.
4. **Water Consumption** – A considerable amount of freshwater is used for fracking a single well.

As hydraulic fracturing continues to be a boom to the U.S. economy, it reminds me that concepts we work on daily in the laboratory and in the classroom can have huge impacts. 3-D printing, autonomous robots, solar-power cars, cars that fly, and the like were all concepts that engineers helped bring to fruition. The effects these innovations have had on society have been largely positive in helping solve some sort of problem.

Likewise, as energy sources evolve, the challenge always will be to develop peripheral technologies to further reduce the environmental impacts for us and our future generations.

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