COMMENT

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Exactly how much damage the Fukushima Daiichi nuclear plant sustained as a result of the 11 March earthquake and tsunami remains to be determined.

Nationalize the Fukushima Daiichi atomic plant

Only by bringing the nuclear power station into government hands can scientists find out what really happened, say **Tomoyuki Taira** and **Yukio Hatoyama**.

Events at the Fukushima Daiichi nuclear plant following the 11 March 2011 earthquake and tsunami are of crucial importance for the future of atomic energy — in Japan and globally. To respond adequately to the accident, we have to know precisely what happened then and what is continuing to happen now.

To establish the facts, all the evidence and counter-evidence for what might have taken place must be gathered and made public. Only then will the world be able to have faith in the containment plan developed by the Tokyo Electric Power Company (TEPCO), or be able to judge how it should be modified.

Particularly important is finding out whether the 'worst-case' scenario occurred: that is, whether self-sustaining nuclear reactions were re-ignited in the core ('re-criticality'), creating more fission products and heat damage; whether the explosions that rocked the plant days after the earthquake were nuclear in origin, releasing radioactive metals from damaged fuel rods; and whether molten fuel has broken through the reactor's base, threatening environmental contamination.

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A group of representatives from the Japanese Diet (called the 'B-team'; in relation to the government's 'A-team') was formed on 24 March to develop a response plan for the worst-case scenario. Set up by one of us (Y.H., former prime minister) and including us both, the B-team's other members are Yukihisa Fujita (now a senior vice-minister of finance) and Hiroshi Kawauchi (now chairman of the Deliberative Council on ▶

Political Ethics). The team's recommendations — to be released in a future report — will be independent from those of Japan's government, the Nuclear and Industrial Safety Agency (NISA) and TEPCO.

Our investigation has already shown that key pieces of evidence remain incomplete. We do not yet know whether the worst-case scenario happened. To find out, we believe that independent scientists must be given access to the nuclear plant, and that the plant should be brought into national ownership.

RE-CRITICALITY

If nuclear reactions are ongoing within the core, they will continue to create fission products, and the heat generated is likely to damage the cooling and decontamination systems. Proof that re-criticality has occurred hinges on the detection of certain isotopes. The radionuclide chlorine-38, for example, has a short half-life of about 37 minutes and can be generated only if neutrons are available. Its presence would therefore indicate current nuclear activity.

Reports of such a detection have been mixed. On 26 March, NISA reported that TEPCO had found ^{38}Cl in a water sample drawn two days earlier, after sea water (which includes sodium chloride) had been injected into the basement of unit 1. On 1 April, NISA questioned TEPCO's analysis, and said that radioactive sodium-24 should also have been present in the sample. However, some scientists claim that ^{38}Cl can be detected even if ^{24}Na is not. On 20 April, TEPCO negated its earlier report, asserting that ^{38}Cl was not seen in the sea water, and neither was ^{24}Na. It did not, however, publish the data from its analysis. Through NISA, we obtained and reanalysed TEPCO's data, which were measured with a germanium semiconductor detector. We concluded that ^{38}Cl was indeed present, and at a level close to that initially reported (1.6 million becquerels per millilitre). In our view, NISA's and TEPCO's questioning of this detection were therefore unfounded.

Another indicator is xenon-135, which is made when uranium or plutonium undergoes fission; it has a half-life of 9 hours. On 1 November, TEPCO detected ^{135}Xe in unit 2. But, because the concentration was low, NISA concluded that the nuclide could have been produced by spontaneous fission of the dormant fuel, so was not necessarily caused by continuing nuclear reactions. The evidence for re-criticality is therefore still inconclusive.

NUCLEAR EXPLOSIONS

Another question that must be answered is what caused the explosions at the site. They were initially reported as being caused by the ignition of hydrogen generated by a high-temperature chemical reaction between the alloy covering the fuel rods and the vapour in the core. But, again, this has not been settled. Other possibilities include a nuclear explosion, or the ignition of other gases.

Knowing whether a nuclear explosion took place is essential for predicting how much radioactivity might have been released, what it would have consisted of and how far it would have spread, as well as the state of the spent-fuel rods stored in a pool in unit 3. Two observations suggest that this is plausible. First, some metals heavier than uranium have been detected tens of kilometres from the plant. Second, the steel frame on top of the unit-3 reactor building is twisted, apparently as a result of melting.

Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) reported finding heavy metals such as curium-242 up to 3 kilometres from the reactor site and plutonium-238 up to 45 kilometres away. These isotopes are deadly poisons if ingested, causing internal exposure to radiation. Because ^{242}Cm has a short half-life (about 163 days), and because the concentrations of ^{238}Pu around the plant were much higher than usual, MEXT concluded that these radionuclides were not fallout from past nuclear tests in the atmosphere, so must have come from the Fukushima reactor. If so, they suggest that broken spent-fuel rods might be scattered around the site — a considerable hazard.

Such elements are too heavy to have been borne in a plume, like the lighter caesium and iodine, so they must have been blown out with great force. Whether a hydrogen explosion would have been powerful enough to scatter heavy metals that far remains unclear. And a hydrogen explosion should not have generated enough heat to melt steel. Initially, TEPCO claimed that the explosion in unit 3 generated white smoke; on re-examination, the smoke was black, and therefore unlikely to have been caused by a pure hydrogen explosion. So a nuclear explosion is a possibility. Whether other explosive gases were present on the site would be equally important to establish.

"Solutions for the Fukushima nuclear disaster must be based on the worst-case scenario."

MELT DOWN

Similarly unconfirmed is how much of the concrete base of the reactor has been breached by molten fuel. This is important because TEPCO plans to fill in the core with water to absorb the radioactivity while it extracts the fuel. If the concrete below the reactor is cracked, then radioactive materials could leak into the groundwater.

Until recently, the government did not believe that this was the case. In a 7 June report to the International Atomic Energy Agency, it reported that most of the melted fuels are being cooled in the lower portion of the reactor pressure vessel and that little fuel is thought to have leaked out into the preliminary containment vessel.

However, two weeks ago, TEPCO admitted that molten fuel may have eaten through three-quarters of the concrete under unit 1, and damaged the bases of two of the other reactors. But again, caution is required. No one has actually looked at the fuel inside the reactor core. So the extent of the leakage is yet to be established.

NATIONALIZE AND INTERVENE

Solutions for the Fukushima nuclear disaster — from how to lock up radioactive contamination for half a century to how to discard the reactor core and the molten fuel — must be based on the worst-case scenario, even if the people most involved remain optimistic that this wasn't the case. Although many facts remain to be established, in our view, two things must be done.

First, the Fukushima Daiichi nuclear power plant must be nationalized so that information can be gathered openly. Even the most troubling facts should be released to the public. Nationalization is inevitable, moreover, because the government is obliged to investigate and provide compensation for the disaster.

As an illustration of how information about the accident is being restricted, our committee struggled to obtain even a manual for the plant when we requested it in August. Initially, TEPCO refused to supply it. When a copy was eventually sent to us, a month later, many passages (including key temperatures and emergency procedures) had been blacked out. TEPCO said that it considered those parts to be its intellectual property and of possible security concern. Only after six months did TEPCO release the full manual to us. It was important that we saw the manual to learn why the company had switched part of the emergency core-cooling system off and on again after the earthquake (and before the tsunami) — to find out when the emergency systems were destroyed.

Second, a special science council should be created to help scientists from various disciplines to work together on the analyses. That should help to overcome the dangerous optimism of some of the engineers who work within the nuclear industry. Through such a council, the technologies needed for decommissioning and decontamination and for construction of a deep geological repository for radioactive waste can be developed, even for a worst-case scenario. ■ SEE EDITORIAL P. 291

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