Safety, Public Acceptance and Future Indian Nuclear Program post Fukushima

Public acceptance, opinion and diligence of policy makers and planners as well as political consensus are vital for deciding on issues like Energy mix for India, its nuclear policy and its nuclear contribution to the energy mix. These need to be arrived at on a country specific manner. Only Nuclear Energy that does not cause any harm to public and environment will be acceptable to public. Safety, security and environmental protection of Nuclear Industry are brought about by multi-organizational, multi-disciplinary and multilayered approach. In addition these need to be taken care of at all stages from cradle to grave i.e. from siting to decommissioning of each nuclear facility. It will require a comprehensive series of articles to explain how safety is taken care of in nuclear industry and in India. An attempt will be made to briefly describe this. While the operator, Nuclear Power Corporation of India Ltd (NPCIL) in our case, is primarily responsible for safety, the Regulatory Body Atomic Energy Regulatory Board (AERB) in India oversees and ensures safety. Firstly a Nuclear Power Plant (NPP) is located at a carefully selected site, keeping safety, security & environment protection in mind and as mandated by AERB code on siting. Design of NPPs is based on several concepts to ensure safety of its operation. These are defense – in – depth philosophy. Independent, redundant and diverse safety trains, fail safe, single failure criterion (failure of one equipment will not affect the function) etc. For example, for many generations 3, 3+ NPPs which India would be importing, four independent, redundant, diverse safety trains are provided, each train capable of providing 100% safety. It is just like providing a car with four independent and redundant brake systems, starting from four brake pedals and finally up to four brake liners with each set capable of giving 100% protection of stopping the car. Highest standard of Quality Assurance is adopted during subsequent manufacturing of equipment, construction, and commissioning. Finally the plant is operated by staff possessing highest levels of safety and security cultures. Safety & security culture ensures safety and security considerations override others such as cost, schedule, production, commercial etc. A simple definition of safety & security cultures is when everybody in the organization like NPCIL does the right thing with respect to safety and security when nobody is looking at them. The safe operation is practically demonstrated by actual safe, secure, reliable and viable operation of more than 330 reactor years completed by 20 NPPs in India. Activities in all these stages are reviewed, licensed through stipulations, enforced and inspected by AERB. All reviews are detailed and comprehensive, based on AERB safety documents including codes which are based on International Atomic Energy Agency (IAEA) documents, thus adopting the current international standards and best practices. These reviews are done by various expert groups, many outside DAE and through three tier committees. For example, the design review by AERB for Narora took five lakh technical man hours. Similar review is mostly completed for the Russian plant at Kudankulam and will be done for other imported reactors. Incidentally imported NPPs are to be licensed by host country as well as AERB.

The safety performance of the 20 NPPs run by NPCIL has been satisfactory. This has been demonstrated by 3000 annual samples of grass, fish, milk, goat thyroids etc taken around each NPP and analyzed by independent MOEF accredited Environmental Survey Laboratories. Results indicate that due to the operation of these 20 NPPs, Public get less than 1% addition to the existing natural background of

radiation which they would be exposed to whether NPP is there or not i.e. if natural background is 200 units, NPP will add two units of radiation i.e. public will be exposed to 202 units of radiation. It is also less than 5% of AERB limits, which are comparable to international safety limits.

During my stint as Vice Chairman of Atomic Energy Regulatory Board and Chairman of two Apex committees, one for operations of NPPs, and other for design review and construction of new NPPs, my committees, which had many non-DAE members, were able to take independent decisions and had a good grip on safety evaluation and decision making. Not once anybody interfered or influenced the decisions. On several occasions plant operation was suspended. Similarly construction license was put on hold for several projects. These were complied fully by NPCIL and restart was permitted after corrective measures were implemented and AERB approved resumption. It is good to hear that the government of India is bringing in an amendment to strengthen AERB, make it independent & autonomous and strengthen the legal framework. I would like to point out that independence is equally obtained by competency possessed by AERB and the esteem with which the regulated hold them. Both NPCIL and AERB can be compared to the best in the world and this feedback I got from foreigners when I attended in Bilateral meetings with US, French, Russian Regulators as well when I chaired a few meetings of Candu Regulators Group and IAEA Regulatory meetings. In fact both NPCIL & AERB have introduced several firsts & innovations. For example NPCIL prepared the first Emergency operating procedures in the world, in 1977 whereas the rest of the world started these after TMI accident in 1979. AERB introduced periodic safety reviews every 5 years a decade earlier than other countries. Let us not have inferiority complex. Many NPPs are islands of Excellence and AERB is recognized for its practices to be world class. The public, opinion makers, media and the country at large should have confidence in the Regulatory bodies and organization like AERB should do everything to imbibe such confidence in them. For Example, one can take independence to any lengthy on the pretext of regulation & production being under one umbrella. After all, the regulatory body has to report to some organization in India. Is it possible for AERB to report to somebody in a neighboring country and vice versa? However constructive criticisms and pressure from policy makers, and media to keep the regulatory bodies on their toes are welcome.

Public acceptance is vital. With this the view I would now like to allay some of the concerns raised in the recent past.

Why imported "Untested" Reactors?

Safety is a moving target and in nuclear business you cannot build a nuclear power reactor to yesterday's specification, it has to be latest and state of the art. The proven reactors are simply not available for construction. The French simply will not sell N3 model and so is the case with other technology players. In that sense all reactors, including 700 MW PHWRs and 500 MW PFBR in India and many in China, are untested but the important consideration is that all reactors currently available in the international market are evolution from respective tested cousins. There is no commercial power reactor which did not do well because it was built for the first time.

The current reactor technologies for reactors which will operate for next six decades or more are of Generation 3 or 3+ designs. The objective of theses designs is to address concerns in the safety, security and economics that have arisen during the 14000 reactor years of operation to date. These reactors have a probability of the reactor fuel core melt an order of magnitude lower than existing reactors. Even if beyond design basis, severe accidents of the type that occurred in Fukushima takes place in these NPPs, there will be none or minimal action required in Public domain. The additional features, among other things, include Passive Safety Systems, Core Catcher, four independent, redundant safety trains including Power Supply and Station Blackout diesels, Hydrogen Recombiner, Passive Cooling etc. For preventing the loss of power, following will be done. In the case of Fukushima Daiichi, the plant had a loss of AC power and could not start the needed diesel generators to cool the reactors. In many Generation 3+ reactors, for the first three days after an unplanned event the operators do not need to rely on AC power to place the plant in a safe shutdown condition. Instead of relying on active components such as diesel generators or pumps, the NPPs rely on gravity, natural circulation and compressed gases to keep the core and containment from overheating. It can be seen that the above design features would have minimized the damage considerably during Fukushima type of accidents if it were to occur in such reactors. Even the presence of a well-designed containment at TMI and Fukushima resulted in much smaller impact extending to few tens of kilometers compared to a larger one for Chernobyl which had only a partial containment. With the above additional modifications for the future generation 3, 3+ reactors planned to be imported to India, the impact in the public domain will be reduced to insignificant level if not none.

There is a limit to the degree of safety and security that can be attained by evolutionary design alone. The features mentioned above cannot be achieved by evolution alone. They require innovative or First of the kind systems/ equipment. Tested reactors will be similar to Fukushima with its problems. Just like the saying “You cannot have the cake and eat it too”, if one wants higher levels of safety/security you have to go for untested NPPs. The alternative is to go for proven NPPs with lower levels of safety. The four 3/3+ designs are in fact built on improving existing NPPs with new, innovative, first of the Kind Systems. The Regulatory Bodies have well recognized methods for validating first of the Kind Systems/ Equipment and these should be carried out by India also. Thanks to delay in India entering into global trade, most of these NPPs would have been constructed and operated also in other countries before entering the respective phases in India. This would also include respective Regulatory reviews in each country (For Example, for the French EPR, USNRC, Chinese, Finland, UK, and French Regulatory reviews would be completed). Indian requirement is the design should be certified by both host country & AERB. The design to have greater level of safety/security is prompting almost all countries to go for Generation 3/3+ designs. An Apex committee has advised China to go for Generation 3, 3+ NPPs.

Even in other industries and equipment many innovative and first of a kind feature are introduced to result in excellent products. A simple example is 3D in latest TVs & DVDs. This was earlier untested & not proven. Moreover, we can any time switch over to 2D as these TVs have all features of older TV. Similarly, untested generation 3+ reactors have all old features plus some new features

described below. Hence while it can never be less safe than present designs, it can have considerably high degree of safety.

Can our plants stand Earthquakes?

Questions are being raised whether the French EPR plant to be located at Jiatapur as well as other plants proposed to be located elsewhere can stand Earthquake (& Tsunami) which can possibly occur at that location.

The sites where NPPs (Indian or Imported) will be located will be first approved by MOEF and then by AERB, each taking care of safety & security issues within their jurisdiction. AERB has issued a code on siting and all stipulations are mandated in this. This includes several requirements including checking for natural disasters. Most of the areas in India are in some seismic Zone or other (Zone 2 to 5). NPPs will not located in Zones 4&5. Fortunately most of India is not in subduction zone & maximum earthquake intensity do not usually exceed 7 which is 30 times less than what occurred in Fukushima. For Example, Maximum earthquake recorded at Jaitapur, which is Zone-3, is 6.4. Costal sites are selected after reviewing TSUNAMI possibilities, effect on marine life etc in a scientific manner and against International & Indian Safety Regulations.

Nuclear Power plants are design against expected natural disasters including earthquake, tsunami etc. During the application for site, preliminary safety details of the NPP need to be submitted including a guarantee that all AERB limits and codal requirements will be adhered to. Only such details which are irreversible later on a detailed future review are seen at this stage. During the period between authorizations for excavation to commissioning, a detailed three tier review of each design detail is performed. Present Indian NPPs go through elaborate review process with respect to them being capable of withstanding natural disasters including extreme meteorological conditions. These include Seismic, flooding (Both due to heavy rain or upstream dam burst and downstream dam not damaged), TSUNAMI, extreme high velocity winds etc. All safety equipment are located above maximum flood level or Tsunami levels taken from historical data and probabilistic approach. For earth quakes, data around 300km is taken and a design basis earthquake is determined. Each safety equipment is qualified by shake-table tests or if too big by calculations and computer modeling. Nuclear sites are not located in high earth quake areas. This is one of the codal requirements.

Due to the above the Madras Atomic Power Plants stood the Tsunami and the Kakrapara Atomic Plants stood the Bhuj earth quake.

The ground acceleration experienced on March 11, 2011 at Fukushima Daiichi is reported to have been about 0.3g to 0.5g. The seismic margin assessment of the EPR shows that the EPR can withstand ground level acceleration up to 0.6g with a high level of confidence that no damage impairing the operability of its safety systems would occur. The earthquake design of Jaitapur Plant will fulfill the complete spectrum of earthquakes that can occur at this location in future.

Protection against tsunamis for the Proposed Jaitapur NPP is achieved by elevating the platform level, taking into account local conditions as well as tide surges or potential tsunamis. Should the water level exceed the Proposed Jaitapur NPP platform level, the reactor building, the safeguard building, and the diesel buildings are equipped with waterproof doors and other features designed to resist not only severe impact loads but also floods.

Safety of Marine Life, Flora & Fauna:

Fear exists in the mind of costal and tribal populations & fisherman about damage to environment including marine life. The discharge temperature limits to environment for NPPs is the same as it is for Thermal Plants i.e. 7°C more than inlet. For plants installed prior to 1999 it is 10°C (It is still so in many countries) which is also safe. (In fact in many coastal locations in India, at any spot the daily variation in temperature itself is 10°C). These limits, both of absolute maximum temperature and differential rise in temperature, are as per international standards and Indian stipulations which have been arrived after intense study. The adverse effects of thermal discharges into coastal waters & other water bodies have been widely studied & documented. Discharges will not cause any damage to marine life or Flora & Fauna. Reports of the fishery department at each of the six Nuclear power locations from the time the respective nuclear power plants commenced operation reinforce this conclusion.

Will EPR and other imported reactors be economical & competitive?

NPCIL has mentioned that the cost of electricity has to be competitive and comparable to the nearest conventional plant of the same vintage. Take Tarapur-1&2 experiences. Way back in 1964, some felt that it is very uneconomic proposition. Five decades later, it has been found to have delivered for last 40 years cheapest electricity, the current tariff being about Rs. 1/ kWh. In this context our experience with PHWRs is also worth comparing. The first unit that was imported from Canada was not cheap but over the years the technology was absorbed and the equipment manufacture was 100% indigenized. Now Indian PHWRs are the cheapest in the world. The contribution of the Indian Industry in bringing the cost of these reactors under control is also enormous and industry is poised to take full advantage of the global nuclear business. In addition, due to high plant load factor (higher than 90%) over expected sixty years life, nuclear though capital intensive but lower fuel costs etc, the production costs will prove the competitiveness. Nuclear power is quite competitive globally in regions which have limited fossil fuels and associated infrastructure. If it is competitive elsewhere, there is no reason to fear it will not be competitive in India.

Why Nuclear and need for choosing the best possible option for India?

The debate on whether to have Nuclear Power for India or not is going on for the last thirty years. With twenty Nuclear Power Plants operating and Six under construction, it is too late to ask this question. Constructive criticism and debate should now be on what additional safety and commercial upgradation should be done to further enhance the safety, security, reliability, viability and acceptability of the NPPs, what type of Nuclear Power Plants should be built, what are specific needs of our culture

and for our country, which technology, in addition to Pressurized Heavy Water Reactors and Fast Breeders, should India absorb for domestic use and tap huge export potential, what additional steps should be taken to speed up putting Thorium usage into commercial domain and further accelerated Dr. Bhabha's three stage program, road map to make India an important global nuclear player similar to IT now etc. For balanced energy mix, energy independence and security, climate change and avoiding green house gases, sustainable development, tapping 25% of World Thorium being in India capable of producing three lakh Mega Watts for three hundred years and the huge potential of India being a major global Nuclear Player in a decade (like IT, auto industries etc now) and many other reasons, Nuclear is inevitable for India.

For India, energy planning should be on four pillars namely, majority being Thermal including Gas with second and third pillars consisting of Renewable including hydro as well as Nuclear and fourthly demand side controls like better energy conservation, efficiency, energy intensity lower T&D losses etc. Each of these pillars should be developed independently and simultaneously and not instead of any one pillar. In the Nuclear pillar Government has announced acceleration of Dr. Bhabha's three stage program of indigenous PHWRs and Fast Breeder Reactors with additionality from imported reactors. This in my view is the right decision. However constructive debate can be encouraged.

Some of the technologies planned by India for Import are likely to witness the most widespread usage globally. Nuclear Industry will change but need for nuclear will not change and global Nuclear Renaissance will continue though perhaps at reduced pace. These plants will be imported by many more countries. Just like India has absorbed PHWR technology (Incidentally India is one of the best countries on technology absorption), indigenized it & is now making cheapest NPPs in the world (which have demonstrated safe, secure, reliable & viable operations for more than 330 reactor years), India could absorb technology of some of the plants planned to be imported, localize it and become a global exporter of the same in a decade. This Global Export from India could be much higher in volume than IT presently. The program will generate more than half a crore extra jobs. We should take a rational view following a scientific and logical approach and choose the best option for our country.

By

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