**The former Chairman of the US Nuclear Regulatory Commission is opposed to continuing nuclear power**

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| **By Gordon Edwards**  |

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| **Background:**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 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 containmentAt 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 in1979; 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 contaminates 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 of 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.  |