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Global Nuclear Energy Scenario Post Fukushima

Nupur Brahma

For the global nuclear industry, the Fukushima crisis last year led to the reinvigoration of the debate relating to energy security, price competitiveness and the need to rethink on the contribution of nuclear power to the global energy mix. Fukushima has undeniably led to the cooling of ambitions of many countries to expand their nuclear power programmes, but there is no indication of slackening in the global nuclear industry, particularly in emerging economies like China and India. The dramatic rise of crude oil prices and the need to spur growth and sustain burgeoning populations in emerging economies has meant that overall nuclear growth continues to be strong, with 60 reactors under construction today, and 163 more on order or planned, according to the World Nuclear Association.

In Europe, the German government initially ordered the suspension of operations at seven of its older nuclear plants (operational before 1980). It later formally announced plans to phase out the remaining nine nuclear power plants with a total capacity of 12 gigawatt (gw) by 2022 at a cost of 40 billion euros. The European Union carried out comprehensive stress tests in 143 nuclear reactors in its 27 member-states in order to assess whether nuclear plants can cope with both natural disasters and man-made failures and malevolent actions. The resultant national reports and peer reviews were made public. Switzerland also abandoned plans to build new nuclear reactors and decided not to replace the country's five existing nuclear reactors, which supply around 40 per cent of its energy, when they reach the end of their working life, with the last to go offline by 2034. In Italy, 94 percent of the voters rejected in a referendum in June 2011, the former Italian Prime Minister Silvio Berlusconi's plans to revive nuclear power plants.

Japan, which derived about 30 per cent of the country's total electricity production from nuclear power plants prior to Fukushima, steadily took offline all 50 of its working reactors for routine maintenance tests or due to safety concerns expressed by host communities. However due to predicted severe summer energy shortages and record imports of fossil fuels, resistance seems to be weakening, with the Japanese government recently announcing the restarting of two of the four reactors at the Ohi nuclear power station. As several countries have shifted away from nuclear energy post Fukushima, in developing countries like China, interest in nuclear power continues to be high to meet surging energy demands, due to increasing urbanisation and an expanding population.

China, which temporarily suspended the approval of new nuclear reactors and ordered safety checks on existing plants and those under construction post the nuclear crisis, has shown indications that it will lift its year-long moratorium on new nuclear projects and announced the approval of the 2020 nuclear strategy. It has also finalised a new set of atomic safety regulations and completed safety inspections on all its nuclear reactors.

In December 2011, Shi Lishan, the deputy director of China's National Energy Administration's new energy and renewable energy department announced at the 21st Century Low-Carbon Chinese Development Summit that China would increase generation capacity by 2 billion kilowatts (kw) over the next 10-20 years, with as much as 300 million kwbeing contributed by nuclear power. At the Second Nuclear Security summit in Seoul in March 2012, Hu Jintao emphasised that nuclear energy plays an irreplaceable role in ensuring energy security and argued that by using a "scientific and sensible approach, nuclear security and energy can work in tandem and that China will take further nuclear safety measures to ensure the safety of its nuclear material and nuclear facilities." At its national nuclear emergency coordination committee meeting held in April 2012, China's nuclear emergency plan was revised and updated and the number of provinces that have nuclear emergency plans increased from 12 to 16. Chinese companies – China National Nuclear Corporation and China Guangdong Nuclear Power Corporation – are also competing for new contracts to build nuclear power reactors in countries like Turkey, South Africa and the United Kingdom.

A number of countries spread across Asia – South Korea, Indonesia, Singapore, Malaysia, Vietnam, Thailand, Turkey, Saudi Arabia, Jordan – have either expressed interest in developing nuclear power or intend to expand their nuclear programmes over the next decade. South Korea has commenced building two new nuclear reactors based on APR-1400 design and capacity of 1,400 mw capacity at Uljin from May this year, scheduled to be online by April 2017 and February 2018 respectively and has plans to build 12 new reactors by 2022. The Korean Consortium led by state-owned Korea Electric Power Corporation (KEPCO) also won a $20.4 billion contract to construct four AP1400 reactors in the United Arab Emirates.

Vietnam plans to build 13 nuclear reactors at eight separate plants with a combined capacity of 15,000 mw; by 2050, aims to generate enough nuclear power to meet 20-25 per cent of its energy consumption. The first reactors will be comprised of both Russian and Japanese designed plants. In 2010 Russia's Rosatom was chosen to build Vietnam's first nuclear power plant comprising two 1200 MW VVER pressurised water reactors in Ninh Thuan Province and $8 billion in loans was sanctioned in November 2011 for this purpose. In September 2011, Japan Atomic Power, a consortium of Japan's nine nuclear utilities, signed a deal with Vietnam to conduct feasibility studies for two new reactors.

Singapore is pushing ahead with a pre-feasibility study with initial findings set to be announced this year. According to S Iswaran, Singapore's Minister in the Prime Minister's Office and Second Minister for Home Affairs and Trade and Industry, Singapore cannot rule out the nuclear option because it doesn't have "the luxury of having too many options in the first place." Malaysia under its Economic Transformation Programme (ETP) is also exploring the option of deploying nuclear energy to meet future demand and a pre-feasibility study and initial site selection study has already been undertaken. Thailand, despite strong public concerns, continues to support nuclear power and has only delayed its first nuclear power plant project by three years to 2023. Indonesia is also pushing ahead with feasibility studies to build two plants with a combined capacity of 18,000 mw by 2022 in the provincial

government of Bangka-Belitung and is carrying out assessments of other potential nuclear sites with the help of the IAEA.

Saudi Arabia plans to spend $100 billion on 16 nuclear reactors planned to be built by 2030 and it has already established the King Abdullah Atomic and Renewable Energy City devoted to research and application of nuclear technology in 2010. The Jordanian Atomic Energy Commission is also reviewing bids from two companies – Atomstroyexport and a French-Japanese consortium ATMEA – to build a nuclear reactor. Turkey, as part of its centennial, targets to have three nuclear power plants functioning by 2023. A $20 billion deal has been finalised with Atomstroyexport for the construction of Turkey's first plant at Akkuyu and negotiations are set to begin with China for a second plant to be constructed at Sinop. Even in the United States and several European countries United Kingdom, Ukraine, Poland, Finland, Belarus, Czech Republic, Bulgaria, Hungary, Netherlands – support for nuclear energy continues to be strong and plans to expand nuclear capacity by building new reactors with increased safety features are in place in a number of countries.

The future of nuclear energy ultimately rests not on the nuclear power companies nor on governments that promote the projects but on regaining and rebuilding public understanding of nuclear power's costs, benefits and risks. Arguments that nuclear technology is the only viable technology of the future which can address the shortfalls arising from fast depleting fossil fuels and climate change ring hollow when faced with hostile public opinion. If nuclear energy has to have a future, governments will need to strengthen national nuclear authorities and will need to call for convergence of international safety regulations and strengthening of the global governance of nuclear energy.

Future of Nuclear Power: An Evolving Global Nuclear Safety Framework

Rajiv Nayan

The nuclear meltdown triggered by the massive earthquake and tsunami in Fukushima brought the future of civil nuclear energy at the centrestage of global debate. Earlier, the Three Mile Island and the Chernobyl incidents had sparked similar debates. The Fukushima incident generated strong adverse reaction to nuclear energy worldwide. While Germany announced the phased closure of its nuclear power plants, other countries were compelled to review the role of nuclear energy in their mix of power sources. The incident led to the closure of 12 reactors in the world by the end of 2011. More than two years after the Fukushima incident, the question remains: what is the future of nuclear energy? Is the current phase of nuclear renaissance going to sustain itself? And more importantly, can nuclear power be safely harnessed to meet the growing energy needs?

Two important global trends underpin the future of nuclear energy in years to come. Firstly, the world is still operating 437 nuclear power plants. In 2011, the IAEA report mentioned that, "seven new reactors were connected to the grid, an increase from five new reactors in 2010, two in 2009 and none in 2008."[1] At present, 68 power plants are under construction all over the world. In the next two decades, almost 80-90 new power reactors are likely to be added. The IAEA records that currently, 373.209 GW is produced by nuclear energy worldwide. It projects that in the next two decades, nuclear energy may account for 501-746 GW.

Countries such as China, Russia and South Korea, which had plans to expand nuclear power generating capacity, still by and large have their faith intact and are going ahead with their scheduled plans. In Europe, except Germany which decided to roll back its programme, nuclear energy pioneers like United Kingdom and France are continuing with their nuclear energy programmes. Italy has not had an active nuclear power programme for years. The IAEA projects that by 2030; at least seven new countries may have a functional power plant. The same report expects that the number of new countries with operational nuclear power reactor may go up to 20. Uranium production also did not witness any slump, according to IAEA estimates. In 2011, it grew by 2.5 percent instead of witnessing decline.[2] Besides, in later years too, usual business activities continued.

Secondly, the Fukushima crisis resulted in extensive review and revaluation of safety concepts in nuclear engineering. The incident in Japan severely tested the integrity of the reactor pressure vessels. The resultant release of radioactivity into the atmosphere caused serious socio-economic disruptions in Japan. It led certain commentators to make exaggerated projections about the health hazards from Fukushima crisis. However, many experts do not agree with such overstated claims about long-term health implications of Fukushima crisis. A former NASA scientist James Hansen and Pushker Kharecha in their paper 'Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power' published in *Environmental Science & Technology* in 2012 argues that nuclear energy is basically a saviour of the modern world, in which fossil fuels resulted in

[1]Nuclear Technology Review 2012, ULR: http://www.iaea.org/About/Policy/GC/GC56/GC56InfDocuments/English/gc56inf-3_en.pdf

[2] International Status and Prospects for Nuclear Power 2012: Report by the Director General, URL: http://www.iaea.org/About/Policy/GC/GC56/GC56InfDocuments/English/gc56inf-6_en.pdf

'the deaths of 1.84 million people between 1971 and 2009'.[3] A World Health Organisation (WHO) study conducted by independent international experts with expertise in areas such as risk modelling, epidemiology, dosimetry, public health, etc., came out with the following findings:

Outside the geographical areas most affected by radiation, even in locations within Fukushima prefecture, the predicted risks remain low and no observable increases in cancer above natural variation in baseline rates are anticipated. Some health effects of radiation, termed deterministic effects, are known to occur only after certain radiation dose levels are exceeded. The radiation doses in Fukushima prefecture were well below such levels and therefore such effects are not expected to occur in the general population. The estimated dose levels in Fukushima prefecture were also too low to affect foetal development or outcome of pregnancy and no increases, as a result of antenatal radiation exposure, in spontaneous abortion, miscarriage, perinatal mortality, congenital defects or cognitive impairment are anticipated.

Taking serious cognisance of the Fukushima crisis, nuclear operators all over the world reviewed the safety procedures for nuclear reactors. The international community, institutions and national governments all took several measures to make nuclear energy safer. Nuclear safety dominated the agenda of meetings in all international forums. The Fifth Review Meeting of the Convention on Nuclear Safety (CNS) held in Vienna in April 2011 extensively debated the nuclear safety agenda. A five-day Ministerial Conference on Nuclear Safety held in Vienna during June 20-24, 2011 also addressed issues of nuclear safety. A series of meetings were held to implement Code of Conduct on the Safety of Research Reactors. A new IAEA Nuclear Safety Guide was published in 2011. The Integrated Regulatory Review Service missions, Operational Safety Review Team missions, Integrated Safety Assessment for Research Reactors service all are carrying out extensive safety survey globally. Similarly, the IAEA safety codes and guidelines have also been reviewed and refined after the Fukushima crisis.

In June 2011 a Ministerial Conference on Nuclear Safety directed the process of learning and acting upon lessons following the accident at Fukushima Daiichi Nuclear Power Station in order to strengthen nuclear safety, emergency preparedness and radiation protection of people and the environment worldwide. This ministerial conference asked the IAEA Director General to "draft Action Plan base on the Declaration of the Ministerial Conference and the conclusions and recommendations of the three Working Sessions, and the expertise and knowledge available therein, and to promote coordination and cooperation, as appropriate, with other relevant international organizations to follow up on the outcomes of the Conference, as well as facilitate consultations among Member States on the draft Action Plan". It "called upon the IAEA Board of Governors and the General Conference to reflect the outcome of the Ministerial Conference in their decisions and to support the effective, prompt and adequately resourced implementation of the Action Plan".[4]

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[3] Kharecha, Pushker A. and Hansen, James E. (2013), "Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power", Environment, Science & Technology, 47 (9), pp 4889–4895, March 15, 2013

[4] "IAEA Action Plan on Nuclear Safety", The Action Plan was approved by the IAEA Board of Governors on 13 September 2011, as endorsed by the IAEA General Conference during its 55th regular session on 22 September 2011. URL: http://www.iaea.org/newscenter/focus/actionplan/reports/actionplanns130911.pdf

In 2011, Industry Cooperation Forum underlined the relevance of 'increased cooperation with utilities; greater interaction between operating organisations in countries with experience in the nuclear area and those in countries introducing nuclear power; more effective communication; and wider dissemination of best operational practices.' An IAEA official informed that countries are now asking for new, innovative reactor designs from sellers so that safety is not compromised. Post Fukushima, while buyers continue to retain their faith in nuclear energy; they are more conscious about design safety. The slump therefore appears to be marginal and temporary and nuclear energy is likely to gather momentum in the near future.

For sustainable development, the need for civil nuclear energy is indispensable. Although nuclear energy plant has a high initial construction cost and long gestation period, it is economical in the long run. Several studies indicate that countries with growing energy needs will be forced to consider nuclear energy in their energy mix. The pursuit of nuclear energy offers important advantages in terms of safeguard against volatile fossil fuel prices, and effective mitigation of climate change concerns. In the final analysis, nuclear energy continues to sustain its image as a clean source of energy with clear advantages over fossil energy sources. In all likelihood, the prognosis for nuclear energy as a clean source of energy is positive, and the current phase of public opposition driven by the fear of Fukushima accident is likely to be dissipated in near future.

Future of Japan's Nuclear Power Policy

Reshmi Kazi

Japan's nuclear energy has been a national strategic priority contributing to almost 30 per cent of the nation's electricity requirements. The consumption pattern was expected to increase to 40 per cent by 2017. However, following the March 2011 Fukushima accident in the Dai-ichi nuclear power plant, Japan's nuclear energy policy is currently in a situation of considerable disarray. The Fukushima nuclear accident triggered a public debate in Japan that is markedly in favour of relinquishing nuclear power. However, in May 2013, the political establishment under Prime Minister Shinzo Abe announced the resumption of operation of 48 out of 50 idling commercial nuclear reactors as part of the island nation's growth strategy. In the following month, approximately 60,000 protesters rallied before the Diet building calling for the suspension of nuclear power plants (NPPs) out of fear for safety. Protestors have collected more than 8 million signatures against the government's decision to restart NPPs.

On the other hand, the Nuclear Regulation Authority (NRA) has finalised the new safety standards for operators seeking to apply for the re-activation of idling nuclear reactors: Kansai Electric Power Company switched off the Number 4 reactor at its Ohi plant on September 16, 2013 leaving Japan nuclear power free for the first time since July 2012 and prompting concerns about power availability in the coming winter. Ohi's Number 3 reactor was halted earlier in September 2013. Japan is thus at the crossroads when it comes to nuclear energy.

In March-April 2011, when the Fukushima NPP suffered a reactor meltdown, the Japanese people could not help remembering the horrors of the Hiroshima and Nagasaki nuclear bombings. In the aftermath of the crisis, 'no-go' zones were designated in nine municipalities within 20 km of the nuclear plant. Twenty-eight months after the Fukushima accident, there still exist zones designated as 'difficult to return to; in a wide area surrounding the plant. In the town of Futaba, approximately 96 per cent zones have estimated annual radiation exposure exceeding 50 millisieverts and the return of residents is deemed difficult. In Fukushima, radiation scare lead 157,000 people to evacuate their homes; some 32,000 of the evacuees now live in temporary housing developments in the prefecture; another 59,000 more dwell in subsidised apartments.

Following the crisis, a series of reports about release of radioactive material from the Fukushima NPP further affected the Japanese psyche. Professor Tatsuhiko Kodama head of Tokyo University's Radioisotope Centre, testified before Japan's Diet committee in August 2011 that radioactive releases from the affected Fukushima NPP were 29.6 times more than those released by the Hiroshima bombing. Radiation levels will decrease by only one-tenth per year, which implies that radioactivity will prevail over the area, leaving it inhabitable for decades. In addition, emissions of radioactive iodine and cesium from the damaged Fukushima nuclear plant were alarming. "Iodine-131 was being released at daily levels 73 per cent of those detected after Chernobyl, while the daily amount of cesium-137 amounted to about 60 per cent."

Following this, in October 2011, Japan issued a White Paper highlighting the risks and weaknesses involved in its energy system based on nuclear power. It stated, "Japan's dependency on nuclear energy will be reduced as much as possible in the medium-range and long-range future." In an attempt at damage –control, the Tokyo Electric Power Company

(TEPCO) stated that the direct cause of the Fukushima nuclear disaster was the 'larger-than-expected tsunami that flooded key buildings'. However, TEPCO's assurances fell flat when in December 2011 the government-appointed Hatamura Panel expressed its skepticism over the claim, saying, "That tsunami alone caused the accident is nothing but a hypothesis." The Panel's final report published in 2012 criticised TEPCO and the Japanese government for its poor handling of the Fukushima crisis and demanded all utilities, regulatory authorities and government councils involved in nuclear power to 're-establish the safety culture'.

Post Fukushima, there has been a significant shift in Japanese public opinion over their country's nuclear power policy. A series of opinion polls conducted in 2011 by Japanese dallies and broadcasters, the Sensex–Nikkei and automobile company Sankei revealed increasing public attitude favouring either decrease or abolition of nuclear power. According to the Japan Atomic Industrial Forum (JAIF), another Yomiuri poll conducted in March 2013 indicated that one-fifth of the 1,500 residents voted for nuclear power to be abolished. Also, more than half the respondents (53 per cent) voted for Japan to decrease its share of nuclear power. In a poll conducted by the *Asahi Shimbun* on June 8-9, 2013, 58 per cent of the respondents out of 1,781 people opposed the restart of Japan nuclear reactors. These latest opinion polls are an expression of the Japanese peoples' deep-seated aversion towards nuclear power.

Despite the wide opposition to nuclear power, there is also a view that energy-deficient Japan cannot abandon nuclear energy. Japan is only 16 per cent energy self-reliant. It is the world's largest importer of LNG, second largest importer of coal and the third largest net importer of oil. In 2010, Japan relied on oil imports to meet about 42 per cent of its energy needs. As a country with limited domestic hydrocarbons, nuclear energy is perceived to be the backbone of Japan's energy security. Initially, Japan was heavily reliant on the Middle East for its fossil fuel imports for meeting almost 84 per cent of its major energy requirements. Following the oil shocks of the 1970s, Japan embarked on a nuclear power programme to induce diversification of its energy resources and reduce its dependence on oil imports from the Middle East.

Japan is also aware that its energy security will be challenged by its Asian neighbours like India and China, which are expanding their economies rapidly. Stiff competition for long-term fossil fuel supplies is inevitable among the Asian powers. Considering the challenges involved, Japan prioritised nuclear energy as the alternative to substantiate and reinforce its energy security for the future. Japan also has a government-supported effective research and development programme which aims to effect energy-efficient measures domestically to enhance the country's energy security and reduce carbon-dioxide emissions. This is why some say continued reliance on nuclear power is essential for Japan's growth and development.

Can nuclear power in Japan be managed safety? The short answer is yes. Japan's NRA has already announced new guidelines to replace earlier regulations which lacked adequate safety measures. It has increased the emergency zones from a 10-km to a 30-km radius from the reactors. The operators must undertake more robust defences against meltdowns or natural disasters. The NRA specifies systematic checks for active earthquake faults underneath the reactors. Operators are mandated to install filtered venting valves in their reactors to reduce the contamination by radioactive substances in the event of releasing steam to prevent damage to the containment vessels. The NRA has established a new Emergency Response Centre that will be able to remote-control the reactors' status in case of a terrorist attack or

natural disaster. Emergency power sources will be in place to keep the reactors cool in the event of long power shortage.

The Abe administration will have to exercise extreme caution in dealing with the domestic opposition to nuclear power. It will have to reach out to the people to redress their apprehensions and gain their confidence. The NRA will have to conduct a scrupulous assessment and ensure utmost safety of the proposed 12 offline reactors before restarting them. The Diet will have to update laws on controlling radiation contamination and prevention. Japan must also improve its nuclear technology and improve safety of its nuclear reactors. No safety measures are ever foolproof but every effort is needed to make NPPs safer.

Post-Fukushima Nuclear Safety Review in India

Kapil Patil

The nuclear accident in Fukushima has significantly affected the public acceptance of nuclear power globally. The echoes of the Fukushima crisis strongly resonated in India, which witnessed protests against nuclear power by certain civil society groups and common people. For lay people at newly designated nuclear power plant (NPP) sites in India such as Jaitapur, Koodankulam, Gorakhpur, Kovada, etc., the safety of nuclear installations has emerged as a serious concern. Upping the ante against nuclear energy, civil society groups filed petitions in the Supreme Court seeking a ban on construction and commissioning of the new nuclear power stations in the country. The opposition from lay people has presented a serious challenge for Indian political leadership to continue unqualified support to the expansion of country's nuclear energy programme, which has enjoyed widespread political support being an important constituent of the overall energy mix.

In response to Fukushima crisis, the Atomic Energy Commission has carried out several structural changes in country's nuclear energy safety management. It introduced a series of new policy measures to mitigate the safety concerns arising from Fukushima accident and enhance faith in the safety of country's nuclear power plants (NPPs). This article presents a brief overview of the nuclear safety review process in India after the Fukushima crisis. Primarily aimed at incorporating lessons from the Japanese nuclear crisis; this process highlights that highest priority has been accorded to the safety of all the nuclear installations in India. Various changes initiated at the institutional levels are primarily aimed at providing requisite safeguards against extreme events which could cause long-term socio-economic disruptions.

'Safety Action Plan'

In the immediate aftermath of Fukushima accident, the nuclear safety management in India witnessed strong political intervention, with Prime Minister Dr Manmohan Singh giving clear directives for reviewing safety of operational nuclear power plants in the country.[1] Being directly in charge of the Department of Atomic Energy, Prime Minister Singh emphasized that safety of NPPs is a matter of highest priority for his government.[2].The Nuclear Power Corporation of India Ltd (NPCIL) set up task forces on March 15, 2011 to assess safety of NPPs under its operation. The Atomic Energy Regulatory Board (AERB) also constituted a committee on March 19, 2011 to review the safety of Indian NPPs against external events of

[1] PM's statement in Parliament on the Earthquake and Tsunami in Japan, March 14, 2011, URL: http://pmindia.gov.in/pmsinparliament.php?nodeid=45

[2] India carrying out safety reviews of n-plants: PM, *India Strategic*, March 2011, at http://www.indiastrategic.in/topstories966.htm accessed on March 16, 2013

natural origin.[3] Based on these safety reviews, several safety measures have been implemented as part of the 'new safety action plan'.

The most important concern of the safety reviews was to evaluate the safety margins of Indian NPPs against extreme natural events that are beyond the scope of engineered safety features in the reactor designs. Numerous studies conducted after the Fukushima crisis have primarily focused on why only three units at Dai-ichi station suffered severe core meltdowns, whereas ten other nuclear reactors at tsunami-affected Dai-inni and Onagawa stations were able to withstand the onslaught of Tsunami station.[4] The Japanese independent commission's report has underscored the inadequate provisions in plant designs for tsunamis and flooding at the Fukushima Dai-ichi station.[5] The inherent safety flaws in the site engineering of the Fukushima Dai-ichi plant caused massive flooding at the site and irreversibly damaged the emergency power back-up systems leading to prolonged station black out conditions. The resultant core meltdown and large-scale radioactive release has highlighted several design flaws in the Fukushima plant's site design and engineering.

In this backdrop, the NPCIL and AERB task forces specifically evaluated the capabilities at NPPs to deal with prolonged Station Black Out (SBO's) conditions and the viability of design water supply routes to carry out decay heat removal. The NPCIL task forces recommended supply of water to reactor and emergency Condenser through appropriate hook up arrangements which will prevent any possibility of damaging the reactor core.[6] The findings of both AERB and NPCIL committees underscored that Indian NPPs are unlikely to be affected by the kind of natural disaster experienced at Fukushima and that sufficient safety margins are available for beyond design basis accidents (BDBA) due to inherent design advantages of the Indian NPPs.[7] The safety review also highlighted strengths in design, best operating practices and stringent regulation in the Indian NPPs. The AERB, on its part, directed the NPCIL to raise safety margins for new reactors (indigenous as well as imported) to account for Beyond Design Based Events (BDBE) like tsunamis, major earthquakes, cyclones, plane crash, etc.

The Dai-ichi station in Fukushima prefecture was designed and engineered to withstand earthquakes of magnitude 7.9 on the Richter scale. However, the earthquake of magnitude 8.9 which shook the Japanese East Coast on March 11, 2011 and 14 meter high Tsunami it triggered were entirely beyond the design-based safety margins provided at the Dai-ichi station. Despite repeated warnings from individual experts and nuclear safety institutions, the operator of these reactors - the Tokyo Electric Power Corporation (TEPCO) - failed to

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[3]Nuclear Power Corporation of India Limited, "Review of Indian NPPs –Post Fukushima Event", at http://www.npcil.nic.in/pdf/presentation.pdf accessed on March 16, 2013

[4]James M. Acton and Mark Hibbs (2012), "*Why Fukushima was preventable*", Carnegie Papers, March 2012, at http://carnegieendowment.org/files/fukushima.pdf, accessed on March 15, 2013

[5] The National Diet of Japan (2012), "The official report of the Fukushima Nuclear Accident Independent Investigation Commission", URL: http://www.nirs.org/fukushima/naiic_report.pdf

[6] Nuclear Power Corporation of India Limited,

[7] AERB National Report, "Actions taken for Indian NPPs subsequent to Fukushima Nuclear Accident, at http://www.aerb.gov.in/t/news/CNS2012.pdf, accessed on March 16, 2013

provide safety margins for BDBE scenarios like massive tsunami-induced flooding at the Dai-ichi station. The Fukushima accident necessitated that safety margins in NPPs must be enhanced to account for various extreme natural and geological events. The AERB's safety audit has accordingly emphasized on defining the level of BDBE for Indian NPPs.

The AERB action plan also suggested several design-related changes at stations hosting multiple units (reactors). The AERB review observed that seismic trip is provided only at the Narora Atomic Power Station and at sites such as Kaiga and Rawatbhata, only one unit has seismic instrumentation, whereas other units share alarm signals.[8] After Fukushima, the NPCIL has been directed to provide seismic trip for all the reactors. Similarly, the NPCIL task forces have recommended setting up of an advance tsunami alert mechanism at the Tarapur Atomic Power Station which houses two Boiling Water Reactors of the Fukushima vintage. In addition to this, the NPCIL has recommended additional shore protection measures at the Madras and Tarapur Atomic Power Stations, which are located near the sea coast. The task forces have suggested additional hook-up points to bring water to the spent fuel pools at Units 1 & 2 each of Tarapur, Rajasthan and Madras, which have been implemented in the immediate aftermath of Fukushima crisis.[9]

Regulatory Overhaul

The Atomic Energy Regulatory Board has been exercising regulatory control since its inception in 1983. In the aftermath of Fukushima accident, the Indian government received widespread criticism for handing over the job of safety audits to the AERB, which institutionally reports to the nuclear energy promoters, i.e. the DAE. Institutionally, the AERB was constituted under the aegis of the AEC which, critics argue, compromises its regulatory mandate. In the light of various international norms and regulatory best practices, the Indian government decided to strengthen the legal framework for regulation of safety in country's nuclear facilities.[10] The bill for a new regulatory authority – Nuclear Safety Regulatory Authority – was introduced in Parliament in September 2011. With the promulgation of the Nuclear Safety Regulatory Authority (NSRA) Bill 2011, the NSRA will subsume the activities of the AERB. This would not only boost confidence NPPs but would also promote the development of expertise in the Indian university systems.

'Managing the Unexpected'

The Fukushima accident called for comprehensive review of emergency preparedness measures to deal with nuclear accidents causing major off-site implications. In order to evaluate the response and coordination among different agencies during the nuclear emergency, the National Disaster Management Authority (NDMA), NPCIL and AERB

[8] Report of AERB Committee, at http://www.aerb.gov.in/t/documents/report-nov.pdf

[9] 'Nuclear plants to get additional safety features', *The Hindu*, April 14, 2011, URL: http://www.thehindu.com/news/national/nuclear-plants-to-get-additional-safety-features/article1696723.ece?ref=relatedNews, Accessed on March 17, 2013

[10] PM promises independent nuclear regulator, *The Hindu*, March 30, 2011, at http://www.thehindu.com/news/national/pm-promises-independent-nuclear-regulator/article1582822.ece?ref=relatedNews, accessed on March 19, 2013

reviewed the existing emergency preparedness measures and response plans at all the NPP sites.[11] The Fukushima accident response system highlighted various shortcomings in the emergency preparedness plans and the inter-agency co-ordination required in monitoring and mitigation of the accident. Subsequent to the Fukushima accident, the NDMA organised mock exercises at all the NPPs and reviewed the preparedness among all the agencies for effective implementation of radiation countermeasures.[12] The AERB has also undertaken a review of off-site emergency plans based on the results of exercises conducted by NDMA and to integrate important elements of the Incident Response System in the existing emergency preparedness plans. These reviews have highlighted some of the key strengths in the existing emergency plans and suggested measures for effective management and mitigation of a nuclear disaster.

The way forward

The Fukushima accident has presented a serious challenge for India's nuclear energy managers. It has clearly shook people's faith in safety of nuclear energy all over the world. Given the heightened sense of concerns over nuclear energy; there is a growing realisation among the scientific community in India about improving the public interface with nuclear energy infrastructure in the country. To allay fears about radiation and nuclear accidents after crisis in Japan, several public outreach channels have been opened up. The DAE is actively working towards improving public participation in its various new and existing projects. While a moderate and manageable nuclear programme can meaningfully supplement the country's growing energy needs, it is imperative that the people's confidence in safety of nuclear energy is restored. One of the ways to achieve this is through making the nuclear safety processes more transparent through effective risk dialogue with all the stakeholders.

[11] NPCIL, Review of Indian NPPs, at http://www.npcil.nic.in/pdf/presentation.pdf. pp.62 accessed on March 20, 2013.

[12] Development of Infrastructure for Rehabilitation of Families in and Around Kaiga Nuclear Plant, at http://pib.nic.in/newsite/erelease.aspx?relid=79895, accessed on March 20, 2013

Safety mechanisms in China post Fukushima: An overview

-Manasi Pritam

There has been a huge furore over various aspects of nuclear safety, security and regulation in the wake of the Fukushima incident in 2011. Apart from the International Atomic Energy Agency's (IAEA) standard safety reviews, there has been considerable pressure on governments by experts and various activist groups to take rigorous nuclear safety measures. Even in China, immediately after the Fukushima disaster, reports claimed that the regime might be rethinking its grand atomic energy plans, even to the extent of abandoning nuclear energy altogether.[1] Such speculation was fuelled by the decision of the Chinese State Council to scrap the approval of new nuclear projects barely five days after the massive earthquake and tsunami hit Japan. The government also halted four nuclear ventures which were due to start construction in 2011 even before the post-Fukushima wave of demonstrations began. What have been the developments regarding nuclear regulation in China since? How did Fukushima impact China's massive nuclear energy drive, if at all? What are the regulatory mechanisms in place in China? These are some of the questions this article seeks to cover.

China has the largest upcoming and most ambitious nuclear programme in the world, with about 40 per cent (26 out of 63[2]) of the world's under-construction reactors and 50 more in the pipeline for construction. All nuclear operations are run by three state-owned corporations – the China National Nuclear Corporation (CNNC), the China Guangdong Nuclear Power Corporation (CGNPC) and the China Power Investment Corporation (CPI). The China Atomic Energy Authority (CAEA) is the regulatory agency in China which is responsible for overseeing all its nuclear energy projects. It is pertinent to remember here that state ownership of nuclear corporations and agencies is a universal phenomenon, barring a few exceptions, and not unique to China.

The consciousness about nuclear safety is not something new amongst analysts and the public, even in China. Before Fukushima, serious concerns had been raised regarding the frenzied pace of the Chinese nuclear energy programme from 2001 onward. In fact, in 2010 the head of China's National Nuclear Safety Administration (NNSA) had warned the public about minor accidents that regularly occurred at Chinese nuclear plants. Xu Yi-chong[3] identifies the following challenges that have compromised the safety of nuclear energy plants in China – the frantic pace of the Chinese nuclear programme, the pressure to commence new

[1] 'Will China's nuclear nerves fuel a boom in green energy', Channel 4, at http://www.channel4.com/news/will-chinas-nuclear-nerves-fuel-a-boom-in-green-energy, Accessed on April 10, 2013

[2] 'World Energy Perspective: One year after Fukushima', World Energy Council publication, at http://www.worldenergy.org/wp-content/uploads/2012/10/PUB_world_energy_perspective__nuclear_energy_one_year_after_fukushima_2012_WEC.pdf , Accessed on April 11, 2013

[3] Xu Yi-chong, 'Nuclear Power in China: How it really works', Global Asia, March 2012. at http://www.globalasia.org/V7N1_Spring_2012/Xu_Yi-chong.html Accessed on April 12, 2013

nuclear projects and approve them in order to fulfil ambitious deadlines, the choice of nuclear reactors and a shortage of qualified nuclear engineers, scientists and skilled workers.

Yi-chong explains that although the Chinese nuclear industry is fully assimilated with the global nuclear industry due to extensive international collaboration (so much so that its Regulations on Nuclear Safety which were adopted in 1996 are a carbon copy of the American regulatory standards), the implementation of safety mechanisms in China is hugely hampered by a fragmented political system with a constant power struggle between weak regulatory institutions, government agencies and powerful corporations (which are owned by different and competing government agencies) with vested interests resulting in poor coordination and planning of nuclear energy policy. Moreover, despite being a member of the IAEA and a signatory of its 1994 Convention of Nuclear Safety, it is difficult, if not impossible, to ensure there is no or little political interference by an authoritarian regime when it comes to adherence to internationally prescribed technical safety regulations that include siting, earthquake risks, population distribution and geotechnical hazards. Even the selection of reactor types (foreign designs versus indigenous designs) has been eclipsed by financial gains, international geopolitical considerations, bureaucratic rivalries and domestic politics rather than safety, which has often led to the precedence of technically inferior designs (Generation II or II+ reactors over the Generation III reactors and the delay in new and fully indigenous Generation IV reactors), even in the post-Fukushima scenario.

Nevertheless, despite the above political, organisational, operational and legal challenges stated above, there are numerous steps that China has initiated to increase nuclear safety in the aftermath of Fukushima that need to be taken into account. For instance, it continues to allow fairly regular visits by IAEA and other international inspectors to review and assess the quality and safety of its nuclear energy plants. China was also the first country to conduct a comprehensive re-evaluation of all its nuclear plants post Fukushima. It also took the drastic step of suspending all its new nuclear projects[4].

After the evaluation, it was decided that the pace of the nuclear program be slowed down, and lofty targets for 2020 be reduced considerably. In October 2012, a new proposal based on rigorous reviews and inspections was introduced by the State Council which is called the 'Medium- and Long-term Nuclear Power Development Plan (2011-2020)'.[5] Broadly, the plan calls towards a "return to normal construction a controlled and orderly pace",[6] to limit the number of new reactors to be built on Chinese Coastal Sites, a ban on new inland nuclear power projects and the requirement that all new projects meet the safety standards of at least Generation III reactors.

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[4] 'China completes post Fukushima nuclear inspection', Reuters, August 2011, at http://www.reuters.com/article/2011/08/11/china-nuclear-safety-idAFL3E7JB0K920110811, Accessed on April 13, 2013

[5] Hui Zhang and Shanghui Zao, 'China moves cautiously ahead in nuclear energy', Bulletin of Atomic Scientists, April 2013, at http://www.thebulletin.org/web-edition/features/china-moves-cautiously-ahead-nuclear-energy Accessed on April 13, 2013

[6] Ibid.

China now expects to grow its total nuclear capacity to 58 million kilowatt (kw) by 2020, a considerable reduction from more than 80 million kw that the country had previously expected and was aiming for. According to a white paper on 'China's Energy Policy 2012', China expects its installed capacity of nuclear power to reach 40 million kw by 2015[7] along with simultaneously relying on developing renewable sources of energy such as hydropower, wind power, solar power and biomass through massive investment.

China's report on 'The 12th Five year plan and the 2020 vision of Nuclear Safety and Radioactive Pollution Prevention Plan', which was approved by the State Council, pointed out the lack of adequate accident prevention and mitigation mechanisms in some of the older facilities and has allocated $13 billion worth of investment in nuclear safety improvement, radioactive pollution control, scientific research and innovation, accident and emergency response, and regulatory capacity building by 2015. This allocation for revamping facilities for the purpose of nuclear safety is undoubtedly one of the highest investments by any state. Of the plan's 34 approved reactors, the construction of four units, due to start in 2011, was suspended; but the construction of three other units was begun after March 2011 and two reactors were connected to the network in 2011.[8] Moreover, the new safety requirements advocated by China's National Energy Commission (NEC) have called for a 10-20 per cent increase in capital costs for each nuclear plant in pushing for home-grown Gen III nuclear reactors.[9]

It is clear on reviewing the developments that China's nuclear programme underwent post Fukushima that China is serious about relying on nuclear power massively for its energy needs in the future, and has therefore taken up the challenge of nuclear safety head-on. It is keen on not making any compromises on nuclear security as it is keen on keeping nuclear energy as its foremost priority for its energy plans while simultaneously pursuing and developing other forms of energy which are renewable such as wind, solar and biomass but only to supplement nuclear energy. At the same time, it is pertinent to note that even though China's response to Fukushima was swift, there remain several political, structural and operational impediments that remain and that it must face in order to pursue its objectives.

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[7] 'China's Energy Policy 2012: Full Text', China white paper, at http://news.xinhuanet.com/english/china/2012-10/24/c_131927649_5.htm Accessed on April 14, 2013

[8] 'World Energy Perspective: One year after Fukushima', World Energy Council publication, at http://www.worldenergy.org/wp-content/uploads/2012/10/PUB_world_energy_perspective__nuclear_energy_one_year_after_fukushima_2012_WEC.pdf, Accessed on April 13, 2013

[9] Hui Zhang and Shanghui Zao, 'China moves cautiously ahead in nuclear energy', Bulletin of Atomic Scientists, April 2013, at http://www.thebulletin.org/web-edition/features/china-moves-cautiously-ahead-nuclear-energy Accessed on April 13, 2013

Interview with Dr Yukiya Amano, IAEA Director General
By Shekhar Gupta,
Indian Express, March 26, 2013

In this Walk the Talk on NDTV 24x7 with The Indian Express Editor-in-Chief Shekhar Gupta, Yukiya Amano, Director General, International Atomic Energy Agency, speaks about the Fukushima disaster, India's nuclear programme and why "nuclear power is much safer than before"

My guest today is somebody who has a formidable job and a tough case. He has to speak for the future of nuclear energy in this very sceptical world and also in an increasingly sceptical country, India—Yukiya Amano, Director General of International Atomic Energy Agency. India is as tough a place as any to go to these days for you.

This is a very nice place.

We are having this conversation almost exactly on the second anniversary of Fukushima. There are doubts about nuclear energy all over the world. IAEA got the Nobel Prize for promoting the idea of peaceful uses of nuclear energy. Do you still have a case or is the case lost?

Fukushima was a very huge accident and a very severe accident. It was a very difficult thing for me because it happened in my own country, Japan, and just after the accident, many people believed that this is the end of nuclear power. Two years have passed and the worst is already in the past. What is happening now, some countries like Germany or Italy or Belgium decided to phase out...

Italy is in very bad odour in my country these days, so I don't think India is going to follow what they have done.

Some countries decided to phase out nuclear power or decided to change course. But many other countries continue to use nuclear power as an important option. According to the IAEA's latest estimate, by 2030, there will be increase in 23 per cent minimum, or 100 per cent maximum. So nuclear power continues to be an important option for many countries.

Since Fukushima, the first new plant has begun to be constructed. It is in the UAE.

Yes.

But what do you tell your own Japanese countrymen who are so doubtful about nuclear energy?

I would say that, of course, the accident was caused by this huge tsunami and earthquake, but there were a lot of human errors and people got a little bit complacent, especially in the

utilities. That was a huge wake-up call for safety. After the Fukushima accident, lots of improvements have been made to enhance the safety level. And I saw it in India.

Are you satisfied with the safety levels in India?

We are not inspectors on safety issues; we are helping countries improve the safety. The important thing is to learn lessons from Fukushima and think jointly how we can make it (nuclear power) safe.

You talked about human errors in Fukushima. That's the worry. Human errors in driving a car may lead to one or two deaths. Human error in flying a plane, hundreds of deaths. But human error in running a nuclear plant...god knows what will happen. Then why take the risk? I am presenting the other case to you.

Yes. There are a lot of lessons we can learn from Fukushima. For example, people thought that a blackout will not happen in Japan, but it did. So the emergency diesel generator should be properly installed.

That's not a problem, because in India we are used to power outages.

Also, water is needed to cool down the plant. I visited Tarapur and I saw the outside hook-up has been installed and they have painted it red so one can see immediately—that in an emergency, we have to hook up water to this pipe and then the reactors can be cooled down. That is essential in case of an accident.

Was Fukushima an obsolete reactor? Would a newer reactor have survived this?

I don't say old reactors are dangerous and new ones are safe, but it is obvious that new reactors can take lessons from past experience... All reactors can be also safe using retro-fitting, for example.

In many countries, even France, which still use nuclear energy and which are still setting up new plants, the basic psychology is, 'I don't mind nuclear power but don't set up a nuclear power plant close to where I live...' Will you live next to a nuclear power plant?

Some distance perhaps. But with proper measures. We cannot say there is 100 per cent safety. But we can make a nuclear plant as safe as humanly possible and even if an accident takes place, we can mitigate the effects by taking various measures. Prevention and mitigation, these two are essential.

As the foremost spokesman for nuclear energy globally, did it get you angry the way Fukushima was handled?

On my part, I concentrated my efforts to help Japanese overcome this difficult phase. And then, I tried to pass the information to everyone in the world. Now we are at the post-Fukushima phase. So my priority number one is to implement the plan that everyone agreed to after Fukushima in order to make nuclear power safer.

You said you don't mind living close to a nuclear power plant but at some distance. First of all, how much distance?

There is no particular distance. We cannot, of course, live inside the power plant. When an accident happens, we have to follow the instructions, the advice of the authorities. For example, in the case of Fukushima, hundreds of people were evacuated but no one was killed or injured. So orderly evacuation is needed in case of an accident but, of course, we had better prevent such an accident from happening.

So what will you say to the fishermen who live around the Koodankulam plant who are protesting and who are worried about what might happen to them?

Monitoring is very important, preventing the accident is important and if an accident happens, reduce the release of radioactivity into the environment to the minimum level possible. But in most of the cases, the release of radioactivity into the environment is very rare or very limited. Surprisingly, the nuclear industry has a good record of safety. The problem is that there are some accidents that are not likely to happen but when it happens, the impact is huge. This is the problem.

At Fukushima, estimates of whether radiation was escaping or how much was escaping varied a great deal. What was your assessment? How much leaked at Fukushima?

I don't have the figure but it was the most serious accident after Chernobyl and there was complacency. But a good example is that another nuclear power plant 20 km south of Fukushima was not affected. With some proper precaution and measures, we can prevent the accident developing into such a serious one.

So have you followed the agitations taking place at Koodankulam? These are Russian reactors that are coming up in south India.

I've been following... In my view, the most important thing is to be transparent.

Those reactors are under your safeguards.

Yes. But safeguard is one thing and safety is another.

But you are going to be there?

Yes, the IAEA is working with the Indian government.

I know, people sometimes misunderstand IAEA safeguards to mean IAEA supervising safety. You are only supervising safety of non-leakage of fissile material and misuse.

Exactly. Safety is the responsibility of the government and our role is to help them.

For clarity, when you say IAEA safeguards, it is to safeguard non-proliferation interests.

Exactly. To prevent the nuclear material from being used for military purposes.

Say something to the fishermen of Koodankulam because its reactors will start producing power in a couple of weeks now.

I think people have to address this issue in a scientific manner and in the most transparent manner. Emotion does not solve the problem. And I recommend to the Indian government to be as transparent as possible. For the population too, it is much better to have a good discussion, good dialogue with other stakeholders.

The problem with nuclear plants is there is so much secrecy around them that people automatically become suspicious.

I would say not secrecy but people complicate an issue which is already complicated. Let's be more simple, let's focus on the basics. Nuclear power plants have the risk of accidents as is the case with many other industries, but we can prevent it. And even though accidents happen, we can reduce that possibility to the minimum level possible.

Now these new reactors India is looking at—the French EPR—have you studied them? Are they safe/unsafe, tested/untested?

I have visited the construction site of EPR in Finland. It is a huge nuclear power plant with lots of safety features. So it is a very well-studied reactor, but there are also other reactors.

That has been shortlisted for our Jaitapur project.

There are many types of reactors and every reactor has advantages and disadvantages. So it depends on the need of the country.

So what about the criticism that India is installing an untested reactor? Is it an untested reactor or is that a misnomer?

It is not yet in operation in the market, but it is based on tested technology. It's not something that comes from heaven. Nuclear power operators have long experience in operating it and this is the result of the improvement.

What is your impression of the Indian nuclear establishment? You have been dealing with them for a long time.

They have some very capable people. You have a pool of human resources—this is very rare in many countries. Human capacity building is the biggest problem in many countries. But in your country, you have hundreds, thousands of people working in this field and they are very bright, responsible people. Now the market is open for cooperation with other countries. The IAEA is sending review missions. Your government accepted peer review for....

Rawatbhata...

Yes. What we call OSART (Operation Review Safety Team) mission to review the operation. I think this openness is very important.

From OSART, what comes next in the hierarchy of...

Not hierarchy, but there are many services and one very important area that we are focusing on is the regulatory body, review of the regulatory body.

The AERB, Atomic Energy Regulatory Board.

The independence of the regulatory body is very important.

Because there are many doubts in India that it is not autonomous enough, that there is a lack of transparency.

That is not the problem only in India but we are recommending all the countries to establish a robust and independent regulatory body. One of the biggest lessons that we learnt from Fukushima is that the Japanese regulatory body was not robust enough, was not independent enough and as a consequence, oversight on the industry was weak.

So they were not asking the right questions?

They were not asking the right questions and they were not taking the right measures. Now it has changed.

Or they were not asking the right questions nor insisting on the answers? They were complacent.

Right.

In fact, that is the worry in India. For many of us who supported the Indo-US civil nuclear deal, this was one of the reasons—we thought greater transparency will make our nuclear energy programme safer because more will be available in the public domain. And peer review...

Your country invited the peer review mission and your country is seriously considering to reform the regulatory body and we are recommending it.

And you are convinced by that, that they mean it?

Every country has a way to do it but the important thing is that the regulatory body should be independent and robust. And the Indian government is working in that direction.

Since India signed the civil nuclear agreement, it's been ratified by the Nuclear Suppliers' Group. India has adhered to its schedule of separation of civil and military installations. In fact, in many of our campuses, two units are civil and, under your safeguards, two are not. What in principle can be the objection to India joining NPT as a nuclear weapons power?

It is for the sovereign states to decide. And we are not the state, we are an international organisation.

I'm seeking your scholarly view.

My personal view is that this world should be free from nuclear weapons. Lots of efforts should be done for that. For the time being, it's the decision of each country whether to join or not to join the NPT.

If India were to join the NPT as a nuclear weapons power, it might just join, because then, it is not discriminatory to India.

Ah. I see. For that, the NPT should be amended. And in reality, it is extremely difficult.

To amend it?

I don't think it is possible.

But do you think the time has come to modernise it so that it is more in tune with the changed times?

The NPT is a product of compromise. Changing it is extremely difficult. What is needed is to implement it, improve the implementation. That is the focus for now.

Just as changing it is difficult, defying it has become easier. Because you see Iran, Israel, North Korea happily defying it. And many countries defying it also in supplying technology to Pakistan?

The task that the IAEA is facing to ensure or encourage countries to fully implement is a huge challenge. But I don't think only the IAEA can do it. We need support from the United Nations and from member states. All the stakeholders need to work together.

Many of us worry that if this could happen in Japan, which is known for a very tough work culture, discipline and punctuality, think of India. We have a chaotic way of working, discipline is all over the place, we believe in the concept of jugaad. Can we handle nuclear power?

I don't think the accident at Fukushima was because of the lack of technology. It was because of severe natural hazards and also complacency. But now, people have learned that even a country, an industrialised country, like Japan, cannot get rid of this. So if countries learn lessons from Fukushima, I think nuclear safety would be much more enhanced.

How much more time before people begin to forget Fukushima and move on, before nuclear energy finds enthusiasm again? Because now it has also got competition from shale gas.

We should not forget because safety is most important. At the same time, we should not be dragged by the accident forever. There are other important elements. How can we ensure development without sufficient electricity? How can economy be competitive? How can we fight against climate change? These elements must be properly considered and in that consideration, nuclear power has a role to play.

And shale gas?

The role is different. Every source of energy has advantages and disadvantages. Like nuclear, shale gas has an advantage. But solar power, windmill, all of them have advantages. I don't exclude any possibility but the key word is the best mix. And nothing should be excluded for now.

So 10 years from now, do we see more nuclear power plants operational or fewer?

Much more. According to our estimates, there will be 80 to 90 more or 100 more...

In the next 10 years?

By 2030. Now 66 nuclear power plants are under construction.

Nobody complains about what is under construction in China anyway. The first EPRs will also be rising in China.

Yes. Although the construction of nuclear power plants is in progress, the total percentage of electricity produced by nuclear power will reduce, decrease.

Because other power will come up...

Yes. Renewable, natural gas and coal will be used much more rapidly.

The Chinese build one coal-fired plant every week.

China's economy is expanding rapidly and they need the electricity.

So is ours. That is why some of us who support the idea of nuclear power, we need more reassurance from people like you.

Safety should come first and this is the lesson that we have learned from Fukushima. But with more caution, with further measures, I am very confident that nuclear power is much safer than before.

Well, you are an optimist.

I have to be, otherwise I cannot do this job.

Stay so, because the problem with nuclear power is you have to resell the idea every two decades. It happened after the Three Mile Island episode, it happened after Chernobyl and it is happening now. But in this case, you will have to first sell it to your fellow Japanese because only when they warm up to nuclear power again, will the rest of the world lower its scepticism.

Already the change is taking place in Japan. Just after the Fukushima accident, they thought, 'Oh, nuclear power is bad. Let's phase out nuclear power by 2030'. Then they started to think perhaps this is not the right answer. And the prime minister said they will not consider the phase-out by 2030. And now they have a very robust independent regulatory body and the prime minister said when safety is confirmed, the nuclear power plants will resume their operation. So already, we have changed.

Stay an optimist and so are we. And I do hope our government works similarly on its regulatory body, because then things will be more reassuring.

We will work together with your government.

Documentation

1) Fukushima Nuclear Accident: Fukushima Nuclear Accident in Focus

IAEA Fukushima Daiichi Status Reports: The IAEA issues regular Status Reports to the public on the current status of the Fukushima Daiichi Nuclear Power Plant, including information on environmental radiation monitoring, the status of workers and current conditions on-site at the plant.

URL: http://www.iaea.org/newscenter/focus/fukushima/status-reports.html

2) The National Diet of Japan: the official report of the Fukushima Nuclear Accident Independent Investigation Commission: Executive Summary and Main Report

On October 30, 2011, the NAIIC Act (officially, the Act regarding Fukushima Nuclear Accident Independent Investigation Commission) was enacted, creating an independent commission to investigate the Fukushima accident with the authority to request documents and request the legislative branch to use its investigative powers to obtain any necessary documents or evidence required. This was the first independent commission created in the history of Japan's constitutional government. On December 8, 2011, our chairman and nine other members were appointed, and charged by the Speaker and the President of the National Diet with the following mandate, in accordance with Article 10 of the NAIIC Act

URL: http://www.nirs.org/fukushima/naiic_report.pdf and
URL: http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/report/

3) The American Nuclear Society Special Committee on Fukushima: A Report, March 2012

The Tohoku earthquake, which occurred at 2:46 p.m. (Japan time) on Friday, March 11, 2011, on the east coast of northern Japan, is believed to be one of the largest earthquakes in recorded history. Following the earthquake on Friday afternoon, the nuclear power plants at the Fukushima Daiichi, Fukushima Daini, Higashidori, Onagawa, and Tokai Daini nuclear power stations (NPSs) were affected, and emergency systems were activated. The earthquake caused a tsunami, which hit the east coast of Japan and caused a loss of all on-site and off-site power at the Fukushima Daiichi NPS, leaving it without any emergency power. The resultant damage to fuel, reactor, and containment caused a release of radioactive materials to the region surrounding the NPS.

URL: http://fukushima.ans.org/report/Fukushima_report.pdf

The American Nuclear Society Special Committee on Fukushima: A Report (Revised), June 2013

The Tohoku earthquake of 2011 is believed to be one of the largest earthquakes in recorded history. It, along with the tsunami it triggered, is estimated to have caused nearly 20,000 deaths and economic losses approaching $500 billion (USD). Yet, despite the sheer scale of destruction in northeastern Japan, the accident at the Fukushima Daiichi nuclear power station (NPS) has come to define the tragedy for many and has become a momentous event in nuclear power technology. The American Nuclear Society (ANS) formed a special

committee, The American Nuclear Society Special Committee on Fukushima (the Committee), to examine the Fukushima Daiichi accident.

URL: http://fukushima.ans.org/report/Fukushima_report.pdf

4) Examination of Accident at Tokyo Electric Power Co., Inc.'s Fukushima Daiichi Nuclear Power Station and Proposal of Countermeasures: Japan Nuclear Technology Institute, October 2011

We, the Examination Committee on Accident at Fukushima Daiichi Nuclear Power Station, recognize that the accident at Tokyo Electric Power Co., Inc.'s Fukushima Daiichi Nuclear Power Station (hereafter called Fukushima Daiichi) caused by the Great East Japan Earthquake has shaken the foundation of the Japanese nuclear industry, and damaged the credibility of Japanese nuclear engineers. It has therefore made people deeply skeptical of the morale of the engineers who could not prevent the accident.
URL: http://www.gengikyo.jp/english/shokai/Tohoku_Jishin/report_20120220.pdf

5) Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety - The Accident at TEPCO's Fukushima Nuclear Power Stations

The Tohoku District - off the Pacific Ocean Earthquake and tsunami caused by the earthquake attacked the Fukushima Dai-ichi and Fukushima Dai-ni Nuclear Power Stations (hereinafter referred to as Fukushima NPS) of Tokyo Electric Power Co. (TEPCO) at 14:46 on March 11, 2011 (JST, the same shall apply hereinafter) and a nuclear accident followed at an unprecedented scale and over a lengthy period. For Japan, the situation has become extremely severe since countermeasures to deal with the nuclear accident have had to be carried out along with dealing with the broader disaster caused by the earthquake and tsunami.
URL: http://www.kantei.go.jp/foreign/kan/topics/201106/pdf/chapter_i.pdf

6) Japanese Ministry of Economy, Trade and Industry comprehensive report on the accident and its implications, March 8, 2012

URL: http://www.meti.go.jp/english/earthquake/nuclear/japan-challenges/index.html

7) Additional Report of the Japanese Government to the IAEA (Second Report)

The Nuclear Emergency Response Headquarters of the Government of Japan prepared for the International Atomic Energy Agency (IAEA) Ministerial Conference on Nuclear Safety convened in June 2011 a report (hereinafter referred to as the "June Report") addressing the situation of the accident at the Tokyo Electric Power Company' (TEPCO) Fukushima Nuclear Power Stations which occurred on March 11 of this year. This report covered the occurrence and development of the accident, responses to the nuclear emergency, lessons learned from the accident until that time, and other such matters.

URL: http://www.meti.go.jp/english/earthquake/nuclear/iaea/iaea_110911.html

8) Fukushima Nuclear Accident Analysis Report (Interim Report): The Tokyo Electric Power Company, Inc., December 02, 2011

This report identifies causes of the accident at the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as “Fukushima accident”) based on the facts and analysis results that have been verified to date and proposes necessary countermeasures to enhance the safety of existing nuclear power plants. Identifying the countermeasures is based on a discussion on technical issues for preventing core damage. It is important to reflect lessons learned from the Fukushima accident
in both facilities and operations to prevent similar events from occurring again.

URL: http://www.tepco.co.jp/en/press/corp-com/release/betu11_e/images/111202e14.pdf

9) TEPCO: Fukushima Daiichi - A One Year Review

First of all, we deeply apologize to all residents of Fukushima Prefecture as well as broader society for the concern and anxiety that has arisen on account of the accident at Fukushima Daiichi Nuclear Power Station (NPS) due to the March 11, 2011 Tohoku - Pacific Ocean Earthquake. The accident at Fukushima Daiichi NPS was caused by the loss of reactor core cooling functions and the prolonged simultaneous loss of all Alternate Current (AC) and Direct Current (DC) power due to the 13 meter-height tsunami brought about by the massive M9.0 earthquake. What followed after was the extremely serious accident in which a series of explosions occurred at the reactor buildings and radioactive materials were released into the atmosphere and ocean.

URL: http://www.tepco.co.jp/en/nu/fukushima-np/review/index-e.html

10) Fukushima Nuclear Accident Analysis Report: Tokyo Electric Power Company, Inc, June 20, 2012

The objective of this report is to investigate the causes of the accident at the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Fukushima Accident" or "this accident") based on the facts known to date and the results of several analyses and to propose necessary countermeasures to contribute to improving the safety at other existing nuclear power stations (hereinafter referred to as "NPS"). Therefore, issues concerning the prevention of core damage have mainly been considered based on the perspective that it is important to utilize the actual event that transpired to improve administration and facilities, and thereby prevent a future recurrence of similar events.

Executive Summary:
URL: http://www.tepco.co.jp/en/press/corp-com/release/betu12_e/images/120620e0102.pdf
Main Report:
URL: http://www.tepco.co.jp/en/press/corp-com/release/betu12_e/images/120620e0104.pdf

11) SANDIA REPORT: Fukushima Daiichi Accident Study, SAND2012-6173, July 2012

In response to the accident at the Fukushima Daiichi nuclear power station in Japan, the U.S. Nuclear Regulatory Commission (NRC) and Department of Energy agreed to jointly sponsor an accident reconstruction study as a means of assessing severe accident modeling capability of the MELCOR code. MELCOR is the state-of-the-art system-level severe accident analysis code used by the NRC to provide information for its decision-making process in this area. The objectives of the project were: (1) collect, verify, and document data on the accidents by developing an information portal system; (2) reconstruct the accident progressions using

computer models and accident data; and (3) validate the MELCOR code and the Fukushima models, and suggest potential future data needs.

URL: http://energy.sandia.gov/wp/wp-content/gallery/uploads/Fukushima_SAND2012-6173.pdf

12) Interim Report: Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo Electric Power Company, December 26, 2011

The Investigation Committee on the Accident at the Fukushima Nuclear Power Stations (the Investigation Committee) of Tokyo Electric Power Company (TEPCO) was established by the Cabinet decision on May 24, 2011. Its objectives are: to conduct investigation for finding out the causes of accidents at the Fukushima Dai-ichi Nuclear Power Station (Fukushima Dai-ichi NPS) and Fukushima Dai-ni Nuclear Power Station (Fukushima Dai-ni NPS) of TEPCO as well as the causes of accident damage; and to make policy recommendations for limiting the expansion of damage and preventing reoccurrence of similar accidents.

Interim Report, URL: http://www.cas.go.jp/jp/seisaku/icanps/eng/interim-report.html
Final Report, URL: http://www.cas.go.jp/jp/seisaku/icanps/eng/final-report.html

13) Recommendation for Enhancing Reactor Safety in 21st Century: The Near Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident, July 12, 2011

The Near-Term Task Force was established in response to Commission direction to conduct a systematic and methodical review of U.S. Nuclear Regulatory Commission processes and regulations to determine whether the agency should make additional improvements to its regulatory system and to make recommendations to the Commission for its policy direction, in light of the accident at the Fukushima Dai-ichi Nuclear Power Plant. The Task Force appreciates that an accident involving core damage and uncontrolled release of radioactive material to the environment, even one without significant health consequences, is inherently unacceptable.

URL: http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf

14) Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station, INPO 11-005, November 2011
The Institute of Nuclear Power Operations has compiled a detailed timeline of events at the Fukushima Daiichi nuclear power station after the March 11 earthquake and tsunami in Japan. The detailed report, prepared as part of the integrated response to the Japan events, was delivered on Nov. 11, 2011, to U.S. industry executives, the Nuclear Regulatory Commission and members of Congress.

URL:http://www.nei.org/corporatesite/media/filefolder/11_005_Special_Report_on_Fukushima_Daiichi_MASTER_11_08_11_1.pdf

15) Japanese earthquake and tsunami: Implications for the UK nuclear industry Final Report: HM Chief Inspector of Nuclear Installations: Office for Nuclear Regulation: An agency of HSE, September 2011
On the 14 March 2011 the Secretary of State (SoS) for Energy and Climate Change requested HM Chief Inspector of Nuclear Installations to examine the circumstances of the Fukushima

accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry. The aim of this report is to identify any implications for the UK nuclear industry, and in doin g so co-operate and co-ordinate with international colleagues. The SoS requested that an Inter im Report be produced by the middle of May 2011, with a Final Report six months later. The Interim Report was published in May 2011. This is the Final Report, referred to above.

URL: http://www.hse.gov.uk/nuclear/fukushima/final-report.pdf

16) IAEA International Fact Finding Expert Mission of the Nuclear Accident Following the Great East Japan Earth-quake and Tsunami: Tokyo, Fukushima Dai-ichi NPP, Fukushima Dai-ni NPP and Tokai NPP, Japan, 24 May- 1 June 2011

Preliminary Summary: The Great East Japan Earthquake on 11 March 2011, a magnitude 9 earthquake, generated a series of large tsunami waves that struck the east coast of Japan, the highest being 38.9 meters at Aneyoshi, Miyako. The earthquake and tsunami waves caused widespread devastation across a large part of Japan, with more than 14,000 lives lost. In addition to this, at least 10,000 people remain missing; with many more being displaced from their homes as towns and villages were destroyed or swept away. Many aspects of Japan's infrastructure have been impaired by this devastation and loss.

URL: http://www.iaea.org/newscenter/focus/fukushima/missionsummary010611.pdf

17) Congressional Research Service: Fukushima Nuclear Disaster, Mark Holt, Richard J. Campbell, Mary Beth Nikitin, January 18, 2012

The huge earthquake and tsunami that struck Japan's Fukushima Daiichi nuclear power station on March 11, 2011, knocked out backup power systems that were needed to cool the reactors at the plant, causing three of them to undergo fuel melting, hydrogen explosions, and radioactive releases. Radioactive contamination from the Fukushima plant forced the evacuation of communities up to 25 miles away and affected up to 100,000 residents, although it did not cause any immediate deaths. Tokyo Electric Power Company (TEPCO) operates the Fukushima nuclear power complex in the Futaba district of Fukushima prefecture in Northern Japan.

URL: http://www.fas.org/sgp/crs/nuke/R41694.pdf

18) The Nuclear Safety and Quality Assurance Meeting's Accident Investigation Examination Committee's Opinion of the Tokyo Electric Power Company's "Fukushima Nuclear Accident Investigation Report (Midterm Report)", November 2011

In order to investigate the accident that occurred at the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Fukushima Daiichi NPS) as the result of the large earthquake and subsequent tsunami that struck eastern Japan on this past March 11, the Tokyo Electric Power Company (hereinafter referred to as, "TEPCO") established an internal Fukushima Nuclear Accident Investigation Committee as well as an Accident Investigation Examination Committee (hereinafter referred to as, "Examination Committee") for the purpose of providing opinions and advice from an objective standpoint as an expert third-party in regard to the aforementioned investigation.

URL: http://www.tepco.co.jp/en/press/corp-com/release/betu11_e/images/111202e15.pdf

19) NEI White Paper on the GE Mk I containment in the United States: Mark I Containment Report, March 19, 2011

This paper describes the Mark I containment design in use in the 23 U.S. reactors and its ability to fulfill its safety function in containing fission product releases under design basis conditions. It also offers, as an initial matter, some observations about the performance of the Mark I containment under many beyond-design-basis events experienced at Fukushima Daiichi in March 2011.

URL: http://files.gereports.com/wp-content/uploads/2011/10/NEI-Mark-1-White-Paper.pdf

20) GE REPORTS: Setting the Record Straight on Mark I Containment History, March 18, 2011

Recently, several news stories have reported that the design of the Mark I containment system in the nuclear reactors at the Fukushima Daiichi Power Plant has a history of problems. As the speculation contained in these stories has been picked up by a number of other media outlets and political commentators, we'd like to set the record straight. We believe it is too early to know specifically what has happened in each of the reactors at Fukushima Daiichi. We are committed to participating in the search for the facts:

URL: http://www.gereports.com/setting-the-record-straight-on-mark-i-containment-history/

21) GE REPORTS: Venting Systems in Mark I Reactors, May 25, 2011

Recent news reports have focused on how the emergency venting system at the Fukushima Daiichi nuclear plant in Japan responded to the massive earthquake and tsunami in March. The reports also pose questions about the performance of U.S. plants with a similar venting system. Here is an update from GE on these two issues:

URL: http://www.gereports.com/venting-systems-in-mark-i-reactors/

22) WHO: Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami, May 2012

The earthquake and tsunami in Japan on 11 March 2011 led to releases of radioactive material into the environment from the Fukushima Daiichi nuclear site. This report describes a preliminary estimate of radiation doses to the public resulting from this accident. These doses are assessed for different age groups in locations around the world, using assumptions described in the report. The dose assessment forms one part of the overall health risk assessment being carried out by WHO of the global impact of the accident at the Fukushima Daiichi nuclear power plant. The health risk assessment is the subject of a separate WHO report published in February 2013.

URL: http://apps.who.int/iris/bitstream/10665/44877/1/9789241503662_eng.pdf

23) The integrity evaluation of the reactor building at unit4 in the Fukushima Daiichi nuclear power station: Government and TEPCO's Mid-to Long Term Countermeasure Meeting Management Council

URL:http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/20120605_01b.pdf

24) Fukushima-Daiichi NPP Site Visit and Decontamination Tour of the Tohoku Region: Presentation to the Ottawa Branch of the Canadian Nuclear Society, February 19, 2013

Japan's Act on Special Measures Concerning the Handling of Radioactive Pollution came into force on January 1, 2012. Based on this act, the following measures are carried out: Planning and implementation of decontamination work Collection, transfer, temporary storage, and final disposal

URL: http://www.nuclearsafety.gc.ca/eng/pdfs/Presentations/VP/2013/20130219-Ramzi-Jammal-Ottawa-Branch_CNS-eng.pdf

24) Demolition and Removal of Structures Damaged or Contaminated as a Result of the Fukushima Accident, Shunichi SUZUKI: January 2013

URL: http://www-pub.iaea.org/iaeameetings/IEM4/30Jan/Suzuki_d.pdf

25) The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events: Forging a New Nuclear Safety Construct, June 2012

The March 2011 Great East Japan Earthquake and Tsunami caused great loss of life and property in the Nation of Japan, and devastation to the environment. The extraordinary forces and flooding unleashed on the East coastal area also led to severe nuclear plant damage and radiological releases at the Fukushima Dai-ichi station. The global impact of the accident at Fukushima prompted the ASME President, Victoria Rockwell, to commission a Presidential Task Force to examine those nuclear plant events and their implications. The unprecedented accident at Fukushima exposed new information on nuclear power plant vulnerabilities to extreme external events and exposed the need for pertinent improvements.

URL: http://files.asme.org/asmeorg/Publications/32419.pdf

26) The Fukushima Nuclear Accident and Crisis Management: Lessons for Japan-U.S. Alliance Cooperation

The immediate cause of the March 2011 accident at the Fukushima nuclear power plant was the melting of the reactor cores and the hydrogen explosions that occurred after the tsunami knocked out all of the plant's electrical supply. In response to this major accident, all relevant actors including the Tokyo Electric Power Co. (TEPCO) and the government authorities have devoted their full energies to cooling the nuclear reactor, receiving cooperation from the United States and France in the process, and currently the situation is calming down. However, there is still a great deal to be done before the reactors can be decommissioned, and with many obstacles still to overcome, the outcome remains unpredictable.

URL: http://www.spf.org/jpus/img/investigation/book_fukushima.pdf

27) Report of Japanese Government to IAEA Ministerial Conference on Nuclear Safety - Accident at TEPCO's Fukushima Nuclear Power Stations - *IAEA*

On 11 March 2011, a nuclear accident took place at the Fukushima Daiichi nuclear power plant (NPP) in Japan, caused by a devastating earthquake and tsunami of unprecedented severity. In many countries public confidence in the safety of nuclear power plants has been shaken. The IAEA responded to the accident with a number of actions: the Incident and Emergency Centre (IEC) of the IAEA was activated; specialized expert missions were dispatched to Japan to assist in understanding the accident and to provide assistance and expertise; on the initiative of the Director General, the IAEA Board of Governors convened to discuss the IAEA response to the accident; and the IAEA Secretariat provided regular briefings for Member States and the international media.

URL: http://www-pub.iaea.org/iaeameetings/42466/IAEA-Ministerial-Conference-on-Nuclear-Safety

28) "Safety Evaluation of Indian NPPs Post Fukushima Incident" - NPCIL

An unprecedented earthquake of magnitude 9 (Richter scale) followed by a Tsunami of height much larger than the value considered in design of Fukushima Dai-ichi Plant had hit north eastern part of Japan on March 11, 2011. There are 13 nuclear power plants, all of Boiling Water Reactor type located in the affected zone. Six of the units are located at Fukushima Dai-ichi (3 under operation and 3 under shutdown), 4 at Fukushima Dai-ini and 3 at Onagawa all operating. The severe earthquake resulted in the disruption of the grid resulting into non-availability of offsite power.

URL: http://www.npcil.nic.in/pdf/Final_Report_Four_TFs_combined_report.pdf

29) IAEA Ministerial Conference on Nuclear Safety - Statement by Dr. S. Banerjee, Chairman of the Atomic Energy Commission & Leader of the Indian delegation - Vienna, June 20, 2011

India joins other countries in expressing its deep condolences to the Japanese people for the sufferings in their country due to the natural disaster that struck them. India also takes this opportunity to convey its appreciation for the efforts of the Japanese people in dealing with the consequences of this tragedy. The accident at the Fukushima Daiichi nuclear power plant in Japan has raised world-wide concerns about the safety of nuclear energy. We convey our appreciation to Director General for the Agency's initiative to organize this timely global Conference on Nuclear Safety. While ensuring nuclear safety is a national responsibility it is imperative that member States join hands to

URL: http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2011/cn200/plenary/p_d1_india.pdf

30) Japanese earthquake and tsunami: Implications for the UK nuclear industry - Final Report - HM Chief Inspector of Nuclear Installations, September 2011

On the 14 March 2011 the Secretary of State (SoS) for Energy and Climate Change requested HM Chief Inspector of Nuclear Installations to examine the circumstances of the Fukushima accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry. The aim of this report is to identify any implications for the UK nuclear industry, and in doing so co-operate and co-ordinate with international colleagues. The SoS requested that an Interim Report be produced by the middle of May 2011, with a Final Report six months later. The Interim Report was published in May 2011. This is the Final Report, referred to above. This report considers the implications for the UK nuclear industry, and has been expanded from focussing mainly on the nuclear power sector to cover all UK nuclear facilities.

URL: http://www.oecd-nea.org/nsd/fukushima/documents/UK_2011_10_finalChiefInspectorreport.pdf

31) Final Report of the International Mission on Remediation of Large Contaminated Areas off-site the Fukushima Dai-Ichi NPP - 7-15, October, 2011

In response to a request made by the Government of Japan, the IAEA organized a fact-finding Mission to support the remediation of large contaminated areas off-site of the Fukushima Dai-ichi Nuclear Power Plant (NPP). The Mission Team included 12 international experts. The Mission had three objectives: 1) Provide assistance related to Japan's plans to remediate large areas contaminated by the accident at the Fukushima Dai-ichi NPP; 2) Review Japan's ongoing remediation related strategies, plans and activities, including contamination mapping; and 3) Share its findings with the international community as part of the joint effort to broadly disseminate lessons learned from the accident.

URL: http://www.iaea.org/newscenter/focus/fukushima/final_report151111.pdf

32) Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station – Nuclear Energy Institute

This report provides a narrative overview and timeline for the earthquake, tsunami, and subsequent nuclear accident at Tokyo Electric Power Company's (TEPCO) Fukushima Daiichi Nuclear Power Station on March 11, 2011. The purpose of this report is to provide an accurate, consolidated source of information regarding the sequence of events that occurred in the first days of the accident. The information contained in this report may be used for determining future U.S. and international industry corrective actions.

URL:http://www.nei.org/resourcesandstats/documentlibrary/safetyandsecurity/reports/special-report-on-the-nuclear-accident-at-the-fukushima-daiichi-nuclear-power-station/

33) The World Nuclear Industry Status Report 2010–2011: Nuclear Power in a Post-Fukushima World - 25 Years After the Chernobyl Accident – World-Watch Institute, Washington, D.C. (USA)

Four weeks after the beginning of the nuclear crisis on Japan's east coast, the situation at the country's Fukushima Daiichi power plant remains far from stabilized. The damaged reactors continue to leak radioactivity, and although it is impossible to predict the overall impact of the disaster, the consequences for the international nuclear industry will be devastating. The present World Nuclear Industry Status Report 2010–2011 was to be published at the occasion of the 25th anniversary of the Chernobyl disaster in Ukraine. The report provides the reader with the basic quantitative and qualitative facts about nuclear power plants in operation, under construction, and in planning phases throughout the world.

URL: http://www.worldwatch.org/system/files/NuclearStatusReport2011_prel.pdf

34) Statement by Dr. Ratan Kumar Sinha, Chairman of the Atomic Energy Commission at 57th General Conference, Vienna, September 18, 2013

It gives me great pleasure to congratulate you, Mr. President, on your election as the President of the 57th General Conference. Under your able leadership, I am sure the current General Conference will accomplish all the tasks before it. India congratulates His Excellency Mr. Yukia Amano on his unanimous election for a second term as Director General of the IAEA. I am sure that the Agency and the international community will benefit from his experience and foresight. India welcomes the new Members to the IAEA and I take this opportunity to congratulate Brunei Darussalam and the Commonwealth of the Bahamas on the occasion of their joining the IAEA family.

URL: http://www.dae.nic.in/writereaddata/gc2013_stmt.pdf

35) Technical Lessons Learned from the Fukushima-Daichii Accident and Possible Corrective Actions for the Nuclear Industry: An Initial Evaluation: J. Buongiorno, R. Ballinger, M. Driscoll, B. Forget, C. Forsberg, M. Golay, M. Kazimi, N. Todreas, J. Yanch, MIT-NSP-TR-025 Rev. 1, July 26, 2011

The accident at the Fukushima-Daichii nuclear plant has generated worldwide news and precipitated public concern about the safety of nuclear power in general. The accident has already caused some governments to re-think their nuclear energy policies, notably including the Japanese and German governments. There have been calls for cancellation of nuclear construction projects and reassessments of plant license extensions. This may lead to a global slow-down of the nuclear enterprise, based on the perception that nuclear energy is not safe enough. However, the lessons to be drawn from the Fukushima accident are different.
URL: http://mitnse.files.wordpress.com/2011/08/fukushima-lessons-learned-mit-nsp-025_rev1.pdf

36) Actions taken by regulatory bodies and international organisations following the Fukushima Daiichi nuclear accident

The following is a collection of information on activities undertaken nationally and internationally following the Fukushima Daiichi nuclear accident. Regulatory authorities from 23 countries, along with 4 regional and 3 international organisations, have contributed information on national response activities, stress tests reports, and complimentary activities and assessments to the stress tests. This page will be updated periodically as information becomes available.

URL: http://www.oecd-nea.org/nsd/fukushima/

37) Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station

This report provides a narrative overview and timeline for the earthquake, tsunami, and subsequent nuclear accident at Tokyo Electric Power Company's (TEPCO) Fukushima Daiichi Nuclear Power Station on March 11, 2011. The purpose of this report is to provide an accurate, consolidated source of information regarding the sequence of events that occurred in the first days of the accident. The information contained in this report may be used for determining future U.S. and international industry corrective actions.

URL:http://www.nei.org/filefolder/11_005_Special_Report_on_Fukushima_Daiichi_MASTER_11_08_11_1.pdf

38) Analysis of WHO report on Fukushima catastrophe Dr. med. Alex Rosen, University Childrens Clinic Düsseldorf, August 03, 2012

On May 23rd, 2012, the World Health Organization (WHO) published what it called a „Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami". The report aims to provide timely and authoritative information on the anticipated scale of doses in members of the public for the first year after the accident" in order to "estimate at global level the potential health consequences of human exposure to radiation during the first year after the Fukushima Daiichi nuclear power plant accident." The media response to the WHO publication echoed the reassuring messages of the report itself:

URL: http://www.fukushima-disaster.de/fileadmin/user_upload/pdf/english/ippnw_analysis_WHO-report_fukushima.pdf

39) Comparing Fukushima releases with Chernobyl: An Update for the 1st Anniversary, Chris Busby, Occasional Paper 2012/2, March 11, 2012

Immediately after the explosions at the Fukushima site I was interviewed by the BBC together with a nuclear expert, Prof Ian Fells (http://youtu.be/4S2qgTrqR6A). I said then that from what I could deduce just from seeing the videos of the explosions, it seemed that the pressure vessels were breached and that the releases would be comparable with or worse than Chernobyl. At that time, Fells and others (Grimston, Wakeford) were reassuring the world that the releases were not as bad as those at 3-Mile Island.

URL: http://www.bsrrw.org/wp-content/uploads/2012/03/fukushima-chernobyl-comparison-report-11.03.2011.pdf

40) CNSC Fukushima Task Force: Nuclear Power Plant Safety Review Criteria, E-doc 3743877, July 2011

In response to the March 11, 2011 accident at the Fukushima Daiichi Nuclear Power Plant (NPP), the CNSC convened a Task Force to evaluate the lessons learned and the operational, technical and regulatory implications for Canadian NPPs, and to develop a strategy for prioritization and implementation of corrective measures. This document describes the scope and criteria of the Task Force review. Under section 12 (2) of the General Nuclear Safety and Control Regulations, the CNSC requested all Canadian NPP licensees to submit detailed information regarding their facilities. The Task Force will review this information as part of its mandate.

URL: http://nuclearsafety.gc.ca/eng/pdfs/japan-earthquake/CNSC_Fukushima_Task_Force__NPP_Safety_Review_Criteria.pdf

41) Disaster Evacuation from Japan's 2011 Tsunami Disaster and the Fukushima Nuclear Accident: May 13, 2013, Reiko Hasegawa (IDDRI)

The triple disaster that hit the Tohoku region of Japan on 11 March 2011 triggered a massive human displacement: more than 400,000 people evacuated their homes as a gigantic tsunami induced by a magnitude 9.0 earthquake engulfed the coastal areas, and the following nuclear accident in Fukushima released a large amount of radioactive materials into the atmosphere. This study analyses the disaster response, with a particular focus on evacuation of the population, and social consequences of this complex crisis, based on intensive fieldwork carried out one year after the catastrophe.

URL:http://www.iddri.org/Publications/Collections/Analyses/STUDY0513_RH_DEVAST%20report.pdf

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