Chapter 11
Three Mile Island and Fukushima

Some Reflections on the History of Nuclear Power

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Abstract This article draws comparisons between the Three Mile Island accident in 1979 and the far more severe accident at Fukushima. It cites lessons that were learned from Three Mile Island and suggests how they improved the performance of the nuclear power industry in the United States. The article also draws other, perhaps less apparent, lessons from the history of nuclear power.

Keywords Three Mile Island · Nuclear industry · Radiation hazards · Nuclear Regulatory Commission

The accidents that occurred at the Three Mile Island (TMI) Unit 2 plant in Pennsylvania in March 1979 and the Fukushima Daiichi plants in Japan in March 2011 are generally and correctly regarded as two of the three most serious in the history of commercial nuclear power (Chernobyl, of course, is the third). For that reason, both accidents need to be carefully studied and appropriate lessons need to be learned. Although TMI and Fukushima differed in causes and consequences, they provide powerful incentives to investigate what happened and to draw conclusions that, if properly applied, can help to prevent, or at least mitigate the effects of, nuclear power accidents in the future.

Any account of TMI and Fukushima must recognize their important dissimilarities. TMI is usually and erroneously described as a disaster. Although it was a gut-wrenching crisis and although a significant portion of the core melted, it did not result in large

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releases of dangerous forms of radiation. The plant emitted several million curies of noble gases after the accident, but they present slight hazards to human health. Only small amounts of volatile radioactive isotopes that pose the greatest risks escaped into the environment. The accident released less than 20 curies of iodine-131 and no strontium-90, cesium-137, or plutonium. Careful epidemiological studies of a cohort of about 32,000 people who lived within a 5 mile radius of the plant have shown no increase in the incidence of cancer or other diseases that could be attributed to the accident. Most of the approximately 144,000 people who voluntarily evacuated returned to their homes within a few days and schools re-opened two weeks after the accident.

By contrast, Fukushima released radioactive iodine, strontium, cesium, and plutonium to the environment. The off-site quantities were larger, more widespread, and more worrisome than the amounts that escaped from TMI. The *Washington Post* reported in April 2011, that "experts predict no long-term health consequences on residents in the region," and that assessment has continued to hold. Nevertheless, the local population has suffered from the stress and trauma of a mandatory evacuation and all the trials of dislocation, uncertainty, and anxiety. For those reasons, Fukushima qualifies as a disaster, though far short of the magnitude of Chernobyl.

Despite those differences, there are critical lessons to be learned from what occurred at TMI that apply to Fukushima and to nuclear power in general.

1. Accidents can and probably will occur in unexpected ways. The TMI-2 accident was largely a result of mistakes on the part of the operators in the control room. Their training did not prepare them for the loss-of-coolant accident that began when the pressure-operated relief valve (PORV) stuck open and allowed the escape of coolant from the core. The instrument panel in the control room provided little useful information on what was happening in the core. The operators feared that the pressurizer was in danger of "going solid" from an excess of water, and therefore, they cut the flow of water to the core from the emergency core cooling systems to a trickle. In that way, they unwittingly transformed what should have been a minor incident into a massive meltdown. At Fukushima, of course, the original causes of the accident were the earthquake and tsunami, which were of perhaps unprecedented and certainly unanticipated magnitude. The worst effects occurred because the diesel generators that were designed to provide back-up power to the plant were submerged by the tsunami. Plant designers and engineers take elaborate precautions to guard against accidents as severe as TMI and Fukushima, but in those cases, their efforts were not enough. It seems axiomatic that other accidents are likely to happen in unexpected ways, and designers, engineers, and builders must do their utmost to ensure that plants can withstand such occurrences or at least minimize the consequences. Extending the margin of safety as much as possible is advisable, perhaps essential. At TMI, the overdesign of the pressure vessel almost certainly kept it from failing after the core meltdown and might well have prevented a more serious accident.
2. When accidents occur, they have to be thoroughly investigated and frankly evaluated. After TMI, extensive and hard-hitting investigations were conducted

by the President's Commission on the Accident at TMI (usually referred to as the Kemeny Commission after its chairman, John G. Kemeny), Congress, the state of Pennsylvania, and the Nuclear Regulatory Commission (NRC). The reports of those investigations, including the one sponsored by the NRC, made no effort to spare the feelings or the sensitivities of the NRC or the nuclear industry. They came down hard on the NRC for failing to do a better job of regulating and the industry for failing to do more to ensure the safety of the plants it built and operated. There was no doubt in anyone's mind at the NRC or in the field of nuclear power that broad reforms were needed if the industry was to survive. However painful it was to be targets of unvarnished criticism, the NRC and the industry took it well and moved on to make impressive progress in both safety and performance.

3. A closely related lesson is that lessons need to be learned, remembered, and heeded. Before TMI, the NRC and the nuclear industry believed that they had resolved questions regarding reactor safety and that nuclear plants were well-protected against a severe accident. TMI was a shocking and humbling experience, and both the NRC and the industry took the lessons of the experience to heart. It was clear from the sequence of events during the accident that although the safety equipment in the plant performed according to design, there were glaring flaws in what were known as "human factors." The NRC made important changes in its regulations to address, among other things, significant shortcomings in operator training, control room design, instrumentation, and communications. Likewise, the industry took a series of steps to fix the weaknesses the accident revealed, including programs to make operator training more rigorous. The action with perhaps the greatest impact was the creation of an industry-funded organization, the Institute of Nuclear Power Operations (INPO), which came to serve as the conscience of the industry and to exert effective peer pressure to bring about necessary changes. The result was that industry performance in the areas of both safety and reliability was vastly improved. For example, the capacity factor across the industry increased from less than 60 % in the 1970s to more than 90 % in the early 2000s. This is not to say that all problems in the nuclear industry were solved. There were still serious lapses—two prominent examples were the embarrassment of sleeping control room operators at the Peach Bottom plant in Pennsylvania in 1987 and the discovery of a football-sized cavity in the head of the pressure vessel at Davis-Besse in Ohio in 2002. Nevertheless, the application of key lessons learned from TMI was a major factor in improving nuclear power safety in the United States.

These lessons of TMI, at least in retrospect, are fairly obvious. But there are also other lessons from the history of nuclear power that are perhaps less apparent and that have important implications for the future of nuclear power in the United States and abroad.

1. Nuclear power will always be judged by standards that are different and more demanding than those applied to other sources of energy or societal risk. This is in part an appropriate response to the possibility of a catastrophic accident

at a nuclear plant. But it is also a function of unique fears of nuclear power. The news media and the public seem far more uncomfortable with the small (though real) likelihood of a disastrous nuclear meltdown than with the well-documented costs in human health and lives of other forms of energy. This pattern also applies to elements of societal risk in general. In 1978, a public opinion sampling of college students and members of the League of Women Voters in Oregon asked them to rank thirty sources of risk "according to the present risk of death from each." Both groups rated nuclear power as number one, ahead of smoking, motor vehicles, motorcycles, handguns, and alcoholic beverages. There is every reason to believe that the same poll would produce similar results in 2011. One indication is that media coverage in the United States of the effects of the Fukushima earthquake and tsunami tended to devote far more attention to the meltdowns at the nuclear plant than to the tragedy that took place throughout the region. Despite the severity of the damage to the plants, at least they remained standing and the amounts of radiation they released, while disturbing, were not catastrophic. This was not the case for the homes, schools, hospitals, factories, and other structures that were flattened by the earthquake and tsunami and in which thousands of people perished.

2. An important reason for the fear of nuclear power is exaggerated public anxiety about radiation. This was made vividly clear after Fukushima when citizens bought out supplies of potassium iodide and Geiger counters from stores—in California! This might have been a reasonable action for residents of Japan, given the uncertainties about the condition of the plants, but it hardly seemed necessary for those who lived on the other side of the Pacific Ocean. The reasons for acute public fear of even low-level radiation are rooted deep in history and have a great deal to do with media coverage. For a period of more than 65 years after Hiroshima, radiation hazards were a source of an abundance of sustained publicity, and, as a result, of uniquely intense public fears. In many cases, the news stories were ill-informed and distorted. Even when media reports on radiation were balanced and accurate, the information they conveyed was frequently unsettling. The distinction between accounts of radiation effects and those of other technological hazards with some similar characteristics, such as dangerous chemicals, electrical shocks, fossil fuels, dam failures, food additives, and genetic engineering, was more quantitative than qualitative. Radiation was different in remaining a regular source of headlines for decades. After Hiroshima, the many ramifications of nuclear energy were big news, and the effects of radiation were a major part of the story. The nature of radiation risks generated public apprehension, but the prevalent anxieties were greatly enhanced by the visibility that radiation issues commanded. Although most experts agreed that public fears of low-level radiation far exceeded the risks of exposure, those fears were hardly unreasonable based on the information or impressions that the public gleaned from the popular media.
3. A final lesson from the history of nuclear power is the importance of knowing something about the history of nuclear power. For example, practically every news story that refers to the early history of the industry quotes a statement

made in 1954 by the chairman of the Atomic Energy Commission, Lewis Strauss, that nuclear power would be "too cheap to meter." This is cited as evidence of how optimistic or how foolish nuclear advocates were as the nuclear power industry got under way. The problem is that nobody, not even Lewis Strauss, believed that nuclear power would be so cheap. Strauss was engaging in a flight of fancy that was not consistent with the views of nuclear experts or the electric power industry then or later. Yet this statement has become part of a misleading mythology about the early history of the technology. Another more recent example is the continuing belief or assumption that TMI was a disaster, or worse, that radiation releases were far greater and the health effects far more extensive than the federal government, the state government, or the nuclear power industry has ever admitted. This charge has no basis in evidence, but it remains an article of faith among some people and makes at least occasional appearances in media reports.

It is essential to get the history of the nuclear power industry and of radiation protection right if we are to deal intelligently and effectively with the serious challenges presented by the Fukushima accident. It is also essential if we are to make informed choices about the options available to us, including a full accounting of the risks and benefits of all energy sources, to meet the growing demands for electrical power in the future.