Face2Face

In this interview with IEEMA, Dr S K Jain, CMD, NPCIL, talks about future of nuclear power generation, future plans for energy independence, safety measures observed in nuclear power plants, distributed nuclear power generation, etc.

Q Nuclear power is a highway to prosperous future of Indian Power sector ....Sir your views please.

A Electricity is a prime driver of economic growth for any nation. The per capita electricity consumption and economic prosperity of a nation are closely interlinked. Our per capita electricity consumption, currently, is about 721 kWh, which is significantly lower compared to the world average. We, as a nation, have also been facing electrical power shortages for quite some time now and this supply-demand gap is projected to widen even more in the coming years. Almost 40 percent of our population does not have access to electricity and, consequently, there are overall fewer opportunities of employment generation. Our industry also suffers losses due to intermittent power supply with our huge population and limited conventional sources of energy. The projections of capacity addition in next two decades, as envisaged in Integrated Energy Policy of the country, is about five times of the current installed capacity. Thus, we must strive to add electricity generation capacity in the country at a faster rate capacity. This will ensure a matching supply of this key input that is so vital to the economic growth of our nation. Nuclear power has a vital role to play in helping fulfill the dreams of millions of Indians in a clean and sustainable way in cost-effectively, while also addressing global climatic concerns.

I would also like to emphasize one more point here that nuclear power is also crucial for the long-term energy independence of the nation.

Q Experts say the future of energy on our planet lies with nuclear, solar and hydrogen. What are your perspectives on this vision ?

A The global energy consumption, along with electricity consumption, has seen a massive surge in the last few decades, and this rising trend is bound to continue in the coming years. In the meanwhile, the world is also facing the prospects of dwindling fossil-fuel resources and rising costs. Fossil resources also have a vast number of other economic uses. So, we cannot simply burn them up just as automobile fuel (oil) or for power generation (oil, coal and natural gas). Nonetheless, the real danger lies in the effects of unchecked fossil-fuel use - in the form of global warming, leading to climate change, which would bring misery to millions of people worldwide in the coming decades, if not addressed. The world must, therefore, change its energy production patterns to ensure that such catastrophic consequences are avoided or at least reduced to manageable levels. And there comes the role of non-fossil sources of power like nuclear and solar. Unfortunately, solar has several limitations, like unavailability of the sun during night time and on cloudy days, as well as its massive land-use requirements. The current power conversion efficiencies also leave a lot to be desired. All these factors, along with very high per-unit cost, limit the use of solar as a potential provider of base-load electricity to the grid. Nonetheless, it can certainly play a supplementary role, especially in far-flung areas and in regions that are not currently connected to the grid. Even then, such electricity would be several times costlier than grid power.

Nuclear power, on the other hand, has compelling merits, which I have mentioned earlier, and has been a proven power-production technology globally for nearly 60 years. Nuclear power has a very small lifecycle carbon footprint compared to other conventional sources of power. Nuclear power generation is clean and non-polluting, and it does not emit CO_2 or other greenhouse gases responsible for global warming. This is a huge advantage of nuclear power. Nuclear also has very small requirements of land use. Nuclear hydrogen generation will be a key to answer the needs of automobile fuel requirements

in the future. Hydrogen is not a source of energy; it is only a 'carrier' of energy, thus, you need some primary source of energy like coal or nuclear to generate hydrogen in the first place. Hydrogen generation is a highly energy-intensive task and nuclear can supply the energy needed to achieve this in a clean and environmentally friendly way. The technology for commercial use of Hydrogen is under development and it indeed is quite promising as a clean and green source of future energy.

Q Earlier this year world's largest uranium mine was found in India, at Tumalapalli in Andhra Pradesh. How exciting is this really for India, and what is the potential of these reserves ?

We are thrilled at the newly discovered uranium reserves in the country. The estimated potential of this find is significantly large and will certainly give a huge boost to our indigenous three stage nuclear power program in the coming years.

Q India is reported to have over 25% of the world's thorium reserves. Tell us about India's lead in thorium based nuclear power, its potential, and our future plans for energy independence. Please highlight challenges therein and the possible solutions.

A India is fortunate to have one of the largest reserves of thorium in the world. India's three-stage nuclear power programme is designed to make optimum use of our vast thorium reserves for sustained power generation to cater to the long-term needs of the nation. The stage -1 of Pressurised Heavy Water Reactors (PHWRs) has been commercially developed and 18 nuclear power reactors based on this are in safe and reliable operation for the last several years.

Four indigenous PHWRs of 700 MWe, two each at Rawatbhata in Rajasthan and Kakrapar in Gujarat are under construction and slated for commercial operation by 2017. Eight more 700 MWe PHWRs are planned for launch in next five year plan (XII Plan).The second stage of Fast Breeder Reactors is commercially developed and a Proto type Fast Breeder Reactor (PFBR) of 500 MWe is under advanced stage of construction at Kalpakkam in Tamilnadu. This reactor will start electricity generation from 2014-15.

The third stage, using Uranium - 233 and Thorium-232 fuel, is developed on Laboratory scale and under commercial development currently. In addition, an Advanced Heavy Water Reactor (AHWR) design is also developed for direct use of thorium. A test facility is currently in operation for evaluating reactor-physics aspect in this respect. We have also been able to use thorium fuel bundles as part of the fuel bundle matrix in our Pressurized Heavy Water Reactors (PHWRs). The thorium utilization curve in the coming decades will take the nuclear power programme in the country to newer heights.

Q Please tell us about the various dimensions of safety to be observed in a nuclear power plant ?

A Nuclear power industry has the highest observance of safety that begins right at the design stage, site selection, construction, commissioning, operation and maintenance. Historically, nuclear power has demonstrated highest levels of safety and extremely low fatality rate among the power producing technologies. The efficacy of nuclear power in India has been proven over the 42 years of its existence through safe, clean and cost-effective commercial nuclear power generation.

Our plants have multilayer of safety, in line with the defense-in-depth philosophy. The approach to safety is based on redundancy as well as diversity.

While the earlier generation nuclear power plants have undergone the renovation & modernization and safety upgrades to the latest state of art, the newer generation nuclear power plants employ the safety features to even greater heights.

Kudankulam Nuclear Power Plant (KKNPP), for example, has several 'additional' safety provisions, like enhanced redundancy, increase in the number of control rods, and notably, passive safety systems (in addition to active safety system), among several other features. Passive systems are based on the natural principles like operation under gravity, natural circulation, thermo-siphoning for cooling of the fuel / removal of residual heat after shutdown (called as decay heat). These do not require external motive force or human intervention to meet the safety requirements.

Q The destruction of the Fukushima power plant in Japan in March 2011 has apparently strengthened the anti-nuclear lobby. Could you please set the record straight for the benefit of our readers and provide reassurance that modern reactor and power plant designs have safeguards against such calamities?

A The damage to the Fukushima NPPs in Japan occurred not due to earthquake but because of tsunami height being much more than the tsunami height for which the plant was designed for. After the earthquake, the grid power of the region had failed. Due to the loss of the outside power, plant was auto shutdown successfully even while the plant was still being shaken by the earthquake. All the instrumentation worked as designed i.e. without any loss of function. Earthquake ground motion was much higher than the reactor trip set limit of 0.135g at Fukushima Daiichi & Daini and at 0.2g at Onagawa NPPs and all the plants were shutdown successfully.

Even after a NPP is shutdown, the reactor core requires cooling, as about 1% of the decay power keeps on generating from the fission products, even after the reactor is shutdown. After the loss of outside power due to earthquake, the electrical power required to drive the pump, which supply water to cool the reactor core is generated by diesel generators, which came on power automatically. However, the subsequent tsunami, which came after 49 minutes after the earthquake, with a tsunami height of 14 to 15 m, as against the designed height of 5.7 m at Fukushima Daiichi Unit-1, the diesel generator stopped functioning, might be due to short circuit in the generator due to ingress of water.

A nuclear power plant is designed for all the known natural hazards like earthquake, cyclone, tsunami and flood. Generally, the plants are designed for the levels of earthquake or cyclone or tsunami or flood, much higher than those experienced in the past, in the vicinity of the plant i.e. NPPs are designed with a good margin.

It is worth mentioning that the Units 2 to 4 and Units 5&6 were designed for a tsunami height of 10 meter and 13 meter against a design tsunami height of 5.7 meter for Unit-1 at Fukushima Daiichi. It is also worth noting that Onagawa, Fukushima Daiichi, Fukushima Daiini and Tokai NPPs are close to the main tectonic boundary between a Pacific plate and Eurasian plate on which an earthquake of magnitude 9.0 is possible and has occured on 11th March 2011. The Tohoku earthquake resulted into a horizontal slip of about 50 m at the fault location in the sea, with the sea bed uplifted in the form of truncated cylinder with a height of about10 m, spread over a width of 100 km as the chord of the cylinder and over a rupture length of 500 kms, with about 5 sub-faults of 100 km each as the axis of the cylinder. The sea bed over a distance of 100 kms to the east of the cylinderical portion, went down as a cocave profile with a maximum dip of about 1 m. This main tectonic boundary fault for Fukushima Daiichi is just at 180 km distance from the plant and now after Tohoku earthquake, it is very apparent that such tsunami heights of 14-15 m are very much possible, at a close distance of 180 km from the main tectonic boundary fault.

The earthquake resulted tsunami has caused loss of human life to the tune of about 28000 plus people either died or missing. However, it is worth noting that even after such a disastrous accident at Fukushima Daiichi which resulted in huge economic loss to the plant facilities & may be that few of the plants may not come back to operation and the accident also resulted in release of radioactivity to the environment, has so far not reported any death of the public because of radiation and may not happen in future as well. On contrary to the plant at Fukushima Daiichi, the tsunami heights at Onagawa, Fukushima Daiini and Tokai were 13 m, 14 m and 5.4 m in height resp, which are practically at the same distance of about 180 km from the main tectonic boundary fault and are different due to the bathemetry of the sites being different. These plants have no damage due to earthquake or tsunami because of their design for earthquake and for tsunami height.

On the contrary to what happened in Fukushima Daiichi, the NPPs in costal sites of India say MAPS at Kalpakkam and KK at Kundunkulam are about 1800 km from the Sunda fault near Indonesia which generated 9.3 M earthquake called as Sumatra earthquake. This earthquake has caused sea bed to come up by about 5 m, over a width of about 130 km and over a rupture length of 1500 km and has generated a tsunami height of 4.46 m and 2.0 m at Kalpakkam and Kudankulam resp. The plants at Kalpakkam and Kudankulam are designed for a tsunami height of 4.57m and 7.5m above the mean sea level.

Similarly, Tarapur and Jaitapur, which are coastal NPP sites on the west coast of India, are around 900 km and 1100 km from Makran fault which is to the south of Karachi and Oman. The Makran fault has a fault length of about 800 km and has generated an earthquake of 8.2M in 1945 giving rise to a tsunami with tsunami height of 1.5 m and less than 1.0 m at Tarapur and Jaitapur respectively. The plants at

Tarapur-1&2 and Tarapur-3&4 are designed for a tsunami height of 5.43 m and 6.33 m above the mean sea level.

As against the nuclear power plants in Japan being in the active tectonic region of the world, the nuclear power plants in India except at Narora are in stable continental region of the world. Similar active tectonic region of India as that of Japan is the Himalaya region. Even the NPP at Narora which is in the active tectonic region is about 300 km away from the tectonic boundary. As against the PGA of 0.5g and 0.68g experienced by the NPPs in Japan, the NPPs in India in stable continental region will not experience PGA more than 0.2g.

As far as the safety of NPPs due to earthquake is concerned, the recent database of good performance of NPPs in Japan, viz., Onagawa NPPs which witnessed May 2003 earthquake of 7.1M having PGA of 0.225g, Kashiwazaki-Kariwa NPPs which witnessed July 16, 2007 earthquake of 6.8M at 17 km epicentral distance having PGA of 0.68g, Shika NPPs which witnessed March, 2007 earthquake of 6.9 M at 18 km epicenteral distance having PGA of 0.225g and also North Anna NPPs in USA which witnessed 23rd August, 2011 earthquake, of 5.8M at 18 km epicentral distance having PGA of 0.27g have not resulted in any damage to these plants due to earthquake. Even Onagawa, Fukushima Daiichi, and Fukushima Daini NPPs which witnessed the 11th March, 2011 Tohoku earthquake of 9.0 M at an epicentral distance of 76 km, 154 km and 163 km respectively and which have seen PGAs of 0.6g, 0.55g and 0.3g respectively have resulted in apparently no damage to the structures, systems and equipment at these plants.

Q What will be the capacity addition from nuclear power generation in the next 20 years ? What are your specific targets for 12th and 13th Plans ? About Kudankulam Nuclear Power Project, how confident are you ? What are the lessons to be learned from Jaitapur ?

A Currently, installed nuclear power capacity is 4780 MWe and contributes to about 3.7% in the country's electricity generation. Kudankulam Unit-1 is ready for fuel loading and the Unit-2 is closely following. Currently seven reactors, including two reactors at Kudankulam are under construction, with an installed capacity of 5300 MWe. On progressive completion of these, the installed nuclear power capacity will reach 10,080 MWe by 2017. In addition, eight PHWRs of 700 MWe each and Eight reactors of 1000 MWe or larger size capacity based on international cooperation, two FBRs, each of 500 MWe and an AHWR of 300 MWe are planned for launch in the coming XII plan. These are expected to comple in early XIII plan. A capacity of 20000 MWe is expected in 2021-22. The vision of the Government as projected in Integrated Policy of the country is to have a share of nuclear power of about 63000 MW by 2032 in country's energy portfolio. More reactors are planned in future to augment the nuclear capacity base.

As I told you in reply to an earlier question, Kudankulam Nuclear Power Plant (KKNPP) is one of the most modern plants that take the safety paradigm even higher. This is a masterpiece of technology that would provide safe, clean and cost-effective power to the people of Tamil Nadu and the neighbouring states.

Q What about the state Governments' support ? What are the major challenges faced by NPCIL for executing and commissioning nuclear projects in the country ? Which States are more active and supportive to you ?

A Like everyone, State Governments also realize the need for rapid addition on the power generation front. The nuclear power plants are set up on request from state governments and sites offered by them are evaluated by a site selection committee of the Government. We have been receiving a support of the respective state governments in implementation of our programme and are confident of their continued support. The Fukushima event has caused some apprehensions in the minds of general public. The apprehension is heightened by misinformation spread by the groups ideologically opposed to nuclear power. We have increased the scale and intensity of the public outreach programme.

In this regard, dissemination of factual scientific information is the key, so that decisions are based on scientific facts and not on emotional panic. One fact, for example, which many people still do not know is that there has not been a single fatality at Fukushima due to radiation exposure till date. All the deaths, more than 28,000, have been due to the twin natural disaster of earthquake and tsunami. There is also a general perception that tens of thousands of people or even more may have died in nuclear accidents, but the reality is vastly different: in the 3 major accidents in the entire history of nearly 60 years of nuclear power generation worldwide, there have been about 50+ fatalities at Chernobyl (Ukraine, 1986), in all, till now, while there has been no loss of life at Three Mile Island (TMI, USA, 1979) and Fukushima (Japan, 2011) till date.

Q Nuclear accidents and the radiation fallout not only harms the exposed generation but also continues to impact generations to come, so say the opponents to nuclear power. How do you address their concerns, what are the measures adopted for preventing these accidents and mishaps? What are the solution and precautions taken while commissioning any nuclear plant?

A The radiation is present everywhere on the earth, and human kind is constantly exposed to it. In addition, for the human, the level of exposure from even at Chernobyl, where there was substantial release of radiation, the actual fatality count was too low (28 after four months, in 1986) compared to what was expected initially. There have been around 4000+ thyroid cancers at Chernobyl, but the actual cancer fatalities have not been more than 15 in the last 25 years. Detailed studies since the Chernobyl accident that took place in 1986 have indicated that thyroid cancer was the only type of cancer that saw a rise in the incidence. Very few isolated cases of other type cancers have been reported by some sources. And even if extreme suspected figures are to be believed, the total number of fatalities may not be more than a 100 or 150 in the worst case, considering even those cases that have no provable linkage to radiation.

Thus, you can see that even in a large nuclear disaster like Chernobyl, the actual radiation deaths have been nowhere near what is mistakenly prevalent in the public consciousness. And as I said earlier, there has been no loss of life in any nuclear accident except Chernobyl in the entire history of nuclear power generation. The one person who died at a French facility in an explosion earlier this year was not a nuclear accident, but an industrial accident at an associated reprocessing facility that was not even located at the nuclear power plant. It is also pertinent to note that the explosions at the affected Fukushima reactors were hydrogen gas explosions and not nuclear explosions. So, in essence, public education is the only challenge that I can see in the current scenario.

Q Recently on 3rd October conference on "Radiation and Reason Fukushima and After" was held at the Foreign Correspondents Club of Japan. What are the resolutions of that conference? Subsequently, there was an International conference on 6th November to 11th November at Delhi. Would you please brief the outcome of this conference ?

A The main focus of "Radiation and Reason: Fukushima and After" organized at Japan earlier this October was to put radiation, its effects and general fear of radiation in proper perspective. It was clearly noted at the meet that the fears related to radiation were far too exaggerated in comparison to the actual reality. At this event, it was also noted that the current prescriptive levels were too conservative and that in reality the actually measured radioactivity levels around Fukushima were indeed very low and not a cause for the kind of panic that was seen in respect of evacuation of the surrounding population, except at a few hotspots were the radiation measured was relatively higher.

In fact, Akira Tokuhiro, a chief speaker at the event, said that much of the evacuation post-Fukushima was essentially a matter of abundant precaution. He also considered some of the evacuation unnecessary in light of the extremely low radiation readings recorded in most of the surroundings of the plant.

SMiRT-21 conference was held between 6-11 November, 2011 at Delhi in which civil structures, reactor vessel, fuel bundle, mechanical, electrical and instrumentation equipment and support structures were discussed during presentations made and attended by many participants from India and abroad.

Various issues like performance of the structures against the operating loads viz., pressure, thermal, radiation effect, external loads viz., earthquake, cyclone, tsunami, flood, internally and externally generated missiles, material behavior, fracture mechanics, concept of leak before break criteria and earthquake ground motion were discussed during the conference. The major areas of discussion being earthquake, ground motion in stable and in active tectonic regions of the world and their different spectral shapes; fracture mechanics studies and material behavior towards the application of leak before break criteria to high pressure and temperature piping systems.

Q Please tell us your views and some details about distributed nuclear power generation, along the lines of the Hyperion Power Modules, designed in modules of a few tens of MWs. Do you feel this could be a possible solution for problems of citing large nuclear plants ? And in a way, also minimize the large scale power evacuation issues arising from mega nuclear parks.

A Hyperion power modules refer to small-size reactors that have been proposed by Hyperion Power Generation, Inc. When built, the company claims, these would be modular, inexpensive, inherently safe and proliferation-resistant. The company is currently trying to get a licence in respect of this. In principle, such reactors can be built, and indeed we can build small reactors of our own design in the future.

Q Do you have specific suggestions for Indian Power Equipment Industry ? What are your expectations from IEEMA and its Members, specifically Transformer, Switchgear, safe shutdown equipment, Cables, Power Generators, rotating equipment manufacturers ? What do you propose for the addition of seismic testing facilities in India to qualify equipment for use in nuclear power plants?

A Indian Power equipment companies have reached to state of maturity and are capable of meeting the current needs /requirements. The Indian Industry capacity would need augmentation to meet the Indian expanding Nuclear Power programme.

Regarding the performance of electrical and instrumentation equipment viz. transformers, switch gears, cable trays, reciprocating and rotating equipment during an earthquake loading, there have been concerns raised some 35 years before, when the issue of seismic design of NPP came up in USA in 1975 and the plants were asked to shutdown and respond to the seismic concerns before restart. Many engineering solutions were given to these concerns, as 76 NPPs were already in operation or under different phases of construction and commissioning in USA and the operating plants were required to be brought back in operation immediately.

However, now it has been well understood in India from the performance of these equipment at the industries in Kandla, Bhuj, Jamnagar and Koyna which witnessed the 7.6 M earthquake of 26 January, 2001 and 6.7 M Koyna earthquake of 10th December, 1967, as well as the performance of equipment at Kashiwazaki Kariwa, Onagawa and Shika NPPs in Japan which witnessed earthquake is that what fails during the earthquake are only brick walls, free standing transformers, unanchored battery banks, false ceiling, lighting fixtures and failures of rigid pipelines due to seismic anchor movement.

During the earthquake, the control equipment in NPPs in Japan as mentioned above worked as desired and the plants could be shutdown even when the earthquake shaking was going on. This is so because, Japan is a seismically very active country, very close to the major tectonic boundary fault and the reactors have tripped on auto on excedance OBE level of ground motion.

No control equipment panel or electrical panel like switch gear or battery charger have failed or have generated spurious signal because of chatter in the relay. The experience based data collected from industries which witnessed Bhuj and Koyna earthquake in India, Kashiwazaki-Kariwa, Shika and Onawaga NPPs in Japan which witnessed earthquakes, did not report any relay chatter. There were instances of relay chatter in U-tube mercury relay or relays with poor design for seismic resistance and are known for their bad performance in general industries which witnessed earthquake or found out during shake table tests are not used now in nuclear power plants or even in general industries for safety systems. With the use of seismically rugged relays, the concern on relay chatter has come in the category of an imagenary concern for a long time.

However, even then, we have been testing such panels on shake table. The things which fail during earthquake as brought out above viz., transformer, damage to battery bank, damage to false ceiling, failure of lighting fixtures etc. are not looked at with the severity which is due to them. NPC has come out with solution to support the transformer, lighting fixture & false ceiling and would like to have dialogue with the manufacturers and the associations of the manufacturers of transformer, diesel generator, compressor, switch gear and control equipment, so that the solutions given are acceptable to the manufacturers and are implementable which will improve the safety of these equipment. Further more, with the suggested upgrades, the electrical equipment will not only be seismically resistant for Nuclear Power Plant but also at the electrical substations and the industries in the country, so that there is no loss of power.

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