

It's not just Fukushima: mass disaster evacuations challenge planners

The Fukushima evacuation zone raises the issue of what would happen during an evacuation in heavily populated US metropolises during a nuclear meltdown.

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More than 180 million people live within 50 miles of a nuclear power plant in the US — the radius the US suggested be evacuated during the nuclear crisis at Fukushima Daiichi.

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On March 11, 2011, Japan suffered a massive earthquake and subsequent tsunami that destroyed roads, bridges, and buildings; killed nearly 16,000 people; and critically disabled three reactors at the Fukushima Daiichi nuclear power plant. By March 12, the U.S. Nuclear Regulatory Commission (NRC) was already considering urging Americans within 50 miles of the stricken nuclear reactors to evacuate, given an explosion in Unit 1 that destroyed the reactor building and exposed spent nuclear fuel and other radioactive materials to the air.

"If this happened in the U.S., we would go out to 50 miles," said Bill Borchardt, NRC executive director for operations on March 17, according to transcripts of the days following the catastrophe. "That would be our evacuation recommendation."

In fact, in the U.S., more than four million Americans live within 10 miles of the 63 sites of nuclear power plants with at least one operating reactor, according to data compiled by the NRC based on the 2000 census. That number swells when the radius extends outward to 50 miles to affect more than 180 million Americans, and includes major metropolitan areas such as New York City, Philadelphia, San Diego and even West Palm Beach, Fla.

In the wake of the meltdowns in Japan and subsequent evacuations, could all these people in the U.S. be evacuated or take some form of protective action in time in similar circumstances?

Planning for the worst

Nuclear power plants are surrounded by two "emergency planning zones" developed out of accident analyses conducted in the 1960s and 1970s: a roughly 10-mile radius around the plant that must anticipate being exposed to a radioactive plume and a roughly 50-mile

radius around the plant that must prepare for possibly being exposed to radioactive particles that drop out of a plume. "Neither are zones that are fixed and that is the absolute boundary," explains the NRC's Patricia Milligan, the senior technology advisor for preparedness and response in the Office of Nuclear Security and Incident Response. "We don't expect that [nuclear power plant operators] would stop taking action because it's at 10.5 miles. The plans are built so that 10 miles provides a reasonable basis and, if you need to expand, you could."

That is exactly what happened in the case of Fukushima. Just hours after the tsunami on March 11 the Japanese government ordered an evacuation of those living within three kilometers of the stricken nuclear reactors and suggested those living within 10 kilometers stay indoors with the windows closed. As the situation progressively worsened and radiation hot spots were discovered farther afield the Japanese government expanded the evacuation order.

The goal in the zones prescribed by U.S. regulations is to avoid any radiation doses that exceed the U.S. Environmental Protection Agency's "protective action guidelines" for exposure to a plume of radioactive material being released from a nuclear power plant. The U.S. rules note that evacuation or sometimes getting indoors "should normally be initiated at one rem," or 10 millisieverts. (A rem is a dosage unit of x-ray and gamma-ray radiation exposure.) Workers within a nuclear power plant can receive doses of up to 50 millisieverts per year. It takes immediate exposure to as much as two sieverts of radiation to cause sickness straightaway.

As bad as it's gotten

Rulemaking is based on the best available data. So what has been learned from previous close calls from nuclear and nonnuclear incidents alike? On March 28, 1979, the nuclear power plant at Three Mile Island in Pennsylvania suffered a partial meltdown that led to the release of radioactive materials. In the fog of confusion that surrounded the event, Pennsylvania government officials advised children and pregnant women within a five-mile radius of the facility to leave. That radius of evacuation ultimately extended some 20-miles around the plant, although the majority of local residents did not evacuate. Those who stayed were urged to remain indoors and farmers were urged to shelter their animals and feed them stored food.

In the end, despite the partial meltdown and release of radioactive material, numerous studies have found limited or no health effects. But the worst accident in U.S. commercial nuclear power history did point out flaws in evacuation planning. "Three Mile Island was a very enlightening accident in terms of how an accident progresses," Milligan notes.

First and foremost, it became clear that nuclear accidents to date, including Fukushima, are slow-moving affairs. In the case of Fukushima, there were at least 14 hours between the loss of electricity to power the pumps keeping cooling water on the nuclear fuel and a melt down. In nonnuclear emergencies, such as the release of toxic gases, only minutes may pass before catastrophe hits. "When there's conditions immediately dangerous to life and health, you don't have hours, you have significantly less time than that to get people out of the way of chlorine gas or a wildfire," Milligan says. Nuclear accidents also tend to affect a much smaller area than, for example, a major hurricane like Katrina that covered a swath of territory 400 miles wide and caused approximately two million people to evacuate Alabama, Louisiana and Mississippi coastal areas. "Evacuations can occur very effectively and very quickly in this country," Milligan adds.

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Evacuations around nuclear power plants in the U.S. are rare but getting people out and away from their homes is relatively commonplace. Evacuations of more than 1,000 people occur all too frequently in the U.S. 230 occurred between 1990 and 2003, a 2005 study from Sandia National Laboratories found. "A significant evacuation occurs on average every three weeks," Milligan notes, for causes ranging from deadly chlorine clouds to wildfires. "Almost all are ad hoc evacuations," meaning no one has practiced or planned for such events, unlike the nuclear industry. For example, a chemical fire and explosions at a hazardous waste facility in Apex, N.C., required the evacuation of approximately 17,000 people in a roughly four-mile radius late on the night of October 5, 2006, although the officials charged with carrying it out could call on the planning for the 10-mile evacuation zone around the Shearon Harris nuclear plant nearby.

Still, radioactive iodine released from a nuclear power plant accident can travel far and fast. To cope with that, the NRC requires that potassium iodide pills that can block the human thyroid from taking up radioactive iodine be available to those living within 10 miles of a plant but no further. "You could get a dose out at 50 miles, especially to children, that significantly increases their likelihood of getting thyroid cancer later in life," notes physicist Frank von Hippel of Princeton University, co-chair of the International Panel on Fissile Materials. "I would have chosen 50 miles or even beyond for potassium iodide availability on an emergency basis."

Local planning authorities either at the state or local level, depending on the place determine what protective action is warranted in the

event of an accident at a nuclear power plant, including an evacuation as in Pennsylvania during the partial meltdown at Three Mile Island. The evacuation begins with whichever way the wind is blowing. "You don't need to evacuate 360 degrees around the plant right away," Milligan says. "At that time, the wind is only going in one direction."

But that wind direction may be a very bad one from an emergency planning perspective. For example, New York City is within 50 miles of the Indian Point nuclear power complex and could be downwind. "There is no way to evacuate New York City on that time scale," von Hippel argues.

The recommendation is not always to leave, of course, as seen in the case of Three Mile Island. "Evacuations are a big deal," Milligan says. "You are taking people out of their homes. It's not something you want to do lightly, for reasons other than definitely needing to avoid a dose" of radiation. In some accidents, it is better to take shelter. "If it's a plume or puff release, people shelter in houses with the windows closed until the puff has passed overhead," Milligan says.

Necessary changes?

In Japan, even in the wake of the deadly earthquake and tsunami that left local infrastructure in ruins, thousands of people were evacuated from the vicinity of the nuclear power plant within 24 hours. As a result, Milligan, at least, does not anticipate any changes to the rules for U.S. nuclear power plants stemming from lessons learned from Fukushima. "The planning zones in place now provide adequate protection for public health and safety," she says. "There is nothing we can see in our look [at Fukushima meltdowns] that would indicate that we would need to expand the plume exposure pathway."

Nevertheless, in the case of Fukushima, the USS Ronald Reagan aircraft carrier sailed into the plume of escaping radioactive noble gases on March 12. More than 100 miles away, sailors on the aircraft carrier found levels high enough to exceed the EPA's guidelines for civilians after roughly 10 hours of exposure. "They went up to 130 miles from the plant, and we were still reading a direct gamma shine of 0.6 millirem per hour," explained the NRC's Stephen Trautman on March 12, according to transcripts. Gamma rays are among the most energetic — and therefore dangerous to health — forms of radiation.

In the end, the question is one of risk. No one has died from radioactive contamination as a result of the Fukushima meltdowns, at least not yet. And it may prove impossible to disentangle any extra cancers due to Fukushima's radiation from those that happen as a result of all the other carcinogenic factors a person is exposed to in the modern world from diet to smoke.

But it remains unclear how far radioactive emissions might reach in the case of a nuclear meltdown like Fukushima. "At that point it's from there, another 50 miles? Another five miles? Another 10 miles? Do you have a sense?" asked NRC chairman Gregory Jaczko on March 12, as he and his staff analyzed computer modeling of a catastrophic meltdown that indicated those guidelines could be exceeded well beyond 50 miles in a worst case scenario. The response from Martin Virgilio, deputy executive director for Reactor and Preparedness Programs: "No sir, I wouldn't...I don't have a value for that."

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