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A vital U.S. energy
source has become enshrouded
in a fog of misinformation
and fear

Nuclear Power in Perspective

By Ralph Kinney Bennett

Is nuclear power a boon to an energy-hungry world, or is it a hellish threat to mankind?

While this question arouses vehement debate, nuclear power is becoming a way of life for nearly 50 nations.

In all, there are 179 nuclear plants operating outside the United States, another 160 under construction, and 69 more in planning. Ironically, the United States (where 75 nuclear plants now produce 13 percent of the nation's electrical energy) no longer rides the crest of the nuclear surge which began there. Why? There are many reasons, among them the licensing procedures of the U.S. Nuclear Regulatory Commission (NRC), which account for the years–up to 14–it takes to bring a plant into operation; also, the NRC's unpredictable regulatory changes which interrupt operations at existing plants and plants under construction. Management and construction difficulties have plagued some projects. Lawsuits and delaying tactics by media-wise anti-nuclear groups have also discouraged the nuclear programs of some electrical utilities.

Repeated referenda, even after the Three Mile Island accident, have demonstrated public support for nuclear power. But polls show that the public has little understanding of nuclear power. Many people believe, for instance, that reactors can blow up like a nuclear bomb (a physical impossibility). Often, ill-founded scare stories about "radioactive death clouds," birth defects, cancer, have been shrouded in a fog of doubt and fear. To dissipate this fog, one needs facts—especially about some of the most misunderstood topics in the nuclear debate: plant safety, meltdowns, radiation and disposal of radioactive wastes.

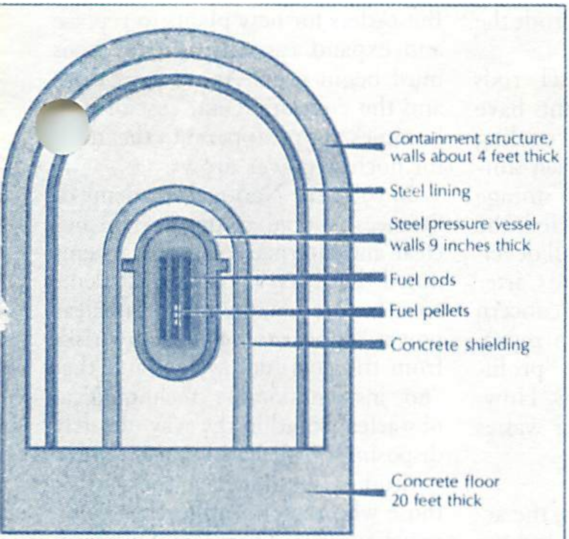
How Safe Are Nuclear-Power Plants? Every practical form of energy involves risks the public chooses to take in return for the benefits of power. Each year, some 300 Americans are killed in mining accidents and in train and trucking accidents during transportation of coal. More die from black-lung-related diseases after long years in coal mines. Studies by the Brookhaven National Laboratory suggest that from 10,000 to 50,000 Americans die prematurely each year, mainly from respiratory diseases attributable to the burning of coal. Oil, too, takes its respiratory toll—some 10,000 lives per year according to one estimate.

By contrast, nuclear power ranks as one of the safest forms of energy. In more than 500 reactor years of service in the United States, there has never been a death or a serious injury to plant employees or to the public caused by a commercial reactor accident or radiation exposure. Says Philip Handler, president of the National Academy of Sciences: "Nuclear power is the safest major technology ever introduced into the United States."

This safety record is largely due to the "defense in depth" principles upon which the plants are designed and built. A formidable series of active and passive barriers separates the outside world from the heat and radiation of the plants' chain reaction. First, the pellets of uranium oxide in which the chain reaction takes place are stacked inside rods of corrosion-, radiation- and heat-resistant zirconium. These rods are immersed in cooling water in the core of the reactor, which is contained within a pressure vessel, the steel shell of which is about nine inches thick. This vessel in turn is surrounded by a thick, concrete wall. And all of this is inside a "containment structure"—a huge, sealed steel shell which is itself encased in an outer steel-reinforced concrete "dome," approximately four feet thick. Its concrete floor may be as much as 20 feet thick. This domed building is designed to withstand earthquakes and even a direct hit by a crashing airliner. More important, it is built to contain any radioactivity that might be released accidentally.

Sensitive detection systems are built into the plant to pick up abnormal increases in radiation and humidity changes, a possible precursor of a radiation leak. There are elaborate systems to control or completely stop the nuclear chain reaction when necessary (by inserting control rods in among the fuel rods). Finally, an Emergency Core Cooling System (ECCS) ensures sufficient water in the event of an accident to draw off the reactor's residual heat.

What About Meltdowns? Critics argue that, through a series of highly improbable coincidental events, a



BARRIERS AGAINST RELEASE OF RADIOACTIVITY

reactor could lose coolant water, leaving the super-hot reactor core at least partially uncovered. This would cause heat to build up within minutes. The zirconium rods would then be corroded away, leaving the fuel exposed. When the temperature reached 5000 degrees Fahrenheit, the fuel would turn molten, and a white-hot viscous mass would form inside the pressure vessel.

Nuclear-power opponents claim that this molten mass would melt its way through the pressure vessel, drop to the floor of the containment building, and there inexorably melt through the steel-reinforced concrete into the earth below. During this process, critics also contend, the containment may break open, possibly because of an over-pressurization of steam. The radioactive gases rising from the molten mass would then escape and, under certain meteorological conditions, be carried over a populated area, possibly causing thousands of deaths.

But according to the most exhaustive nuclear-accident-risk study ever undertaken, the chances of this happening have been estimated at *one in 100 million* reactor years.

The accident at Three Mile Island came nowhere near such a catastrophe. It released little radiation, killed or injured no one. The accident did show, convincingly, that the ECCS worked fast and automatically. Unfortunately, a human error then caused it to be shut off, eventually exposing the reactor core. But this provided surprising news. It had been assumed that a meltdown would occur within a few minutes of such an exposure. The top of the core at Three Mile Island was exposed intermittently for a total of about eight hours, but the heat reached only about 2000 degrees Fahrenheit, far below meltdown temperature.

Nuclear experts are coming to think that even if there were a complete meltdown, the consequences would not be as awesome as critics have predicted. Technical experts on the President's Commission on the

Accident at Three Mile Island conjured up what *might* have happened in the "worst case." They determined that the molten fuel indeed *might* melt through the steel-reinforced concrete floor, but it would take at least three days, and might never happen. Most probably, the fuel would solidify and slowly dissipate its heat. In the end, the scientists concluded, "containment would not fail and result in an uncontrolled release of fission products to the atmosphere."

What About Radiation? Routine radiation emitted from all nuclear-power plants in the United States amounts to only three-tenths of one percent of the annual radiation to which we are exposed from *natural* sources (cosmic rays, the earth itself, etc.). During the accident at Three Mile Island, people living within a 50-mile radius may have received an additional dose equal to about one percent of a typical medical X ray, or about as much as you get in a year from your color TV. Despite all the headlines, the accident's radiation effects were insignificant.

A scientific gauge of the effect of radiation on human tissue is the "rem," an acronym for "roentgen equivalent man." (Roentgen is the unit of radiation delivered.) Radiation sickness, an illness affecting the body's ability to produce blood cells—from which you either recover or die within weeks—would usually result from exposure to at least 200 rems in a single large dose. A dose of 600 rems or more without medical treatment would almost certainly be fatal. But such large doses are virtually unknown outside of a few isolated cases in nuclear laboratories. Some uranium miners, workers with radium, and recipients of early X-ray treatments received significant exposures, but these were absorbed over many months or years. Radiation exposures that the public normally experiences are so much smaller that they are measured in *millirems*—that is, in thousandths of a rem.

The average American is exposed to about 200 millirems a year (about a fifth of a rem) from radioactive elements in the soil, brick, stone and other building materials—even from potassium, a naturally radioactive element found in our bodies. Routine radiation from *all* the 75 nuclear plants now operating in the United States accounts for only a tiny fraction of that: 3/100 of a *millirem.* If all our power were delivered from nuclear plants, this would rise to an estimated 2/10 of a millirem a year, or about 1/300 of our average yearly exposure from medical X rays.

Nonetheless, some nuclear critics maintain that *any* radiation is dangerous and that low-level radiation is a great unseen killer. But man has been living with these subatomic particles bombarding him since the beginning of time, and the effects seem to have been minimal. The three major pathological effects of radiation—cancer, radiation sickness and genetic mutation—are virtually untraceable at levels below 50 rems and are statistically modest above that. For instance, a group consisting of 24,000 survivors of Hiroshima and Nagasaki—perhaps the most exhaustively monitored medical test group in history—has demonstrated fewer than 200 cases of cancer above what would be statistically normal.

Radiation can be dangerous. The *chance* of a harmful effect increases as the dose increases. Radiation is also a fact of everyday life and, when harnessed (as in nuclear medicine), a benefit. But the fact remains that radiation is an unknown to most of us, and we fear the unknown.

What About Nuclear Wastes? A typical 1000-megawatt, coal-burning plant produces wastes at a furious rate—500 pounds per second of carbon dioxide, a thousand pounds of ashes a minute, a ton of sulfur compounds every five minutes. Smoke from the plant is composed of tiny particles of solid matter, including poisons like arsenic and cancer-causing organic compounds like benzopyrene. These wastes find their way into the air or into landfills and dumps where some byproducts eventually get into rivers and streams.

By contrast, a nuclear-power plant has no belching smokestacks, and nuclear wastes are five million times smaller by weight and billions of times smaller by volume than coal wastes. They consist of radioactive gases (which are held at the plant until their heaviest radioactivity has subsided, then vented when the weather permits quick diffusion), waste water containing radioactive isotopes—and the major residue: fission products from the chain reaction, locked inside the reactor fuel rods.

After about three years of operation, spent fuel rods are removed from the reactor and cooled in deep pools of water at the plant site, where they dissipate some of their radioactivity. They can then be taken to a reprocessing plant where the various fission products are separated and valuable plutonium and uranium are recovered.

The remaining wastes are quite small and therefore easily monitored—the wastes from one year's operation of a 1000-megawatt plant would easily fit under a card table. (The ashes alone from a 1000-megawatt, coal-fired plant would fill 40,000 trucks.)

The reprocessed wastes can be sealed into a permanent medium such as borosilicate glass and encased in special titanium-alloy canisters. These canisters can then be buried deep in the earth in a geologically stable formation such as huge salt beds, where they will gradually lose their radioactivity.

Controversy over underground burial of the wastes centers on fears that ground water might find its way into the burial site and then carry radioactive elements back up to the surface. Yet the critical radiation period for these materials is at most a few hundred years. And it has been estimated that it would take 10,000 years or more for underground water to erode and destroy the canisters, and another 30,000 years to erode the glass.

Unfortunately, spent fuel rods from the nation's power plants have been piling up in their cooling ponds—older plants may reach storage capacity in 1983. These storage problems and other fears led the federal government to halt all development of reprocessing. (The Carter Administration expressed concern that plutonium produced in reprocessing could be used in the "proliferation" of nuclear weapons. However, reprocessing of nuclear wastes is going ahead in Europe.)

THE ANTI-NUCLEAR PROTESTS, the accident at Three Mile Island and the sluggishness of the NRC have all had a pronounced effect on the nuclear industry. While other nations forge ahead with new plants, often using American-patented systems, our domestic industry is in a state of atrophy, living off plant orders made in the early 1970s. Three of the four U.S. reactor manufacturers are losing money, and valuable scientists and engineers may be forced to leave the field.

Generating capacity now on order or being built is expected to fill our needs through the end of the 1980s. But orders for new plants to replace and expand capacity in the 1990s must begin soon. As oil prices rise and the environmental cost of c[illegible] becomes more apparent, the n[illegible] for nuclear power grows.

In 1980, the National Academy of Sciences' special committee on nuclear and alternative energy systems noted that even if reactor accidents were factored in, the risks of nuclear power "appear to be far below risks from the coal-fuel cycle," and that "no insurmountable technological obstacles" stand in the way of safely disposing of nuclear wastes.

Studies like this have shown that those who understand nuclear power believe in it. They do not underestimate its risks. But they are able to see them in proportion to the greater risks to life and health—and the economy—posed by other energy sources. In the end, the decision the American public makes on nuclear power will reflect whether we still have the technological faith in ourselves that has been the key to unparalleled progress.

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