

A POST-NUCLEAR FUTURE MIGHT NOT BE AS SAFE AND CLEAN AS YOU THINK

Nuclear energy is once more on the defensive, thanks to Fukushima. But day to day, fossil fuels are far riskier in the toll they take on people, not to mention their effect on global warming. And some renewables like ethanol and hydropower carry their own substantial, if underrated, risks. If Germany's move to shut down its nuclear plants turns out to be the start of a trend, what does it mean for our safety?

In the wake of the March 11 tsunami in northeast Japan, which added Fukushima to Chernobyl and Three Mile Island on the short list of nuclear disasters, many countries have been reconsidering their nuclear programs. On May 30, Germany became the first to make a major decision: Chancellor Angela Merkel committed her country to phasing out all of its nuclear plants by 2022. German environmentalists greeted the announcement with enthusiasm, but officials in France, which generates more than 70 percent of its power from nuclear plants, described the decision as irresponsible, and bound to worsen global warming.

Are the Germans taking a far-sighted step in eliminating a dangerous technology? Or are the French correct that the Germans are misjudging the true consequences of their energy choices? In an industry as politically charged as energy, it's difficult to separate fact from spin, but in this article we'll try to compare the risks of the major forms of power generation: coal, oil and gas, renewables, and nuclear.

Coal

Coal generates 42 percent of the world's electricity, according to the International Energy Agency, and its share is growing. In the short term, the World Health Organization estimates that as many as 1 million people a year die from coal-related causes. The degree of deadliness, however, depends on how advanced the coal-fired plant is.

In the United States, about 24,000 people die every year from coal-related pollution, according to the American Lung Association. (That's a huge source of mortality: to put that number in perspective, a little more than 30,000 die annually in car accidents in the United States.) In Germany, coal generates about 40 percent of the power, but statistics about coal-related mortality are not easy to find. It is clear, however, that as far as European power generation goes, German coal plants contribute a lot to the Continent's air pollution. The World Wildlife Fund says that 10 of the 30 dirtiest power plants in Europe are in Germany. (Another 10 are in the United Kingdom.) But the world's most dangerous coal plants are by all accounts in China: [they are thought to kill as many as 500,000 people a year.](#)

There is another cost as well: coal and other fossil fuels contribute to global warming, which [Vaclav Smil](#), an environmental professor at the University of Manitoba in Winnipeg, Canada, calls "the biggest risk of all," one that has the potential for huge casualties. Various studies blame coal for between a quarter and a third of the world's CO₂ pollution.

Coal's defenders say that the degree of dirtiness depends a lot on the age of the generating plant. Newer plants tend to be much cleaner – one researcher estimates that in the United States, 10 percent of the plants are responsible for 43 percent of the coal-

related ecological damage and that simply replacing half of these dirty (or rather, dirtiest) plants would cut American coal emissions in half. “It would be like replacing a 1952 Plymouth ... with a Toyota Prius,” writes one pundit.

Oil and Gas

As fossil fuels go, oil is much cleaner than coal, but natural gas is cleanest of all—giving off about one-third of the emissions of coal. In recent years, the oil and gas industry has focused not on expanding the fleet of oil-burning power plants but improving access to natural gas. The industry’s increasing ability to “crack” gas locked in shale has opened up huge new reserves for development in the United States and Europe, making the fuel much more attractive in terms of cost and as a matter of energy security.

Beyond the air pollution inherent in burning any fossil fuel, gas has special risks of its own, however. Gas pipelines can and do leak occasionally, sometimes killing a handful of people and sometimes killing hundreds. Worldwide, 1,971 people died from gas accidents between 1969 and 2000, according to a 2005 Swiss study.

Separately, critics argue that the unconventional natural-gas fields now being developed could pose [some major new environmental risks](#). The method used to extract the gas trapped in shale—injecting water or steam— could risk contaminating the groundwater, many environmentalists say.

Industry spokesmen counter, however, that the method, called hydraulic fracturing or “fracking,” has been used for more than 60 years and, they say, has so far had no ill effects. First, spokesmen say, the gas is far below the water table, and second, you can’t contaminate water with water. The fluids being pumped into the ground are themselves 99 percent water and sand, [according to](#)

[Thomas J. Pyle](#), president of the Institute for Energy Research, an industry trade group.

Renewables

When it comes to safety, renewables might seem hard to argue against. Northern Europeans have used windmills for more than 800 years and hydropower (in the form of waterwheels) has been around since the ancient Greeks, and neither has ever generated any waste. But not all renewables are equally clean or safe.

Ethanol, for instance, is cleaner-burning than petroleum, but still produces some carbon. Critics have argued that the environmental damage involved in growing masses of corn or sugar cane—the major raw materials of ethanol—is considerable and that the shift in priorities would be disruptive to the food supply. One study even claimed that distilling corn into ethanol is such an energy-intensive process that it may take 29 percent more energy to produce a gallon of ethanol than the gallon holds.

There could be other knock-on effects as well. The same study that found the negative energy balance also estimated that powering a car on ethanol requires 0.6 hectares of land per year per car—meaning that if Americans were to run one-third of their cars with ethanol they would need as much cropland to produce the fuel as they need to feed themselves. [Another study](#) argued that if farmers converted more forests to cropland and diverted grain to corn production, greenhouse gas emissions could actually increase.

However, as with most forms of energy generation, proponents say that new ethanol plants are much cleaner than old plants and that the latest production techniques could sharply reduce the environmental impact. A 2009 University of Nebraska study finds that ethanol burns 48 to 59 percent cleaner than regular petrol. [The study](#) also says that although it now takes about a liter

of petrol to produce 13 liters of ethanol, this ratio could rise to one liter against 19 by using advanced techniques that increase corn yield even as they reduce the amount of energy required to grow the corn.

Meanwhile, Brazilians argue, [using a very different set of numbers](#), that the real problem with ethanol is trying to distill it with corn, because sugar burns much more cleanly than corn-based ethanol—91 percent cleaner than petrol, compared with 18 percent cleaner for corn—and is much less expensive to produce.

At a second glance, too, hydropower can also have major negative consequences, given that many dams are built upstream from large population centers. China has run into repeated problems with shoddy construction of public works that some people call “tofu projects”—and these problems could be disastrous if they affected a dam. “This being China, there are all these ‘little’ towns of a million people here, a million people there,” says Smil of the University of Manitoba. Back in the Maoist era, in fact, a collapse of 62 dams on the Ru River after a typhoon led to more than 171,000 deaths.

Putting aside the risk of flooding in the event of a collapse, dams cause enormous displacement when they are built. More than 18 million people have had to move in recent years as China pursued a vast hydroelectric program all over the country, including over 1 million people displaced by the Three Gorges Dam project. In addition, some scholars estimate that as many as 143 million people have been affected by the changes wrought by the new dams. The Yangtze River carp catch, for instance, has fallen 90 percent since the dam construction began.

Wind and solar are generally seen as the safest forms of power, with risks largely confined to manufacturing and installation of equipment. But even these forms of power generation have a

catch: they're variable—the sun isn't always out, and the wind doesn't always blow. At some point, battery technologies might be able to overcome that limitation. For now, however, that variability presents both a limiting factor and a risk for planners.

Nuclear

By the numbers, nuclear looks surprisingly good. About 50 people were killed in the worst nuclear accident in history, Chernobyl. [An IEAE reports](#) suggests that over 20 years, among the 600 000 liquidators, about 4 000 have probably died due to their exposition to radiations, though the report points out the careless conditions of the intervention. None were killed at Three Mile Island. A handful at Fukushima. As frightening as these accidents were, nuclear power is much less risky in terms of fatalities and injuries than conventional energy sources, particularly when carbon production is factored in. (*)

Where the bigger risks come in for nuclear power is not so much during power generation as in waste disposal after production, [an issue covered earlier in this series](#). Disposal is a problem that is far from solved, although perhaps more out of a lack of political commitment than technical know-how.

Plant decommissioning presents a second set of environmental risks. [The industry argues](#) that only 1 percent of the radioactive material normally present when a plant is in operation is left behind when the plant is finally shut down, and that dismantling or entombing a plant can be done safely. In fact, the decommissioning process so far [suggests](#) that the most serious health risks are the same as those that arise with the dismantling of any old plant, such as the danger of exposure to asbestos or collapsing structures.

Thinking About Risk

In commenting on what the shift in China away from coal and

more toward hydropower means for the environment, Jonathan Sinton, China program manager at the International Energy Agency, has said, “There are no ideal choices, it is ‘a no-win situation.’ ”

The same might be said of most of today’s energy choices. Is it better to keep coal plants online until solar matures or build more gas plants now? Is it better to use ethanol than natural gas? Is it better to build safer nuclear plants based on modern designs or keep the older ones going until nuclear can be phased out?

To some extent, the answers have to do with how you define “better.” For emotional reasons, nuclear is clearly the odd man out right now. Certainly, the waste does pose special kinds of risks. After all, for all its faults, a chunk of coal can’t blow up a city. Nor is it lethal for thousands of years—although it could be argued that the CO₂ it yields might be, at least indirectly. However, [some studies](#) that have tried to break down risk per terawatt hour rate coal the worst (161 deaths per TWh), followed by oil (36 deaths), biofuels and peat (24), hydro (1.4), solar (0.44), wind (0.15), and nuclear (0.04).

The fact that nuclear power is so mysterious to people may lead them to exaggerate its dangers. A number of psychologists and practitioners of the fast-growing discipline of behavioral economics have noted that human beings are not especially good at evaluating risk.

One classic study of risk-assessment by pioneering psychologist Amos Tversky, recounted by Peter L. Bernstein in his book, *Against the Gods: The Remarkable Story of Risk*, polled 120 Stanford students to ask their estimate of the probability of dying by various causes. In the poll, the students underestimated the share of heart attacks at 22 percent (in fact, it’s 34), and natural causes of death overall at 58 percent (in fact, it’s 92). On the other

hand, they overestimated the probabilities of death by accident (32 percent versus 5 percent in reality) and by murder (10 percent versus less than 1 percent).

Tversky concluded from this study and others that yielded similar results that people were only “quasi-rational,” and that “human choices were orderly, though not always rational in the traditional sense of the word,” according to Bernstein.

Another interesting inference that can perhaps be drawn from the study is a tendency to exaggerate involuntary risks (murder) and think much less about the much higher voluntary risks that people assume every day, like overeating.

Smil argues that this kind of selective vision is part of the difficulty faced by proponents of nuclear power. “People are willing to smoke and overeat and drive cars fast—there is no speed limit on the German autobahn,” he notes. “But involuntary risks they will not accept.”

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