

tenance, and a sense of public responsibility—failed. For more than two hours on 28 March 1979, reserve coolant injection that could have saved the plant from a major catastrophe was manually throttled because the problem was misdiagnosed. And two of the technical failures leading to the accident—the stuck pressure relief valve and the clogged polisher—had occurred before and had not been properly addressed. Even with the redesign of the failed gadgets, TMI remains an icon of a profit-driven industry cutting corners.

One would expect that the decision to give unparalleled government subsidy to the nuclear power industry would be made after public discussion and input from the best scientific and technical authorities in the country. Instead, decisions have been made in a political setting. Even the possible future directions for nuclear power generation were chosen in a casual and cavalier way. As far as anyone not on the inside knows, no one was invited to the Vice President's Energy Task Force in 2002 who might have supported funding for development of Carlo Rubbia's thorium reactor.⁴

Walker recognizes in his book that the Nuclear Regulatory Commission has tried hard to improve its regulatory function. (See a review of Walker's book in *PHYSICS TODAY*, February 2005, page 63.) However, TMI continues to be discussed because we have not yet come to terms with the fact that it was allowed to happen.

Rather than disparage those who raise concerns about nuclear safety, physics educators might try to present students with facts not colored by free teaching materials paid for by those with a financial interest in biasing materials used in schools.

The lay public is not as stupid as some experts would have us believe. For one thing, there are out there in America some 2500 young adults who have an appreciation for the complexities of nuclear power, which they gained in a physics unit at Huron High School in Ann Arbor, Michigan.⁵ In that unit they learned to think for themselves, to shy away from a decision to be simplistically for or against nuclear energy, and to apply knowledge about how a reactor works, from control rods, primary coolant, and emergency core cooling system, to pressurization, relief valves, and loss-of-coolant conditions.

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5. See course materials in W. Scheider, *A Serious but Not Ponderous Book About Nuclear Energy*, Cavendish Press, Ann Arbor, MI (2001).

Walter Scheider
(cavendish@worldnet.att.net)
Ann Arbor, Michigan

In light of Edwin Karlow's letter supporting nuclear power (*PHYSICS TODAY*, February 2006, page 11) and the article "Stronger Future for Nuclear Power" in that same issue (page 19), I would like to remind readers of the many reasons why nuclear power is a bad idea.

Nuclear power is not economically viable. Karlow explains the subsidies that the nuclear power industry needed in the past and pleads for continued subsidies in the future. Contrary to the early promise that nuclear power would be so cheap we would not need electric meters, nuclear power is very expensive. The main reason is that it is so dangerous; expensive safeguards must be attempted.

The risk of a catastrophic accident persists. Nuclear power plants are built and run by humans, who make mistakes and who can be pressured into making decisions that put profit above safety. And the same government that took care of us after Hurricane Katrina will assume responsibility for us after a nuclear accident.

Nuclear power plants are possible terrorist targets. A dedicated attack against a nuclear plant could not be prevented, and the highly radioactive spent fuel is poorly contained in many plants and is particularly open to attack.

The waste disposal problem is not solvable in the near future. The politically chosen Yucca Mountain disposal site is nowhere near opening, precisely because of its geological problems, and because of local opposition. So spent fuel will continue to pile up around the country, producing increasingly dangerous sources of radioactive materials vulnerable to human error, accident, and attack.

Current nuclear plants are being operated unsafely. The Nuclear Regulatory Commission is lax in its supervision of those plants. The NRC does not have workable evacuation plans for

many power plants, including the Indian Point plant just upwind of New York City and the oldest plant in the country, in Oyster Creek, New Jersey. Fire safety problems have not been addressed. Routine operation of nuclear plants results in planned and unplanned releases of radioactivity, and there is no safe level of radiation exposure. The procedures for extending the life of unsafe reactors do not allow meaningful public input.

The most important reason why nuclear power is a bad idea is that it results in nuclear weapons proliferation. A fuel-processing plant for a standard 1000-MW reactor could produce enough uranium for between 10 and 30 uranium weapons per year. Its waste reprocessing plant could produce enough plutonium for 30 plutonium weapons per year. It is no accident that Iran and Venezuela, nations awash in oil, are pursuing nuclear power. India and Pakistan received nuclear fuel and technical help from other countries to develop nuclear power, and took advantage of this opportunity to make nuclear weapons. And the material can find its way into the hands of terrorists. Even a small nuclear attack or a small war between newly nuclear states would be devastating to humanity. Having invented nuclear weapons, we physicists have a moral responsibility to do everything we can to lower the probability of their use.

I am a climatology professor doing research on global warming. In my opinion, we must reduce our greenhouse gas emissions to mitigate future negative consequences to the climate. But nuclear power is not the answer.

Alan Robock
(robock@envsci.rutgers.edu)
Rutgers University
New Brunswick, New Jersey

Atoms and quarks, two 20th-century revolutions

One aspect of Albert Einstein's heritage seems to have been overlooked in the many centenary celebrations of his annus mirabilis. The 20th century began with the confirmation of the revolutionary finding that matter was not continuous but made of atoms and molecules. It ended with a second revolutionary finding that matter is made of even tinier objects called quarks. The similarity between the two revolutions has been missed. Einstein played a crucial role in the first. A number of physi-