DEFENCE BEYOND DESIGN: TOWARDS A NEW NUCLEAR PARADIGM

SITAKANTA MISHRA

The realm of 'nuclear technology' is amongst the most beguiling subjects of the human civilisation for the fact that words like 'atom' and 'radiation' have engendered both lasting fear as well as abounding hope in many. However, what is less certain is *why* it has entrenched such strong group (pro- and anti-nuclear) alignments.[1] Fingers point towards the 'risk' associated with nuclear technology; but *risk perception* is a "combination of facts and fears, intellect and instinct, reason and gut reaction"; it is a 'subjective', not a purely rational and fact-based process.[2] Therefore, any hasty response to a perceived risk may pose a danger by itself. Moreover, risk is calculated by multiplying the probability of the consequence by the severity of the consequence.[3] On the other hand, the unrealised lofty goal of abundant energy through the nuclear route and a few nuclear disasters have given rise to public scepticism. The scientific community, however, reiterates that the fear of nuclear power is out of proportion to the actual risks involved.

Dr **Sitakanta Mishra** is a Research Fellow at the Centre for Air Power Studies, New Delhi.

1. James Conca, "Why Are We So Afraid of Nuclear?", http://www.forbes.com/sites/jamesconca/2013/03/24/imagine-theres-no-fear/, March 24, 2013.
2. David Ropeik, "Why Are We Afraid of Nuclear Power", http://www.project-syndicate.org/commentary/why-are-we-afraid-of-nuclear-power-, October 15, 2010.
3. Elizabeth Landau, "Why Does 'Nuclear' Scare Us So Much?", http://edition.cnn.com/2011/HEALTH/03/28/nuclear.fears.psychology/

The need is to deconstruct the real and assumed threats (accident, misuse, and terror) to demystify the 'nuclear fear' by understanding how perceptions arise and are passed down generations in the complex system of society.

With proper management techniques and safety culture, nuclear energy can be a viable source of energy security.

The debate between the nuclear proponents and opponents has degenerated into mutual barrages of scientific facts and assumptions as each side manoeuvres in search of an impregnable position, giving rise to a competing culture of reality.[4] The tendency is to interpret reality through the lens of present knowledge and awareness largely conditioned by inclinations and convictions culminating in an imbroglio. This study, premised on the assumption that *nuclear energy cannot be discarded*, argues for a better management paradigm by venturing beyond the 'design basis threats' and responses processes.

For various reasons, there has been a lot of scare-mongering around nuclear technology that has inspired an unusual amount of controversy. The need is to deconstruct the real and assumed threats (accident, misuse, and terror) to demystify the 'nuclear fear' by understanding how perceptions arise and are passed down generations in the complex system of society. Professor Richard Dawkins in his famous book *The God Delusion* (2006) explains that "memes" as sentient traits compete and pass along to subsequent generations as vigorously as physical traits expressed through biological genes.[5] Fear of radiation, thereby the nuclear energy technology, is an obvious candidate for incompatible memes like those of different religions.[6] On the other hand, scholars, sociologists and policy-makers must take the onus to expose how the 'power of propaganda' and 'vested interest' has deliberately misrepresented nuclear technology. This study views that

4. Gary L. Downey, "Risk Culture: The American Conflict Over Nuclear Power", *Cultural Anthropology*, vol. 1, no. 4, November 1986, pp. 388-412.
5. Richard Dawkins, *The God Delusion* (Bantam Press, 2006); "Why Are We So Afraid of Nuclear?", http://www.forbes.com/sites/jamesconca/2013/03/24/imagine-theres-no-fear/
6. Conca, n. 1.

the *law of entropy*[7] is on their side because it is easier to make a mess than to clean it up. Instead of simplifying the complex, the spawning of heterogeneous meanings around nuclear energy in unpredictable ways has manifested in a kind of "atomic schizophrenia" in the society.[8] To address this, a fundamental change in attitudes towards nuclear energy is warranted by an out-of-the-box paradigm concerning nuclear safety and security at this juncture.

A fundamental change in attitudes towards nuclear energy is warranted by an out-of-the-box paradigm concerning nuclear safety and security at this juncture.

THE CURRENT STATE OF AFFAIRS

Undoubtedly, the nuclear energy discourse stands at a crossroads today. The issues of security, safety, fuel cycle, non-proliferation, and economic impediments remain, and may become more troublesome, particularly if out-of-the-box innovations to the current nuclear paradigm are not devised and practised within the next few years. The World Nuclear Industry Status Report 2013 reveals that the world's power generation has declined steadily from a historic peak of 17 percent in 1993 to about 10 percent in 2012. Also, ten years ago, particularly in Europe, the construction cost of Generation III nuclear reactors was estimated at around $1,000/Kilo Watts (KW) that allowed the nuclear industry to claim that nuclear power is competitive. By 2012-13, the typical cost estimate for Generation III+ designs was of the order of $7,000/KW.[9]

Unless a breakthrough is achieved, the share of nuclear energy in comparison to renewable will continue to decrease in the coming years. Then, is this the 'end of nuclear power'? Simply calling for this would be irresponsible. The pace of nuclear energy production and projects in recent

7. *The law of entropy* is the second law of thermodynamics which states that the entropy of an isolated system never decreases, because isolated systems spontaneously evolve toward thermodynamic equilibrium.
8. Raminder Kaur, *Atomic Mumbai* (New Delhi: Routledge, 2013), p. 58. Kaur describes "atomic schizophrenia" as a state reflecting the "split in the mind" specifically to describe how the constructive and destructive possibilities of the new atomic power saturated people's minds.
9. Mycle Schneider, "The World Nuclear Industry Status Report 2013", July 2013.

years has gone down but is not completely out. A focussed observation on the post-Fukushima nuclear energy drive worldwide would reveal that most countries with, or planning, nuclear programmes, opted for a slowdown rather than complete cessation. Nuclear energy continues to represent a major energy source – supplying about 11 percent of the world's electricity and 21 percent in the Organisation of Economic Cooperation and Development (OECD) countries.[10] At the end of 2010, the total global capacity fell from 375 Giga Watts (GW) to 369 GW at the end of 2011, but has since gradually risen to 374.3 GW by January 2014.[11] The year 2014 started with 435 operable reactors, along with 71 reactors under construction, totalling around 75 GWe – the highest number since 1989.[12]

The Fukushima disaster has made everybody conscious about proceeding on the basis of the lessons learned. Today, though strong pockets of optimism are visible in Asia, America, the UK and Russia, the opposite is true when one looks at Germany, Switzerland, and Spain. Many countries in different parts of the world, for example, Australia, Austria, Denmark, Greece, Ireland, Italy, Latvia, Lichtenstein, Luxembourg, Malta, Portugal, Israel, Malaysia, New Zealand, and Norway remain opposed to nuclear power.[13] Also, it will take more time to rebuild trust in Japan. Therefore, there are still challenges ahead for the nuclear industry; nevertheless, "the nuclear energy perspectives remain solid with the signs of bouncing back in the near future".[14] Over the past two years, an upward trend can be seen considering the number of new reactors. Having dropped from 16 in 2010 to four in 2011[15], reactor construction starts increased to six in 2012 and reached 10 in 2013.[16] Some other significant developments include the start

10. "World Energy Needs and Nuclear Power", World Nuclear Association, April 2014
11. Jong Kyun Park, Director, Division of Nuclear Power, IAEA.
12. "Steady State for Nuclear in 2013", *World Nuclear News*, January 7, 2014.
13. "Nuclear Power Phase-out", http://en.wikipedia.org/wiki/Nuclear_power_phase-out
14. Tarik Choho, chief commercial executive officer, AREVA, "Has the Nuclear Industry Emerged from the Cloud of Fukushima?", *Power Engineering International*, January 27, 2014.
15. Director General, IAEA, "International Status and Prospects for Nuclear Power 2012", GOV/INF/2012/12-GC(56)/INF/6, August 15, 2012, p. 1.
16. Mycle Schneider and Antony Froggatt, "The World Nuclear Industry Status Report 2013", http://www.worldnuclearreport.org/IMG/pdf/20130716msc-worldnuclearreport2013-lr-v4.pdf, p. 8.

of reactor construction in the USA after a gap of three and a half decades, start of the construction of the first reactor in Belarus, a country heavily impacted by the fallout from the Chernobyl accident in 1986, and the start of work on Barakah-2 in the United Arab Emirates (UAE). More importantly, Asia remains the focus of expansion and of near and long-term growth prospects. In fact, out of the 71 reactors under construction, 47 are in Asia;[17] similarly, 43 of the last 53 new reactors to be connected to the grid since 2000 are also in Asia.[18] In Europe,[19] many countries are either on the expansion mode or have such plans.

The case of Germany is a "dramatic exception".[20] Nobody is bothered to enquire today how Germany is suffering from an acute power shortage after its decision to phase out its nuclear power projects. One estimate suggests that by 2020, Germany will have produced an extra 300 million tonnes of CO2 (Carbon Dioxide) as a result of its nuclear closure: equivalent to almost all the savings that will be made in the 27 European Union (EU) member states.[21] Undoubtedly, a shift in thinking in some countries can be perceived in the post-Fukushima years, but many others are unswervingly pursuing their expansion plans. Despite setbacks in Germany, Switzerland and temporarily in Japan, nuclear energy projects are progressing well in many countries like Russia, France, Finland, China and India. Over 45 countries are actively considering embarking on nuclear power programmes.[22]

However, the entire blame for the relatively ominous state of the nuclear energy market today cannot be put only on public cynicism and the anti-nuclear coterie. There still exist many unaddressed concerns that the nuclear

17. n.15, p.4
18. Jong Kyun Park, Director, Division of Nuclear Power, IAEA, "Has The Nuclear Industry Emerged from the Cloud of Fukushima?", *Power Engineering International*, January 27, 2014.
19. "Nuclear Power in the World Today", http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World-Today/, April 2014.
20. John B Ritch, "Will The Nuclear Power Industry Regain Public Trust?", http://forbesindia.com/article/biggest-questions-of-2012/will-the-nuclear-power-industry-regain-public-trust/31592/1#ixzz2bv1ot0KC, December 29, 2011.
21. George Monbiot, "Out of Steam", *The Guardian*, February 5, 2013.
22. World Nuclear Association, "Emerging Nuclear Energy Countries", http://www.world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/

establishment requires to attend to promptly. One such example is the cost of nuclear energy. How cheap can nuclear energy be and how quickly can it reach the rural masses? Is not the notion that nuclear power would be "too cheap to meter" a misnomer?

The future of nuclear energy lies in addressing concerns on the basis of an evaluation of the current strengths and weaknesses in the nuclear establishment, governance and public perception. How effectively, in what time span, and in what manner, the concerns are addressed will largely determine the fate of nuclear energy in the world, and more so in India. This is not to dismiss the global or India's nuclear achievements over the years; but one needs to accept the fact that this is not the whole story. There is always scope for improvement and capacity building.

OUT-OF-THE-BOX PARADIGM

The nuclear safety-security discourse is mainly based on the principle of 'defence-in-depth' and 'defence-by-design' where high level safety features are built-in during the design phase of the plant and also utmost care is ensured for the safe-keeping of materials and technology from the cradle to the grave. The high level built-in safety features mainly include high-quality construction, fail-safe design, engineered equipment and procedures to manage accidents, and provide robust containment, emergency support, etc. However, can a zero accident/incident guarantee be given? Of course, the postulated threat scenario is conservatively considered while embedding safety features into the plant but "defence can deteriorate as time passes". Plant upgradations and modifications are undertaken at successive intervals to meet the new challenges and ageing of the plant.

One serious concern is how to manage the 'unimaginable risks'. Literally, there can be no absolute safety or security. Then, how much safety is safe enough? A more robust defence system (safety-security) to enhance the capability to deal with all risks and to remain prepared to effectively deal with unforeseen hazards is the prescription of this study. Based on a more structured consideration looking far beyond the current concerns and preparedness, the *defence beyond design* paradigm constitutes 10 conceptual

aspects, which are overlapping in their explanation and open-ended in their scope. These are given below:

Understanding Beyond Ideology

The debate over the nuclear "energy technology options and development pathways" is seriously marred by *perceptions of risk*. Rival explanations are advanced to explain the question, "Why are products and practices once thought to be safe, perceived increasingly as dangerous".[23] The ideological or cultural factors seem to have a stronger impact on individual/group risk perceptions[24] as they themselves 'choose what to fear', primarily conditioned by their inclinations and prejudices nurtured over generations.

While some are critical about nuclear energy as hazardous, many others find it a viable energy security option. The divide is visible across political lines in many countries and political predilection guides this – the right is instinctively pro-nuclear and the left is against it.[25] Each group advances its argument with sufficient logic and rejects information that is contrary to its viewpoints. In turn, "the conditional effects of ideology" impact the pubic risk attitudes, and also "the long- and short-term dynamics of belief updating after the occurrence of major accidents" influence the degree of public acceptance of nuclear technology.[26] How do nuclear technology risk concerns vary for given individuals?

Evaluating the Indian nuclear energy discourse and risk debate within the left-right divide would not be prudent as it has not evolved strictly along this line. The resistance to nuclear energy projects in India is concentrated in pockets and led by only a few anti-nuclear ideologues and groups. The role of the respective state government is found to be crucial in managing the controversy. In addition, the global anti-nuclear

23. Aaron Wildavsky and Karl Dake, "Theories of Risk Perception: Who Fears What and Why?", *Deadalus*, vol. 119, no. 4, Risk (Fall, 1990), pp. 41-42.
24. Susanne Rippl, "Cultural Theory and Risk Perception: A Proposal for a Better Measurement", *Journal of Risk Research*, vol. 5, no. 2, 2002, pp. 147–165.
25. Polly Toynbee, "For the Right, Nuclear Power is the Answer", *The Guardian*, July 20, 2006.
26. Fabio Franchino, "The Social Bases to Nuclear Energy Policies in Europe: Ideology, Proximity, Belief Updating and Attitudes to Risk", http://www.socpol.unimi.it/docenti/franchino/documenti/File/Nuclear_energy_Franchino.pdf, p. 1.

As is the case with all forms of energy, nuclear energy certainly involves risk. The question is: how much risk is involved? How can benefit be gained? And is the risk worth taking, comparing the risk and benefit involved?

lobby and Non-Governmental Organisations (NGOs) are reported to have provided support to the local movements. Therefore, the politico-ideological angle of the Indian public's risk perception needs to be examined to devise measures to foster popular thinking beyond the political/ideological spectrum on the new nuclear projects. In India, it needs to be vigorously propagated that "energy has no ideology or political colour"[27] and, to a large extent, that nuclear energy is relatively a benign option to mitigate the energy crunch and climate change concerns. As is the case with all forms of energy, nuclear energy certainly involves risk. The question is: how much risk is involved? How can benefit be gained? And is the risk worth taking, comparing the risk and benefit involved? In all these, 'risk perceptions', individual traits, and group mobilisation play important roles.

Of course, one may wonder if the belief and assessment of the scientific community that nuclear energy as safe is not coloured by ideology and economic self-interest. First, in the case of any accident, it is the workers, scientists and their families residing within the plant premises who would be affected first. Second, the language and manner in which the information and views of the scientific community on nuclear energy are communicated to the public by the scientists themselves matter most in eradicating public misperceptions. Third, the scientific community as a whole does not communicate with the general public—whatever information comes out from the elite scientists, get distorted by the media, leading to erroneous public perceptions. Also, a few nuclear disasters have really made any alteration of people's perceptions about a risk difficult; rather, this has resulted in closed-mindedness.[28] The need of the hour, therefore, is to

27. "Interview With The Group: Yes To Nuclear", http://www.eurasia-rivista.org/interview-with-the-group-yes-to-nuclear/16878/
28. Matthew C. Nisbet, "Nuclear Fear, Science, and Ideology", http://bigthink.com/age-of-engagement/nuclear-fear-science-and-ideology, April 3, 2011.

break out of this vicious circle by moving beyond ideological politics and prejudices to framing technology options and development pathways. A comprehensive nuclear information management system would help repose greater confidence in nuclear energy technology.

Transparency in the functioning and decision-making of the establishment is a major aspect that generates confidence among the public. Information that can be shared by the operator, the regulator and the government must be carefully calibrated so that it does not unnecessarily cause panic.

Information Beyond Facts

Management of nuclear information is crucial in nurturing greater confidence in nuclear energy and winning public support for new projects. However, just flooding of mere facts and figures about the issue will not help. Nuclear information management must take into account the targeted population, specific concerns, and mode of communication within a specific timeframe. Transparency in the functioning and decision-making of the establishment is a major aspect that generates confidence among the public. Information that can be shared by the operator, the regulator and the government must be carefully calibrated so that it does not unnecessarily cause panic. It must be kept in mind that the local inhabitants are emotionally attached to their land and for them, it is an intense matter. They perceive the decision about location of a nuclear energy project as an imposition on them which will root them out from their homeland. Therefore, the attitude of the officials or authorities while dealing with the local population matters immensely.

The challenge is how to explain to the general audience in simple language about the criticality of nuclear issues. The explanation that the facilities are protected in accordance with a design basis threat is too esoteric for non-experts.[29] The Nuclear Security Governance Experts Group (2013) recommends a completely innovative approach to convey information to the people at

29. NSGEG, "Promoting Greater Transparency for Effective Nuclear Security", February 2013, http://www.stanleyfoundation.org/nsgeg/NSGEGLondonReport022013.pdf, p. 10.

the local, state and national levels, keeping in mind their differing levels of knowledge and concerns, roles and responsibilities. An important step, it emphasises, is to improve the media's understanding of nuclear issues through frequent engagement with them and their inclusion in nuclear security exercises.

The impact that the nuclear project would have on the lives of the local population is the most intriguing aspect that allows speculations to emerge. Except for energy production, what are the other benefits or how they would enrich the locals' lives are the less catered for issues. Showcasing of the benefits accrued by the people in completed project sites elsewhere would help to motivate the locals. How promptly the grievances of the project-induced-displaced-people are addressed is crucial to win their hearts. A kind of 'nuclear nationalism' needs to be infused among the public to help them weigh the larger national interest along with their long-term personal benefits. This is possible only by providing them information rather than just nuclear facts, with a personal, community and national touch. They should be made aware that their support is a crucial part of the nation-building process. There is a need to reduce the communication gap between the community living adjacent to the plant and the scientific community living within the premises, to remove all apprehensions.

Responsibility Beyond Rules

The governance structure of the current nuclear safety and security system needs to be more comprehensive, integrated and transparent. Of course, "there is the challenge of governance. A country's ability to run a nuclear power programme safely and securely depends on its capacity to successfully and sustainably plan, build, and manage a large and complex facility and its associated activities."[30] Today, the business world enjoys much less credibility and the scientific establishment is far less influential than it once was.[31] Therefore, to restore social faith and confidence in nuclear technology, emphasis on performance and accountability beyond

30. Justin Alger and Trevor Findlay, "Strengthening Global Nuclear Governance", *Issues in Science and Technology*, Fall 2004, p. 74.
31. Stanley Rothman and S. Robert Lichter, "Elite Ideology and Risk Perception in Nuclear Energy Policy", *American Political Science Review*, vol. 81, no. 2, June 1987.

the written rules and regulations must be undertaken.[32] Largely, the current nuclear governance structures have relied on the implementation of more regulations and revisions to meet corporate governance standards. But governance responsibilities extend beyond companies or entities in charge of managing the day-to-day responsibilities. All concerned, both within the establishment and outside, must be made aware of their corporate as well as ethical responsibilities in the national governance of nuclear projects.

Apprehension Beyond Postulation

All nuclear reactors are designed with many safety features, keeping in mind some postulated events (both internal and external) that may occur during its life. Normally, postulated initiating events (anticipated operational occurrences or accident conditions) and the consequential transients are specified during the design phase of the plant to ensure specific safety measures for all possible scenarios.[33] However, unforeseen incidents may occur. For example, Japan was struck by a severe earthquake and tsunami for which its nuclear plants were not prepared. Also, new scientific methods may reveal new threat scenarios that no one ever thought about. Therefore, a comprehensive identification of all possible accident sequences and apprehending threats beyond the established postulation methods must be a part of the process to make the probable events sequences as large as possible. Adequacy of the selection of postulated initiating events would help in mitigating any chance of surprise and uncontrollability.[34]

Preparedness Beyond Routine

Every nuclear facility is managed by well laid out procedures and guidelines. Routine safety and security functions are strictly adhered to. However, the human factor involved in all these processes is fallible. The

32. NSGEG, "Responsibility Beyond Rules: Leadership for Secure Nuclear Future", http://www.nsgeg.org/NSGEG_Responsibilty_Beyond_Rules_2013.pdf, p. 1.
33. IAEA, "Deterministic Safety Analysis for Nuclear Power Plants", *Specific Safety Guide No. SSG-2*, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1428_web.pdf, p. 6.
34. Ibid., p. 41.

Fukushima Investigation Commission revealed that lack of governance and communication among different entities, lack of competencies for those accountable for nuclear security, and lack of clear understanding of accountability and liability among licensees and regulators had culminated in "wilful negligence" by the top management in their response.[35] Viewing it as a "man-made" incident, the commission pointed out the complacent mindset of those accountable for nuclear safety. This suggests that routine responsibilities or accountabilities tend to drift towards negligence, for the human factor involved in the process is fallible.

What is expected, therefore, is development of a type of safety-security preparedness culture beyond the mere routine tasks. In this pursuit, a more inclusive nuclear safety-security culture needs to be nurtured at the national level, led by "nuclear security champions" who have extensive knowledge, inter-cultural skills, and are charismatic top-notch problem solvers.[36] Their main task would be to come up with practical, tailored solutions to specific problems and generate a broad-based consensus on issues by communicating and coordinating with the national leadership and nuclear security implementers.[37]

Governance Beyond Regime

The complex formal and informal institutions, mechanisms, relationships, and processes that regulate the nuclear establishment and the nuclear policy discourse constitute the 'nuclear governance'. In other words, it is the structural-institutional factors or the regime that manages nuclear energy activities. It is characterised as "interpretative" where there is a need to explain how and why specific decisions are arrived at.[38] Persuasion and facilitation comprise the key technique of an interpretative approach of governance. This has, in fact, resulted in a state-centric command and

35. The National Diet of Japan, *The Official Report of the Fukushima Accident Independent Investigation Commission*, 2012, http://www.nirs.org/fukushima/naiic_report.pdf
36. Santoro David, "Championing Nuclear Security", Carnegie Endowment, September 10, 2012, p. 2.
37. Ibid.
38. Keith Baker and Gerry Stoker, "Governance and Nuclear Power: Why Governing is Easier Said than Done", *Political Studies*, 2012, p. 1.

control structure. Nuclear power has remained the exclusive sphere of the state domain and the "responsibility for nuclear safety rests with the state". This has given rise to the question: why are nuclear projects backed by the state everywhere with heavy investment and subsidies? What is needed, therefore, is "an integrated approach" to develop "an integrated decision-support framework for assessing the sustainability of nuclear power relative to other energy options (fossil fuels and renewables), considering both energy supply and demand"[39] by making the citizens the stakeholders.

Under the current practice, the regime imposes responsibility on the operators to run the reactors safely and securely. At times, some issue may arise which is beyond the control of the operators. Even if the alleged operator-regulator nexus requires attention, it must be looked at from beyond the regime structure and function.

Upgradation Beyond Intervals

Realistically, every defence measure is time critical and can deteriorate as time passes. Therefore, routine upgradation of safety-security measures is a normal feature of every nuclear plant. Also the need-basis actions and provisions are strictly adhered to all along. However, the nuclear defence architecture that encompasses safety, security and safeguards, needs to be structured beyond the design-basis threats, taking into account the intricacies of technical interfaces, professional integrity, social psychology, national obligations, and international collaborations.

Analysing the past few nuclear accidents, one can deduce that a lackadaisical attitude or negligence on the part of the operator and regulator led to such situations. For example, as the Japanese Nuclear Accident Independent Investigation Commission concluded, the "Fukushima nuclear power plant accident was the result of collusion between the government, the regulators and Tepco, and the lack of governance by the

39. Adisa Azapagic, "Sustainability Assessment of Nuclear Power: An Integrated Approach", http://www.springsustainability.org/

One must learn from the Japanese Commission findings of "poor communication by the utility and bureaucrats responsible for nuclear safety", which led the Japanese prime minister to lose trust in them and his resultant attempt to manage the crisis directly with the help of aides and advisers.

said parties".[40] The disaster was the result of "a multitude of errors and wilful negligence" by the plant operator. Further, according to the findings of the commission:

> What must be admitted – very painfully – is that this was a disaster 'Made in Japan.' Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the programme'; our groupism; and our insularity. … This conceit was reinforced by the collective mindset of the Japanese bureaucracy, by which the first duty of any individual bureaucrat is to defend the interests of his organisation.[41]

The post-disaster management is the most crucial part of nuclear governance. One must learn from the Japanese Commission findings of "poor communication by the utility and bureaucrats responsible for nuclear safety", which led the Japanese prime minister to lose trust in them and his resultant attempt to manage the crisis directly with the help of aides and advisers. Such prime ministerial intervention is believed to have worsened the situation. What the report brings out for everyone to learn are the issues of transparency (obligation to disclose) and onus. Views have been expressed to repeal the non-disclosure clauses in Section 18 of the Atomic Energy Act as it is anachronistic

40. David Dalton, "Fukushima Was 'Man-Made Disaster' Caused By Wilful Negligence, Report Finds",05.07.2012_No152 / News in Brief, http://www.nucnet.org/all-the-news/2012/07/05/fukushima-was-man-made-disaster-caused-by-wilful-negligence-report-finds
41. The National Diet of Japan, the Official Report of the Fukushima Nuclear Accident Independent Investigation Commission, 2012, http://www.nirs.org/fukushima/naiic_report.pdf, p. 09.

in this age of right to information.[42] Purely from the point of view of enhancing positive popular perceptions on nuclear safety, such a step may be considered, taking into account the necessity of secrecy in other aspects of the nuclear programme.

Perceptibly, over the years, the term 'nuclear' has become more politics and psychology than physics. What is needed, therefore, is delinking of the flawed political connections as this is not a political issue.

Nuclear Beyond Politics

The link between nuclear technology (thereby nuclear energy) and statecraft has been intrinsic since the dawn of the nuclear era. But gradually, it has become an intricate subject of partisan politics or political discourse for various reasons. In a federal political system, especially in a coalition political arrangement like in India, the state governments have a bigger say in new nuclear projects than the Union government. The equation between the state government and the central political leadership determines the smooth advancement of new nuclear projects in countries like India. For example, the All India Anna Dravida Munnetra Kazhagam (AIADMK) government in Tamil Nadu was opposed to the nuclear power plant initially. The Trinamool Congress (TMC) government in West Bengal opposed the proposed nuclear plant in Haripur in East Midnapur. Chief Minister Mamata Banerjee made it clear that she would not allow a single nuclear power plant to be established in the state during her tenure.[43] Given this trend, one can assume that nuclear energy projects will increasingly become a matter of Centre-state bargaining as more new projects are in the pipeline in India. This will hamper the pace of the projects and thereby, their cost-effectiveness.

Perceptibly, over the years, the term 'nuclear' has become more politics and psychology than physics. What is needed, therefore, is delinking of the

42. EAS Sarma, "The Report of the Independent Commission in Japan on Fukushima: Lessons for India", http://www.dianuke.org/the-report-of-the-independent-commission-in-japan-on-fukushima-lessons-for-india/#sthash.UkkZ8oKu.dpuf, July 15, 2013.
43. "West Bengal CM Mamata Banerjee Rejects Proposed Haripur Nuclear Project", http://post.jagran.com/west-bengal-cm-mamata-banerjee-rejects-proposed-haripur-nuclear-project-1313662443#sthash.fD36cy3F.dpuf, August 18, 2011.

flawed political connections as this is not a political issue. Objections to, and support for, nuclear power should go beyond political partisanship as "the merit of nuclear power lies in the science and, thus, bows to no political or partisan mongering, and especially not to dedicated deniers. It's important to separate the scientific pros and cons of nuclear energy from the political credentials of those who support or oppose it".[44]

Curiosity Beyond Apprehension

The word nuclear arouses curiosity, but with apprehension, among many people. Many are just afraid of the unknown – afraid of something they cannot see. Secondly, most people link nuclear technology with nuclear weapons unknowingly. Knowing the basics about how different weapons are from reactors can contribute to mitigating this misunderstanding; for instance, it's been known for years that, contrary to popular belief, reactors can't blow up like a bomb. Also, many draw baseless parallels with events that have happened elsewhere for altogether different reasons, to the nuclear issue at home.

There is a flawed connection between environmentalism and nuclear energy, culminating in the boycott of nuclear power. The fundamental fact to be understood is that every power source carries some risks, and the danger from nuclear proliferation mainly exists because of human fallibility, not because of some inherent problem with nuclear energy. People tend to forget that what distinguishes man from the other species is his ability to uncover nature's secrets, and appraise and harness them, especially the ones that cannot be seen. Man's great capacity to face unknown challenges, understand them, and use them for his benefit, underpins much of our technological prowess. In fact, the promise of nuclear technology to produce cheap, clean and abundant energy has not been altogether unfulfilled.[45] If managed properly, it has the potential to take care of all our energy needs.

44. Ashutosh Joglekar, "Top 5 Reasons Why Intelligent Liberals Don't Like Nuclear Energy", February 6, 2013, http://blogs.scientificamerican.com/the-curious-wavefunction/2013/02/06/top-5-reasons-why-intelligent-liberals-dont-like-nuclear-energy/
45. Ted Nordhaus et al, "How to Make Nuclear Cheap", Breakthrough Institute, July 2013.

Innovation Beyond Systems in Vogue

Nuclear energy technology is now around six-seven decades old. Science has progressed greatly to examine new types of threats, geological or man-made, to nuclear projects. A review of all nuclear disasters would explain that the major problem is related to melting of the core, and managing the decaying heat and disaster-proof technology. The successive generations of reactors being developed have addressed many of the earlier shortcomings. For example, Generation III+ and Generation IV reactors have many passive safety features and redundancy to control any unforeseen contingency. The Generation III+ reactors are water-cooled and water-moderated thermal and modular designs. Several of this design, like the EPR and VVER-1000, have a core catcher: if the core were to melt down, it would melt into a large structure which spreads out the molten fuel into heat resistant channels to quickly cool and halt reactions. The Generation IV designs that are created by the Generation IV International Forum (GIF) include metal-, salt-, and gas-cooled designs, high temperature reactors, and breeder reactors.[46] However, more stringent and improved safety, safeguards, and security features, in other words, disaster-resistant technology, in both existing and new nuclear energy plants, would restore the waning confidence in nuclear energy.

Considering the past decades' experience in nuclear reactor designs and siting, a revolutionary out-of-the-box innovation in reactor technology is warranted. The six factors that greatly influence the development and deployment of nuclear reactors are cost-effectiveness, safety, security and non-proliferation features, grid appropriateness, commercialisation roadmap (including constructability and licensability), and management of the fuel cycle.[47] Revolutionary innovations in all these areas would make nuclear energy projects not only safe and secure but also significantly cheap, thereby increasing public acceptability. The much talked about Molten Salt Reactors (MSRs) are believed to be safer than the light water reactors and

46. Stephen M. Goldberg and Robert Rosner, "Nuclear Reactors: Generation to Generation", American Academy of Arts & Sciences, 2011.
47. Ibid., p. 1.

Efforts are on in many parts of the world to address the thorniest problem associated with nuclear power production – nuclear waste. No country has yet been able to find an amicable solution to permanently address the nuclear waste issue as the life span of nuclear waste is very long.

consume existing nuclear waste, are probably worth pursuing. One special feature of these, as proponents claim, is "If there is a loss of power, or the reactor gets too hot, the plug melts, allowing all the fuel and coolant to fall into an underground chamber full of neutron poisons/absorbers, quickly killing all fission reactions."[48] China and the US have been experimenting on this design for several years now and may help the nuclear industry to overcome the persisting shortcomings.

In another initiative, the San Diego based company General Atomics has designed a small size reactor that is claimed to be safer than existing reactors and reduces nuclear waste by 80 percent.[49] In case of a power failure, it is designed, by the use of ceramics, to shut down and cool off, without the need to continuously pump in coolant. Using helium as a coolant instead of water allows the plant to operate at higher temperatures, and the reactor also incorporates a new gas turbine for producing electricity. The technology is claimed to generate more power from a given amount of heat produced in the reactor core. The idea of building nuclear power stations on floating platforms, much like those used in the offshore oil and gas industry, is viewed as making them safe and secure from an earthquake, tsunami, station blackout or cooling failure. Rosatom is building a floating nuclear power station, the Akademik Lomonosov, a large barge carrying a pair of nuclear reactors capable of together generating up to 70 Mega Watts (MW), due to be completed in 2016.[50]

Efforts are on in many parts of the world to address the thorniest problem associated with nuclear power production – nuclear waste. No country has yet been able to find an amicable solution to permanently address nuclear

48. Nordhaus, n. 45.
49. Kevin Bullis, "A Nuclear Reactor Competitive with Natural Gas", August 19, 2013, http://www.technologyreview.com/news/518116/a-nuclear-reactor-competitive-with-natural-gas/
50. "All at Sea", *The Economist*, April 26, 2014.

waste issue as the life span of nuclear waste is very long. Innovation is warranted in the field of nuclear waste management with new techniques. The dual fluid reactor concept is a probable one that attempts to address the problem.[51] A group of nuclear physicists in Berlin, who are working on the concept, claims to be able to reduce the life span of nuclear waste from 100,000 years to 300. An article by Fabian Schmidt and Conor Dillon in the *Deutsche Welle* website narrates:

Certainly, innovative research costs a lot and necessitates patience. Additional investment needs to be earmarked and focussed efforts especially to be planned to carry out need-based innovations for the nuclear industry.

> The key is swapping nuclear fuel rods for salt mixtures. Liquid salts with heavy nuclei – plutonium chloride or uranium chloride are the examples used by the nuclear physicists in the project – would flow in continuous circles. After burning in the reactor core and producing energy, the liquid is then channelled through an internal treatment plant, where burned components are separated off and the mixture is enriched once more with fresh, long-life radionuclides. It's then sent back through the reactor core for another round of energy production. Those burned components are radioactive. They, too, would need to be stored in a safe location. After 300 to 600 years, though, they would be recycled as valuable metals, with any unused nuclides heading back to the reactor.[52]

Certainly, innovative research costs a lot and necessitates patience. Additional investment needs to be earmarked and focussed efforts especially to be planned to carry out need-based innovations for the nuclear industry. At best, can India be part of these many global attempts for nuclear industrial innovations?

51. Fabian Schmidt and Conor Dillon, "Can Nuclear Power be Eco-Friendly?", http://www.dw.de/can-nuclear-power-be-eco-friendly/a-17056028, September 3, 2013.
52. Ibid.

A VALUE JUDGEMENT

Lastly, this is not to argue that technical fixes can close all the loopholes in the nuclear industry in general. If a value judgement is entertained, the future of nuclear energy depends largely on how promptly we propound and practise an "inclusive" nuclear safety-security definition extending beyond material protection, safety preparedness, and assimilating interrelation of stakeholders, novel initiatives, and all nuclear regimes.[53] In other words, transition towards a multi-sector engagement with a holistic understanding of the utility of nuclear energy is the gateway for a vibrant nuclear industry. This would, of course, be a long drawn out endeavour. However, the growth in nuclear energy will continue because, with or without Fukushima, we face the same challenge of energy scarcity.

53. NSGEG, "Improving Nuclear Security Regime Cohesion", The Stanley Foundation, http://www.stanleyfoundation.org/nsgeg/Improving_Nuclear_Security_Regime_Cohesion.pdf, p. 7.