Fukushima-daiichi nuclear accident: Current status and lessons

"People must not be informed but made dependent upon the authority of the government." [1]

The Fukushima-daiichi nuclear power plant is located 155 miles north east of Tokyo, on the eastern Pacific coast of Japan in Fukushima Prefecture. At the site, Tokyo Electric Power Company operated six General Electric designed boiling water reactors, which commenced operation between 1971 and 1979. The earthquake and tsunami that struck the nuclear plant on March 11, 2011 led to the meltdown of three reactor cores, the destruction of four of the six reactors and widespread contamination of Japan and the Pacific Ocean.

Today, one year after the start of the accident, thousands of workers are still battling to maintain a fragile and highly dangerous site.[2] They are confronted with intensely radioactive molten fuel, tens of thousands of gallons of highly contaminated water, and radiation levels so high that access to key areas is prevented. Since March 2011, has been written about what is probably the world's greatest technological failure and challenge. Twelve months on, this short briefing attempts to summarize the present situation at the site and some of the key lessons that have emerged from the accident.

Current status

Twelve months after the earthquake and tsunami hit Fukushima, the nuclear and radiological situation at the plant continues to be severe. Reactors 1, 2 and 3 contain 259 tons of intensely radioactive reactor fuel. Much of this has melted and lies both at the bottom of the steel reactor vessel and on the concrete base of the containment building. An additional 496 tons of highly radioactive spent fuel remains in the cooling pools inside the four destroyed reactors. Tokyo Electric has to maintain cooling of all of this fuel due to the heat generation that will persist for years.[3] The condition of each reactor varies, with some of the fuel having melted through the steel containment of the reactors into the concrete bases below.[4] Cracks in the containment provide a direct pathway for contamination to escape into the environment. At times, as much 500 tons a day of groundwater enters the plant.[5] The tens of thousands of tons of water pumped onto the site since March 2011, has created one of the greatest threats in terms of ongoing and future radiation risks. Tokyo Electric is trapped — it must continue cooling the molten fuel by pumping in around 6,000 tons of water each week, but it needs to keep the water level below a certain height or it overflows into the Pacific Ocean.[6] Any breakdown in cooling, such as further earthquake damage and loss of electricity, could lead to the collapse of structures, further fuel meltdown and large radiation releases.[7] Tokyo Electric has struggled to install sufficient tank storage capacity for the 175,000 tons of water it has processed at the site. An underground steel barrier hundreds of meters long is to be installed between the reactors and the ocean in an attempt to prevent further underground water contamination.[8] Reports have even suggested that a concrete barrier will be built under the entire site.[9] This is not only a massive and expensive engineering challenge it is likely to be ineffective.

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1 The position of the rulers during the Tokogawa period in Japan from 1600, see Studies in the Intellectual History of Tokugawa Japan, Maruyama Masao, 1974, as cited in The Enigma of Japanese Power, Karel van Wolferen, 1989.
2 See, statement of plant chief, http://www.seattlepi.com/news/article/Plant-chief-Fukushima-Dai-ichi-still-vulnerable-3366418.php
3 See, http://www.nisa.meti.go.jp/english/press/2012/02/en20120220-4.pdf
4 See, http://www.theaustralian.com.au/news/world/fukushima-nuclear-catastrophe-closer-than-thought/story-e6frg6so-1226211693322
5 See, http://www.japantoday.com/category/national/view/tepco-says-up-to-500-tons-of-groundwater-flowing-into-fukushima-nuclear-plant
6 See, http://www.nisa.meti.go.jp/english/press/2012/02/en20120220-4.pdf
7 See, Agence France-Presse, 14th February, http://news.nationalpost.com/2012/02/14/crippled-fukushima-plant-at-high-risk-from-further-quakes-seismologist-computer-model/
8 See, http://mainichi.jp/select/weathernews/20110311/archive/news/2011/08/31/20110901k0000m040122000c.html
9 See, http://www.independent.co.uk/news/world/asia/pm-vows-to-lsquorebuild-the-nation-from-scratchrsquo-2246329.html

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Tokyo Electric has agreed with government agencies that removal of the used or "spent" nuclear fuel from the reactors should begin within a few years, with the molten fuel to be removed from around 2021. Tokyo Electric has stated that decommissioning of the site will take place over 40 years, but it is likely to be a much longer period.[10]

Given the extent of the damage, and the risks and challenges of dealing with the damaged reactor and nuclear waste, all these projections seem wildly optimistic with true stability, let alone clean up, not being achieved for many decades. The fuel is unlikely to be removed.

Key lessons for reactor safety

Nuclear reactors cannot cope with station blackout: The Fukushima-daiichi accident has dramatically revealed that nuclear power plants are unable to manage safe shutdown when confronted with a complete loss of electrical power or so-called "station blackout." The implications for reactors operating in Japan, in the United States and around the world are severe. Three hours after loss of all power on March 11, the fuel in Fukushima-daiichi reactor 1 was fully exposed after the water boiled dry. Twelve hours later the entire reactor core of 50 tons had melted. Twenty four hours later the reactor suffered a catastrophic hydrogen explosion. Reactors 2 and 3 suffered the same fate in the following days.[11] The backup systems of diesel generators and batteries available at reactors in Japan and around the world are clearly unable to maintain sufficient cooling functions to prevent fuel meltdown. The rapid generation of hydrogen gas produced from the reaction between molten fuel and the steel cladding demonstrates that: 1) the type of cladding material used in tens of thousands of tons of reactor fuel worldwide is highly vulnerable;[12] 2) that vents are unable to maintain gas pressure below containment failure;[13] and 3) containments are not able to withstand highly energetic hydrogen explosions.[14]

Nuclear power plants cannot withstand major seismic events: Although not yet fully disclosed, there are sufficient grounds to believe that at least one of the reactors at Fukushima-daiichi was so severely damaged by the earthquake on March 11 that its cooling capacity was unable to prevent damage to the fuel and release of radioactivity.[15] This has major implications for all reactors operating in high seismic risk regions in the first instance in Japan, but also worldwide including reactors such as San Onofre and Diablo Canyon in California and Indian Point near New York City.[16]

Spent fuel pools can be a threat: The loss of cooling function at the Fukushima-daiichi site exposed once again the risks of catastrophic release of radioactivity from the many tons of spent fuel stored in pools at the reactors. The risks from the Fukushima pools were estimated by the U.S. Nuclear Regulatory Commission to be so high that they warned all U.S. citizens to avoid entering within 50 miles of the reactor site. It is a worldwide problem and has been known for decades.[17] While the spent fuel stored at Fukushima-daiichi amounted to around 2000 tons, reactors in the United State hold a combined total of 65,000 tons.[18] Despite recommendations to remove spent fuel from water filled pools, U.S. reactor operators are not required to store the fuel in dry, hardened containers. Seventy five percent of U.S. spent fuel is still stored in pools.

Nuclear safety complacency and regulatory failure can lead to disaster: In February 2011 the nuclear regulator in Japan granted Fukushima-daiichi unit 1 a ten year extension to its operating license.[19] One month later it suffered a complete fuel meltdown. This approval came despite the government being warned over the years of clear evidence of major safety problems, and that Tokyo Electric had falsified inspection records and tried to hide cracks in the steel reactor pressure vessels at the site.[20] The Fukushima accident was in part caused by complete regulatory failure.[21] This is the general approach to nuclear safety adopted by regulators worldwide, including the NRC in the United States.

10 See, http://www.tepco.co.jp/en/press/corp-com/release/betu11_e/images/111221e10.pdf
11 See, http://www.largeassociates.com/3196%20Fukushima%20GP%20de/TEPCO%20history%20of%20melt%20may%2015th.pdf in reported commissioned by Greenpeace Germany.
12 See, http://www.iaea.org/newscenter/focus/fukushima/missionsummary010611.pdf and http://www.largeassociates.com/3201%20IAEA%20Mission%20Statement/R3201-A1%20Final.pdf
13 See, http://www.nytimes.com/2011/05/19/science/earth/19nuke.html
14 See, http://fairewinds.com/
15 See, http://www.largeassociates.com/3196%20Fukushima%20GP%20de/R3202-A1.pdf and http://ajw.asahi.com/article/0311disaster/fukushima/AJ201112060052
16 See for example, http://sanonofresafety.org/earthquake-and-tsunami-risks/, http://www.msnbc.msn.com/id/42103936/ns/world_news-asia_pacific/t/what-are-odds-us-nuke-plants-ranked-quake-risk/
17 See, http://www.nirs.org/press/09-07-2006/1
18 See, http://www.huffingtonpost.com/robert-alvarez/americas-nuclear-spentfue_b_871718.html
19 See, http://www.world-nuclear.org/info/inf79.html
20 See, http://cnic.jp/english/newsletter/nit92/nit92articles/nit92coverup.html
21 See, http://www.japantimes.co.jp/text/nn20120219a2.html

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As of today, in the U.S. 71 reactors out of 104 have been granted decades long extensions to their original 40 year licenses.[22] None have ever been refused.

Transparency and public disclosure are necessary: It took Tokyo Electric and the government two months to admit that three reactors at the Fukushima-daiichi site had suffered near complete nuclear fuel meltdown. This contrasts with independent analysts who reached that conclusion within days of the accident beginning on March 11.[23] The risk of rapid fuel meltdown and the time frame in which it occurs has been known for decades within the nuclear industry and by regulators (as well as their critics), such as the Nuclear and Industrial Safety Agency in Japan and the NRC in the United States.[24] But the approach of both industry and regulators has been to dismiss the possibility of such an event as too remote to consider, let alone to plan for.[25] It happened at Fukushima and it will happen again.

Emergency response and evacuation plans were inadequate: Vital data showing the dispersal of radioactivity and the areas contaminated by fallout were not used correctly by government, nor given to the public.[26] The failure to promptly communicate the scale of the accident and the spread of radioactivity has had a number of serious consequences. Emergency response measures designed to protect public health from the large-scale radioactive releases proved inadequate. Thousands of people were evacuated to areas that were even more contaminated.[27]

Nuclear safety stress tests are flawed: In the months since March 2011, Japan, and nations around the world including the United States and the European Union have embarked on so-called safety "stress-tests" for operating nuclear reactors. Outside Japan, reactors of the same design that were destroyed at Fukushima, have continued to operate. In particular, in the United States, the NRC has failed to demand closure of the 23 boiling water reactors of similar design to Fukushima-daiichi, despite knowing for 40 years that they were unsafe.[28] In contrast, the German government announced the immediate closure of its seven oldest reactors and one other.[29] The stress tests consider some of the implications of Fukushima, but fail to address others.[30] In addition, the investigations into the Fukushima accident are still underway, without full information on the accident event. In Japan, after the shutdown of all but two of their 54 reactors, the pressure from the nuclear industry, backed by government, is to restart them as soon as possible — but the safety standards in Japan are in effect no different from those before March 11, 2011, including seismic risk compliance.[31] This is one of the principal reasons why communities across Japan are determined to stop the start up of Japan's nuclear power plants.

Updated March 1, 2012

22 http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/license-renewal-bg.html
23 See, report drafted ten days after the accident for Greenpeace Germany, http://www.largeassociates.com/3196%20Fukushima%20GP%20de/R3196-A1%2010%20April%202011.pdf
24 See for example, http://www.ornl.gov/info/reports/1981/3445600211884.pdf
25 See, http://docs.nrdc.org/nuclear/files/nuc_11102801a.pdf for flaws in current probabilistic risk assessments.
26 See, http://mdn.mainichi.jp/features/archive/news/2011/04/20110429p2g00m0fe016000c.html
27 See, http://online.wsj.com/article/SB10001424052702304567604576453342206030686.html
28 See, http://www.nirs.org/reactorwatch/accidents/mkistatement10711.htm and http://www.fairewinds.com/content/new-containment-flaw-identified-bwr-mark-1, and http://www.ucsusa.org/assets/documents/nuclear_power/UCS-Response-to-NRC-90-day-recs-8-1-11.pdf and http://www.nytimes.com/2011/03/16/world/asia/16contain.html
29 See, http://www.bbc.co.uk/news/world-europe-13592208
30 See, http://www.largeassociates.com/3211%20EESC/R3211-Presentation.pdf
31 See, http://www.yomiuri.co.jp/dy/editorial/T120222005167.htm

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