Japan's Evolving Nuclear Disaster And Its Impacts On Nuclear Aspirations In Asia

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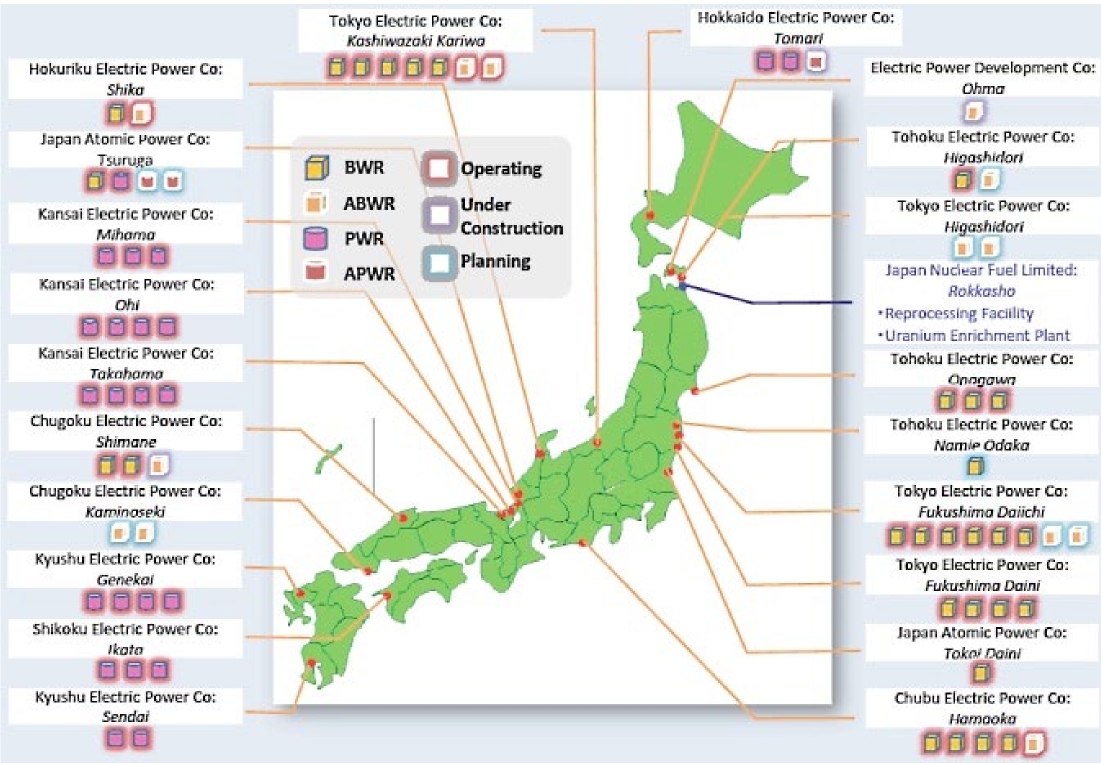
Japan, the most disaster-ready nation in the world, is struggling to cope from the massive 9.0-magnitude earthquake and the resulting tsunami that struck on Friday. The extent of the disaster is now unfolding, but it is clear that this is a tragedy of immense proportion, tempered only by Japan's effective building standards and the culture of safety that permeates throughout its industry. One of the major outcomes of the quake is the emerging radiation threat from Japan's nuclear power plants that provide nearly a third of the country's power output.

In the coming weeks Responsible Research will release its upcoming sector report, 'A Nuclear Asia', in which we examine the drivers and implications of Asia's rush to build nuclear capacity. The events taking place in Japan will leave a lasting impact on global nuclear energy programmes. They will likely add to already significant fears of nuclear energy in the West and they may delay some programmes in Asia. While these events highlight the frailty of technology in the face of unforeseen events, nuclear power plants today are designed to withstand earthquakes of far greater magnitude than the one that hit Japan – the largest that has hit that country in its modern history and among the top five worldwide in the past century. The following note provides an update on recent events at Japan's damaged nuclear reactors and an assessment of the likely impacts to Japan's nuclear energy programme and to nuclear incumbents across Asia.

The events. Immediately after the earthquake, four of Japan's 17 nuclear power stations – Onagawa, Fukushima Daiichi, Fukushima Daini and Tokai – automatically shut down as was intended. Minor damage was incurred at Onagawa and Kukushima Daini. The most significant damage, and the centre of global attention, occurred at units 1,2, and 3 at Fukushima Daiichi nuclear power plant. Daiichi 1 is a 439 MWe boiling water reactor (BWR) constructed in July 1967 and brought online in March 1971. It was scheduled for shutdown in early 2011, but in February 2011, Japanese regulators granted an extension of ten years for continued operation of the reactor. It is Japan's oldest nuclear reactor in operation. Daiichi 2 and 3 were brought online in 1974 and 1976, respectively, and are the second and third oldest among Japan's 55 operating reactors.

Figure: Nuclear power plants in Japan



Source: TEPCO

The sequence of events at Daiichi is opaque, however it appears that the problems have been exacerbated by the tsunami that struck within hours of the earthquake. Control rods have been successfully inserted at all of the reactors at Daiichi, thereby killing the chain reaction. However, even after nuclear power plants are shutdown, nuclear fuel within the reactor core requires cooling to prevent meltdown and the release of radiation. Immediately after the earthquake, the six-unit Daiichi station lost power, crippling the reactor's cooling system.

- Emergency diesel generators were set up to provide backup power for the cooling system, but they apparently ran for a few hours before being damaged by the ensuing tsunami.
- Officials decided to reduce rising pressure inside Daiichi 1 and 3, so they vented some of the steam build-up to prevent the reactor core from exploding, and thus starting down the road to a meltdown.
- Temperature in the reactor vessel apparently kept rising, heating the zirconium cladding that makes up the fuel rod casings. Once the zirconium reached 1,200 Celsius, it reacted with the water, becoming zirconium oxide and hydrogen.
- When the hydrogen-filled steam was vented from the reactor vessel, the hydrogen reacted with oxygen, either in the air or water outside the vessel, and exploded. According to reports, the reactor vessel was not damaged, but the secondary containment building partially collapsed, as it was designed to do in order to release pressure.
- Without power, and without plant pipes and pumps that were destroyed in the explosion of the reactor's containment building, authorities have now resorted to drawing seawater to Daiichi 1 and 3 in an attempt to cool off the overheated uranium fuel rods.

The use of seawater to cool the reactor represents a final effort to contain a possible complete meltdown. At this point, it appears that Daiichi 1 and 3 have both suffered damage to their nuclear fuel – partial meltdown – and steam now being continuously vented from the reactors apparently contains radioactive cesium-137 and iodine-131 which have a half life of 30 years and eight days, respectively, and are thus very dangerous. According to reports, electric switching equipment designed to reactivate the cooling equipment is in a basement room that has been flooded by the tsunami.

As of Sunday, 170,000–200,000 people were evacuated from the 20km radius around Fukushima Daiichi. Twenty-two residents near the plant have reportedly shown signs of significant radiation exposure, and three workers from the plant are experiencing symptoms of radiation sickness.

The death of one worker at Daiichi has been reported as a result of a crane accident. By all accounts, emergency workers at Daiichi and at the other damaged nuclear power plants have acted heroically in recent days. These events are rapidly unfolding and our hopes and prayers are with them as they work to prevent further releases of radiation.

Implications for Japan. Prior to the Sendai earthquake it appeared that Japan's nuclear energy programme was on the rebound. Despite the strong reputation of Japanese nuclear technology with the third largest nuclear industry behind the United States and France, the industry has recently faced major challenges at home, which has stalled the development of new projects. In 1991 there was a radioactive leak at Mihama NPP; in 1995 the country's experimental liquid metal fast breeder reactor (FBR) had to be closed after 640 kg of liquid sodium leaked from its secondary coolant loop; in 1997 fire and explosion released radioactivity into the atmosphere at Tokaimura NPP; and on 9 August 2004 four workers were killed and seven were injured by super-heated steam from a burst pipe at Mihama NPP. And in 2002 Japan's largest utility and largest operator of reactors, Tepco, had to temporarily shut down all of its 17 reactors after it was discovered that it had falsified its safety inspection records. In July 2007, the 6.6-magnitude Chuetsu earthquake damaged Tepco's Kashiwazaki-Kariwa nuclear power plant, causing some minor radioactive leaks that were initially reported to be much greater, causing Tepco's stock to plummet 7.5 per cent.

Despite these events, in late 2010, Tepco appeared newly re-committed to nuclear energy. In September 2010 the company said it planned to invest ¥2.5 trillion (US$30.5 billion) on low-carbon projects domestically by 2020 to generate more than half of its power free of carbon. Most of this capacity will be nuclear. Four ABWR plants for Tepco are listed as planned. Tepco's shares dropped to an eight-year low after the company announced plans to raise ¥540 billion (US$6.6 billion) via a share sale to fund this planned expansion. The following month, in October 2010, Tepco assumed the lead of the newly formed International Nuclear Energy Development of Japan Co (JINED), a public-private partnership consisting of nine utilities, and Japan's leading nuclear equipment suppliers: Toshiba, Hitachi, and MHI. JINED was established to sell nuclear reactor contracts to developing nations and has already signed contracts to supply reactors to Vietnam and Turkey – these would be Japan's first foreign reactor sales.

These events will certainly cast doubts over Tepco's ability to safely operate nuclear power stations in Japan and about the nuclear energy industry in general among the population. It seems certain that Daiichi has been destroyed. Japan has an aging fleet of nuclear reactors. As the country recovers, lifecycle extensions will become a major issue.

Implications beyond Japan. The fallout from Japan's unfolding nuclear disaster will likely be felt most deeply beyond its borders, and especially in the West. According to a count from the World Nuclear Associate (WNA), an industry sponsored lobby group, as of the start of January 2011, there were 442 operable nuclear reactors in 30 counties with a total net capacity of 377GWe, generating just over 13 per cent of global power output – a 30-year low. Of the current global fleet of nuclear reactors, according to the International Atomic Energy Agency (IAEA), the international nuclear regulatory body, 75 per cent of all operable nuclear reactors are 20 years or older and 25 per cent are over 30 years old. This is particularly the case in the United States where more than 80 per cent of the country's 104 reactors have received licences for extension or refurbishment. The disaster at Daiichi will likely cast doubt on the attractiveness of granting operating extensions to what is now obsolete technology. However, in our view, the prospects for replacing retired nuclear power plants with new late-model technology are dim. Therefore, we believe that these events will serve as a further catalyst for the current shift of the global nuclear energy industry from the West to the East.

Indeed, barring a major disaster in Japan, we do not foresee these events having a material impact on the nuclear energy programmes of Asia's nuclear incumbents. Japan was the first country in Asia to bring a nuclear reactor online, and hence it's fleet is the oldest. By contrast, the nuclear power fleets of Asia's other nuclear incumbents – China, India, South Korea, Pakistan, and Taiwan – are weighted toward newer technology. China built its first reactors in 1994 and we predict the events in Japan will not materially halt its nuclear programme.

Likewise, we expect that India's programme will not be delayed by these events, but rather by its own internal economic and political uncertainties. South Korea has the region's most aggressive domestic and international nuclear energy programme. It aims to increase nuclear power as a share of output to 59 per cent by 2030 and to sign nuclear equipment and service contracts worth US$400 billion by 2030. In our view, Korea's domestic nuclear programme will not be slowed to a major degree given the close relationship between President Lee MB and the nuclear energy industry. Only reactors in tsunami prone areas of South Korea are likely to be slowed by the events in Japan. Taiwan has the most organized opposition to nuclear energy and not without coincidence is Asia's only nuclear incumbent that does not have a well-defined nuclear development programme. The events in Japan are not likely to sway either side of Taiwan's already divided nuclear programme.

Similarly, we do not expect these events to have a major impact on the nuclear energy programmes of Asia's nuclear aspirants. Since 1985, only three countries brought their first nuclear reactor online. According to industry forecasts, this is expected to accelerate rapidly over the coming decades. In our view, the events in Japan may slow the adoption of nuclear energy by some of the world's nuclear aspirants, especially those that are not fully committed to its adoption. Although Japan's newer reactors appear to have faired much better through the country's worst earthquake on record, fears will be raised that even late-model reactors may not be safe. In countries with a vibrant civil society and where a strong culture of public participation exists, nuclear energy may be deemed to be non-viable for political reasons. As we will describe in our forthcoming report, we believe strong government support is absolutely required for successful nuclear energy programmes. In emerging Asia, we do not believe that Indonesia, Thailand, or the Philippines will be able to steward the development of nuclear energy in the near- to mid-term. These events will only add to their existing reticence. However, we do not expect that these events will slow the nuclear energy programmes among Asia's most 'determined, desperate, and organised' aspirants, specifically, Vietnam, Bangladesh, and Malaysia.

In sum, we believe that Japan's unfolding nuclear disaster will have an impact on global nuclear energy markets. But we expect that they will further shift nuclear energy away from North America and Europe to Asia. We do not believe that these events will slow the breakneck nuclear developments taking place in China or South Korea (or Russia). Nor do we expect these events to have significant further ramifications for India's already challenged programme. Among Asia's nuclear aspirants, certain countries that have already committed will likely proceed with their plans, while those that are on the fence will likely stay there.

Figure: Nuclear reactors – Operating, Under Construction, Planned, and Proposed

	Nuclear Generation 2009		Reactors Operable January 1, 2011		Reactors Under Construction January 1, 2011		Reactors Planned January 1, 2011		Reactors Proposed January 1, 2011		Uranium Requirement 2010
	TWh	% e	No.	MWe net	No.	MWe net	No.	MWe net	No.	MWe net	tonnes U
Argentina	8	7	2	935	1	745	2	773	1	740	123
Armenia	2	45	1	376	0	0	1	1,060	0	0	55
Bangladesh	0	0	0	0	0	0	0	0	2	2,000	0
Belarus	0	0	0	0	0	0	2	2,000	2	2,000	0
Belgium	45	52	7	5,943	0	0	0	0	0	0	1,052
Brazil	12	3	2	1,901	1	1,405	0	0	4	4,000	311
Bulgaria	14	36	2	1,906	0	0	2	1,900	0	0	272
Canada	85	15	18	12,679	2	1,500	3	3,300	3	3,800	1,675
China	66	2	13	10,234	27	29,790	50	57,830	110	108,000	2,875
Czech Republic	26	34	6	3,686	0	0	2	2,400	1	1,200	678
Egypt	0	0	0	0	0	0	1	1,000	1	1,000	0
Finland	23	33	4	2,721	1	1,700	0	0	2	3,000	1,149
France	392	75	58	63,130	1	1,720	1	1,720	1	1,720	10,153
Germany	128	26	17	20,339	0	0	0	0	0	0	3,453
Hungary	14	43	4	1,880	0	0	0	0	2	2,200	295
India	15	2	19	4,183	6	4,120	18	15,700	40	49,000	908
Indonesia	0	0	0	0	0	0	2	2,000	4	4,000	0
Iran	0	0	0	0	1	1,000	2	2,000	1	300	148
Israel	0	0	0	0	0	0	0	0	1	1,200	0
Italy	0	0	0	0	0	0	0	0	10	17,000	0
Japan	263	29	55	47,348	2	2,756	12	16,538	1	1,300	8,003
Jordan	0	0	0	0	0	0	1	1,000	0	0	0
Kazakhstan	0	0	0	0	0	0	2	600	2	600	0
Korea, North	0	0	0	0	0	0	0	0	1	950	0
Korea, South	141	35	21	18,675	5	5,800	6	8,400	0	0	3,804
Lithuania	10	76	0	0	0	0	0	0	1	1,700	0
Malaysia	0	0	0	0	0	0	0	0	1	1,200	0
Mexico	10	5	2	1,310	0	0	0	0	2	2,000	253
Netherlands	4	4	1	485	0	0	0	0	1	1,000	107
Pakistan	3	3	2	400	1	300	2	600	2	2,000	68
Poland	0	0	0	0	0	0	6	6,000	0	0	0
Romania	11	21	2	1,310	0	0	2	1,310	1	655	175
Russia	153	18	32	23,084	10	8,960	14	16,000	30	28,000	4,135
Slovakia	13	54	4	1,816	2	880	0	0	1	1,200	269
Slovenia	6	38	1	696	0	0	0	0	1	1,000	145
South Africa	12	5	2	1,800	0	0	0	0	6	9,600	321
Spain	51	18	8	7,448	0	0	0	0	0	0	1,458
Sweden	50	35	10	9,399	0	0	0	0	0	0	1,537
Switzerland	26	40	5	3,252	0	0	0	0	3	4,000	557
Taiwan	40	21	6	4,927	2	2,700	0	0	1	1,350	863
Thailand	0	0	0	0	0	0	2	2,000	5	5,000	0
Turkey	0	0	0	0	0	0	4	4,800	4	5,600	0
Ukraine	78	49	15	13,168	0	0	2	1,900	20	27,000	2,031
UAE	0	0	0	0	0	0	4	5,600	10	14,400	0
United Kingdom	63	18	19	10,962	0	0	4	6,680	9	12,000	2,235
USA	799	20	104	101,229	1	1,218	9	11,622	23	34,000	19,538
Vietnam	0	0	0	0	0	0	2	2,000	12	13,000	0
WORLD**	2,560	857	442	377,222	63	64,594	158	176,733	322	368,715	68,646

Operating = Connected to the grid;
Building/Construction = first concrete for reactor poured, or major refurbishment under way;
Planned = Approvals, funding or major commitment in place, mostly expected in operation within 8-10 years;
Proposed = Specific program or site proposals, expected operation mostly within 15 years.
Source: WNA

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