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NUCLEAR OPPORTUNITIES POST-FUKUSHIMA

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Irrespective of its negative impact on nuclear energy programmes worldwide, the Fukushima nuclear disaster has highlighted a host of technological opportunities. At the outset, it has prompted nations to innovate reactor designs different from those in vogue. Meanwhile, decommissioning of aging reactors, recycling, and waste disposal issues hint at a profitable market for related technology and expertise in the years to come.

Fukushima disaster has brought to fore the challenges in responding effectively to severe and multi-unit accident conditions. The critical issues are core melting, managing decay heat, and backup power to sustain the core cooling process. Scientists are now hopeful of inventing disaster-resistant designs with more advanced safety techniques. Successive generation of reactors, developed after Gen II reactors, address shortcomings in these domain. For example, the Generation III+ and Generation IV reactors have added many passive safety features and redundancy. Several of these, like the EPR and VVER-1000, have a core catcher: if the core were to meltdown, it would melt into a large structure which spreads out the molten fuel into heat resistant channels to quickly cool and halt reactions. The Gen IV model, created by Generation IV International Forum (GIF), includes metal-, salt-, and gas-cooled designs, high temperature reactors, and breeder reactors.[i]

Six factors that greatly influence the nuclear reactor designs are: cost-effectiveness, safety, security and proliferation resistance, grid appropriateness, commercialization roadmap (including constructability and licensability), and management of the fuel cycle.[ii] Revolutionary innovations in these areas have the aim to make nuclear energy not only safe and secure but also significantly cheap. The Molten Salt Reactors (MSRs) that consume existing nuclear waste claim to be safer

and half the price of the light water reactors (LWRs).[iii] They have been experimented in China and the US for several years. One special feature of these models, as its proponents claim, is that "if there is a loss of power, or the reactor gets too hot, the plug melts, allowing all the fuel and coolant to fall into an underground chamber full of neutron poisons/absorbers, quickly killing all fission reactions."[iv]

In another initiative, the San Diego based General Atomics has designed a small size reactor claimed to reduce nuclear waste by 80 percent.[v] It is designed by using ceramics to shut down and cool off without the need to continuously pump in coolant, in the case of a power failure. Using helium as a coolant, instead of water, allows the plant to operate at higher temperatures, and the reactor also incorporates a new gas turbine for producing electricity. The technology is claimed to generate more power from a given amount of heat produced in the reactor core.

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Efforts are also being made to address the nuclear waste disposal problem. The dual fluid reactor concept by a group of nuclear physicists in Berlin claims that they are able to drop the life span of nuclear waste from 100,000 years to 300.[vi] Fabian Schmidt and Conor Dillon claim that the "liquid salts with heavy nuclei...would flow in continuous circles. After burning in the reactor core and producing energy, the liquid is then channelled through an internal treatment plant, where burned components are separated off and the mixture is enriched once more with fresh, long-life radionuclides. It's then sent back through the reactor core for another round of energy production".[vii]

Decommissioning of aging nuclear plants is another area of huge business opportunities worldwide. Decommissioning includes clean-up of radioactivity and dismantling of the plant, and the process begins only after fuel and coolant are removed. According to World Nuclear Association, about 100 mines, over 100 commercial power reactors, 46 experimental or prototype reactors, over 250 research reactors and a number of fuel cycle facilities, have been retired from operation.[viii] Lake Barrett, a former US nuclear regulator who headed the Three Mile

Island cleanup, views this as a potential business and "an exciting new area".[ix] Particularly, Japan eyes this opportunity as it has advanced technology such as robotics and specific organisational set up called the Decommissioning Company. It has also created the International Research Institute for Nuclear Decommissioning (IRID) which brings together nuclear plant operators, construction companies and organizations of nuclear experts to promote R&D or decommissioning technologies, as well as cooperation between international and domestic organizations. According to IRID Managing Director Kazuhiro Suzuki, the standard cost for decommissioning of a nuclear reactor is about $700 million today and the severely damaged Fukushima reactors could be 10 times higher.[x]

Reportedly, the "IRID has received 780 proposals for funding from around the world for ideas and technologies related to the treatment and management of contaminated water, as well as 220 others about retrieving the three melted cores".[xi] Japanese companies including Toshiba, Mitsubishi and Hitachi have been developing robots that can monitor radiation, decontaminate, remove contaminated debris or repair damage, and some of them have already been mobilized at the plant.

Similarly, UK has the National Decommissioning Agency founded in 2005. A team of nuclear engineers from Sellafield (UK), where one of Britain's worst nuclear accidents occurred, has proposed to help the decommissioning of the crippled Fukushima power plant.[xii]

Having completed decommissioning of 10 regular reactors and the Three Mile Island cleanup, the US government and nuclear industry see a profitable market too. In February this year, around two dozen American companies came to Tokyo for demonstration and business talks with 50 Japanese companies in this regard.[xiii]

Above all, the Fukushima disaster has set a nuclear safety bench mark for states to maintain effective nuclear safety culture necessitating exchange of best practices through bilateral or multilateral nuclear cooperation. This will go a long way in ensuring a sustainable nuclear energy drive across the globe.

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[i] Stephen M. Goldberg and Robert Rosner, "Nuclear Reactors: Generation to Generation", *American Academy of Arts & Sciences*, 2011.
[ii] Stephen M. Goldberg and Robert Rosner, "Nuclear Reactors: Generation to Generation", *American Academy of Arts & Sciences*, 2011, p. 1.
[iii] Graham Templeton, "The 500MW Molten Salt Nuclear Reactor: Safe, Half the Price of Light Water, and Shipped to Order", http://www.extremetech.com/, March 13, 2013
[iv] Ted Nordhaus, et al, "How to Make Nuclear Cheap", Breakthrough Institute, July 2013.
[v] Kevin Bullis, "A Nuclear Reactor Competitive with Natural Gas", August 19, 2013, http://www.technologyreview.com/news/518116/a-nuclear-reactor-competitive-with-natural-gas/
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[vii] ibid.
[viii] World Nuclear Association, "Decommissioning Nuclear Facilities", February 27, 2014.
[ix] Quoted by Mari Yamaguchi, "Japan Sees Future Business in Fukushima Cleanup", *Star Tribune*, March 08, 2014.
[x] Yamaguchi, n. 9
[xi] Ibid
[xii] Esther Tanquintic-Misa, "Nuclear Experts from UK to Help in Fukushima Decommissioning, Province Commits to Use 100% Renewable Energy by 2040", *International Business Times*, February 03, 2014.
[xiii] Yamaguchi, n. 9.