# Fukushima
## The improbable can happen

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*Dr Medvedev revealed to an unbelieving world the nuclear disaster which took place at Kyshtym in the Urals during the 1950s, confounding nuclear 'experts' who denied his case. He tells this story in a preface to the new edition of his classic study,* The Legacy of Chernobyl*, which Spokesman are publishing on 6 August to mark Hiroshima Day. This excerpt is taken from the new preface.*

The first nuclear reactor for the Fukushima I plant was designed in the early 1960s, ordered in 1966, and put into operation in 1971 for the Tokyo Electric Power Company (TEPCO) by General Electric. It was modest in terms of power; a 460 MW boiling water reactor (BWR). The second reactor of the same type was more powerful (784 MW), and the last (the sixth reactor), which came into operation in 1979, was 1100 MW. The design was expected to withstand seismic events of magnitude 7,5. This was the force of the California earthquake of 1952. The San Francisco earthquake of 1906 was 7,8. The Great Tokyo Earthquake of 1923 was magnitude 8,3. The earthquake on 11 March 2011 was magnitude 9.

The Fukushima I nuclear accident is now considered the second largest after Chernobyl. But it is still developing, and might yet take the lead in the IAEA list of nuclear accidents. It is much more complex because it involves several reactors and the spent fuel storage tanks, with about 25 times more radioactivity than there was in the Chernobyl reactor. The picture of the accident grows darker and darker almost daily: partial meltdowns in reactors 1, 2 and 3; hydrogen explosions which destroyed the upper parts of buildings housing the reactors; damage to the containment inside reactor 2; fires and leaks. The amount of radioactivity released into the environment has already reached the Chernobyl level. However, in Chernobyl the release was gases and aerosol into the air. In Japan, there are mostly radioactive solutions which contaminate soil and sea. (In Japan, there is also much more plutonium.)

Igor Ostretsov, a nuclear engineer of Soviet pressurised water reactors, whom I consulted, wrote that the location of the emergency power generators so close to the sea and at sea level, just facing the great tectonic fracture, was a serious mistake. He also considers unfortunate and unsafe the location of very heavy spent fuel storage tanks filled with water in the same building above the reactor. Such a location made it easier to load the fuel rods from the reactor into the storage pool, but it also made 'suspended' storage tanks very vulnerable to any earthquake.

The earthquake damaged these tanks, causing them to leak. Their location made it difficult to refill them with cooling water. Helicopters and fire engines were used out of desperation.

Another design fault identified by Ostretsov was the absence of a ventilation system for radiolytic and zirconium-steam-reaction-produced hydrogen gas. This resulted in an accumulation of the gas in the reactor building, and caused explosions which destroyed the building and many critical systems, particularly the cooling loops. The use of seawater was another desperate measure, as the water evaporates, leaving salt, which further damages the fuel rods in the core and in storage pools.

The boiling water reactor (BWR) system has one more problem. The same water, which functions as a neutron moderator and is part of the fission control, is also feeding steam directly to the turbines without an intervening heat exchanger. This purified and deionised water is pumped to the bottom of the fuel channels and boils, producing steam used to drive the turbines. This water accumulates fission radionuclides.

Heavily contaminated water, particularly with iodine-131 and caesium-137, is the main problem. Reactors do not produce carbon dioxide, which is an advantage. But they produce an enormous amount of heat. Working reactors therefore consume a huge amount of cooling water; 21,000 tons per hour in Fukushima I-1 , 33,300 tons per hour in Fukushima I-3, and 48,300 tons per hour in Fukushima I-6. Even after shutdown, residual heat from accumulated radionuclides constitutes up to five per cent of project power (depending on the fuel cycle), enough to cause meltdown. Partial meltdowns were reported at Fukushima after the emergency shutdown. Thus, several thousand tons of water per hour are still needed to cool the residual heat of the cores and the spent fuel in storage. With the circulating systems damaged, this water has to be dumped in the sea. There is no project provision to store this amount of radioactive water. Temporary storage was possible only for the reduction of iodine-135 (half-life 6,7 hours) and iodine-131 (half-life 8 days). The iodine isotopes were produced in working reactors. (Nearly 80 million curies of radioactive iodine were released into the air in Chernobyl).

Now, three months after the Japan earthquake, the danger from iodine has diminished. The main problems are strontium-90, caesium-137, plutonium and a few more long-lived radionuclides. The danger of new meltdowns is not yet over. The main problem for years to come will be managing more than 500 tons of spent fuel in the reactors and in storage pools, more than 4 tons of which is plutonium. The cooling systems of the reactors and spent fuel tanks were found beyond repair and the current methods of cooling continue to wash out the radioactivity into the environment. The project to dismantle the whole nuclear plant with its six reactors might take many years.