

Background:

January 11, 2019

Commercial nuclear power plants are water-cooled. They are fuelled by ceramic uranium fuel pellets stacked inside long narrow rods made of zirconium metal. A number of these rods are bound together into a fuel assembly — in Canada such an assembly is called a fuel bundle.

Heat is produced by splitting uranium atoms. That heat is transported by the liquid water coolant which flows past the zirconium tubes containing the fuel. The heat is used to produce steam that will turn the blades of a steam turbine to generate electricity.

As the uranium fuel undergoes nuclear fission (splitting uranium atoms), hundreds of varieties of intensely radioactive byproducts build up inside the fuel. These are (1) broken fragments of uranium atoms, called “fission products”; (2) heavier-than-uranium elements, including plutonium, called “transuranic actinides”. These byproducts are millions of times more radioactive than the original fuel.

Loss of Cooling

During a severe nuclear accident, the cooling is lost. Even if the reactor has been safely shut down just beforehand, and the fission process has been totally arrested, the temperature of the fuel will still soar to destructive levels without adequate cooling.

The problem is that radioactivity cannot be shut off. The radioactive byproducts created during nuclear fission remain in the fuel, and they continue to generate heat. In the case of a 1000 megawatt reactor, immediately following shutdown, over 200 megawatts of heat continue to be generated by the ongoing atomic disintegrations of the radioactive waste byproducts. After one hour this drops to about 30 megawatts of heat, which is still a tremendous rate of thermal energy release.

If the coolant is no longer circulating — perhaps because of a station blackout, as at Fukushima, or due to a large pipe break followed by a failure of emergency cooling -- that “residual heat” or “decay heat” will not be removed from the core of the reactor.

Make no mistake, even 30 megawatts is a lot of heat — unless it is rapidly removed, that heat is more than enough to melt the fuel and the

surrounding structural materials of a nuclear reactor at a temperature of 2800 degrees C (5000 degrees F). That's more than twice the melting point of steel. It's the beginning of a partial or total core meltdown.

Hydrogen Gas Buildup

At about 1800 degrees C (3300 degrees F), long before the fuel melts, the solid zirconium "cladding" surrounding the fuel starts to melt. Any failure of the zirconium cladding allows the escape, under high pressure, of dozens of radioactive waste byproducts that were previously trapped inside the fuel. The superheated steam that now fills the reactor vessel is then suddenly infused with a multitude of radioactive gases, vapours, aerosols and ashes, all ready to be expelled into the atmosphere if there is any failure of containment.

At an even lower temperature, 700-800 degrees C, steam reacts chemically with the zirconium metal. Recall that water molecules are combinations of hydrogen and oxygen atoms (H₂O). The blistering hot zirconium metal strips the oxygen out of the steam, forming zirconium oxide, while releasing all the left-over hydrogen. Hydrogen gas mixes with the steam-filled radioactively contaminated air to form an explosive mixture. Any spark will detonate the hydrogen in a devastating blast, more powerful than a natural gas explosion.

Such hydrogen gas explosions almost always accompany a nuclear meltdown. There were several such explosions during the partial meltdown of the NRX reactor at Chalk River, Ontario, in 1952; during the Three Mile Island partial meltdown in Pennsylvania in 1979; and during the triple meltdown at Fukushima Dai-ichi in Japan in 2011. Such explosions will often damage the containment envelope of the nuclear reactor, spewing highly radioactive materials into the outer atmosphere.

Radioactive Exposures

People, animals and plants are irradiated from above by "skyshine" from gamma-radiation-emitting gases passing overhead. Metallic radioactive vapours such as cesium-137, iodine-131 and strontium-90 will condense on vegetation, soil, buildings, skin, clothing, and surfaces of all kinds, leaving a lasting legacy of radioactive contamination, irradiating living things by "groundshine". And these radioactive materials gradually work their way

into the food chain, sometimes re-concentrating along the way, yielding contaminated crops, meat, fish, water, milk, mushrooms, berries, and much else besides. Ingesting or inhaling such materials will lead to the internal irradiation of people and animals by radioactive materials that lodge in the lungs, the bones, the blood, or the soft organs of the body.

For example, radioactive iodine condenses on pastureland, and the concentration of radioactive iodine in the grass becomes about 100 times greater than in the air above the pasture. The concentration of radioactive iodine in cow's milk is about 100-1000 times greater than it is in the grass they eat. Then, when a young child drinks the cow's milk, the concentration of radioactive iodine in the child's thyroid gland is about 7-10 times greater than it is in the contaminated milk. So, a child's thyroid can be exposed to radioactive iodine levels that are several orders of magnitude greater than that found in the contaminated air that they might breathe.

Radioactive cesium accumulates in meat and fish, often making them unsuitable for human consumption. Even today, hunters in Germany and the Czech Republic are compensated by their respective governments if they kill a wild boar, because they cannot eat the meat due to radioactive cesium contamination from the Chernobyl accident 33 years ago. In Japan, wild boars in the Fukushima forested areas have levels of radioactive cesium in their bodies that are 10 to 150 times greater than the maximum permissible levels for human consumption. Boars love mushrooms, and fungi are especially adept at concentrating radioactivity.

Nuclear Regulatory Commission ex-Chairman

Gregory Jaczko is adamantly opposed to the idea of keeping existing nuclear reactors running as a way to offset climate change, because each reactor is like a time bomb ready to explode if the cooling is cut off by a total station blackout, by equipment failure, by major pipe breaks, or by acts of warfare, sabotage, or terrorism. The societal dislocation caused by the spread of radioactive material over wide areas, affecting drinking water, food and habitation for decades or centuries, is as bad as the ravages of climate change for the communities so affected.

As Chairman of the US Nuclear Regulatory Commission at the time of the Fukushima disaster, Jaczko has a unique insight into the factors that make nuclear power plants dangerous even after so-called "safe" shutdown. He

knows, too, that the arguments levied against renewables are ultimately incorrect, as technology to store energy and to rechannel it is growing by leaps and bounds. Investing tens or hundreds of billions of dollars into maintaining old nuclear reactors, which are becoming increasingly dangerous as they age, is simply stealing money away from investments in the renewable revolution that is our best hope for a sustainable energy future.

Gordon Edwards.

LAS VEGAS SUN EDITORIAL

Former NRC chairman remains clearly opposed to nuclear energy

Las Vegas Sun, Wednesday, Jan. 9, 2019

<https://lasvegassun.com/news/2019/jan/09/former-nrc-chairman-remains-clearly-opposed-to-nuc/>

In a perfect world, nuclear energy would be a perfect tool for combating climate change. Nuclear power plants don't burn fossil fuels, don't emit greenhouse gases into the environment and don't speed global warming.

But with the Union of Concerned Scientists and other groups reversing their former opposition to nuclear energy, former Nuclear Regulatory Commission Chairman Gregory Jaczko is going on the offensive to explain why nuclear energy is nowhere near a perfect solution to the climate crisis.

In a new book, Jaczko reiterates his longstanding criticism of the nuclear industry and his opposition to development of traditional nuclear power plants, which he says are unsafe despite technological improvements designed to make them safer.

Exhibit No. 1 in Jaczko's argument is the Fukushima disaster. While Japan and other countries used nuclear power to limit their carbon emissions, he contends that the catastrophe at Fukushima wiped out environmental gains that Japan made by burning less fossil fuels,

"What happens after Fukushima is they shut down all of their nuclear plants over time," Jaczko said during a phone interview with the Sun. "So

then what did they do? They had to turn to polluting fossil fuels. So you wind up with this solution where it's kind of boom or bust: You've got nuclear power, but once you turn it off then what do we do? Well, we have to turn to dirty fossil fuels."

Jaczko said the fundamental problems with development of nuclear energy included that the basic design of plants hadn't changed and that the industry wouldn't pay for technological improvements that would reduce the damage from accidents.

A case in point involves eliminating the kind of hydrogen gas blasts that many people likely remember seeing in footage from the Fukushima disaster.

The gas builds up when steam inside the reactor interacts with one of the metals used to contain nuclear fuel. Jaczko said new container materials have been developed that would limit the gas buildup, but the industry hasn't adopted them because they're prohibitively expensive.

Meanwhile, he says, the cost of generating electricity through natural gas and renewables is lower in most parts of the country than nuclear generation. Although nuclear proponents point out that renewables can't provide continual power — turbines don't generate when the wind doesn't blow and solar panels don't generate when the sun isn't shining — Jaczko calls that argument a red herring. He points to innovations that are making power storage more affordable — not just advancements in battery design but such methods as pumped-storage hydroelectricity, in which water is pumped to a higher elevation during overnight hours when electricity demand is low and then is released to operate turbines during peak hours.

"So to me, the idea that somehow we're going to preserve these reactors and that's a climate solution is just wrong," he said.

Then, of course, there's the issue with nuclear waste — a hazard we're familiar with in Southern Nevada. Jaczko, whose concerns about the proposed Yucca Mountain nuclear waste repository were a leading reason he was hand-picked for the commission by former Sen. Harry Reid, hasn't grown any fonder of the waste facility since he left the commission. He continues to be alarmed about the long-term safety of the site and the prospect of transporting high-level waste from across the country to Nevada.

Jaczko's bottom-line assessment is that despite decades of development, nuclear energy remains too hazardous and costly to be a viable source of power.

"There's going to be an accident," he said. "The only question is when and where."

It's a compelling argument, and anyone who may be warming to nuclear energy in the fight to reverse climate change should examine it.

The book, "Confessions of a Rogue Nuclear Regulator," is available now at Amazon, Barnes & Noble, and other outlets.