Nuclear power gateway to prosperous future: Kalam

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Every single atom in the universe carries an unimaginably powerful battery within its heart, called the nucleus. This form of energy, often called Type-1 fuel, is hundreds of thousands of times more powerful than the conventional Type-0 fuels, which are basically dead plants and animals existing in the form of coal, petroleum, natural gas and other forms of fossil fuel. Imagine a kilometre-long train, with about 50 freight bogies, fully laden with about 10,000 tonnes of coal. The same amount of energy can be generated by 500 kg of Type-1 fuel, naturally occurring Uranium, enough to barely fill the boot of a small car. When the technology is fully realised, one can do even better with naturally occurring Thorium, in which case the material required would be much less, about 62.5 kg, or even less according to some estimates.

Energy and economy

Today, India finds itself going through a phase of rapid ascent in economic empowerment. Our focus for this decade will be on the development of key infrastructure and the uplifting of the 600,000 villages where 750 million people live. All this will need massive energy. It is predicted that the total electricity demand will grow from the current 150,000 MW to at least over 950,000 MW by the year 2030.

International scenario on nuclear energy

So, will we allow an accident in Japan, in a 40-year-old reactor at Fukushima, arising out of extreme natural stresses, to derail our dreams to be an economically developed nation? When a few European countries, particularly Germany, decide to phase out nuclear power that should not become a blanket argument to take a view against our nuclear programme.

The decision of Germany suits its current scenario. It is a relatively power-sufficed nation— so it can afford to lose a few plants. More important, Germany has completely exhausted its nuclear resources.

The Indian population is misled when it is said that some Western nations have ended their nuclear programme, or that Japan is reconsidering nuclear power plant expansion. The study indicates that most of the prosperous nations are extracting about 30-40 per cent of power from nuclear power. In India, we are not generating even 5000 MW of nuclear power from the total of about 150 GW of electricity generation, most of it coming from coal. What is needed for our India, we Indians have to decide. Moreover, India is blessed with the rare, and very important, nuclear fuel of the future – Thorium. We cannot afford to lose the opportunity to emerge as the energy capital of the world. India has the potential to be the first nation to realise the dream of a fossil fuel-free nation, which will also relieve the nation of about $100 billion annually which we spend in importing petroleum and coal.

The greenest sources of power - solar and wind power are not stable and are dependent excessively on weather and sunshine. Nuclear power, on the other hand, provides a relatively clean, high-density source of reliable energy. Today, there are 29 countries operating 441 nuclear power plants, with a total capacity of about 375 GW(e). The industry now has more than 14,000 reactor-years of experience. Sixty more units, with a total target capacity of 58.6 GW, were under construction.

Much of the destructive power of nuclear accidents is compared against the benchmarks of the atomic bombing of Japan by the U.S. forces during the Second World War. You cannot compare a nuclear bomb with a nuclear power plant. Civilian nuclear applications in the form of a power plant are designed to deliver small amounts of energy in a sustainable manner over a far larger time frame.

Humankind's ability to combat nuclear challenges

We need to put the Fukushima-Daiichi events in the historic frame of nuclear accidents and analyse them. While there was huge loss to property and disruption of normal life, there was no direct loss of life due to the accident. As a silver lining, the way the accident was handled — compared to the Chernobyl disaster of 1986 — showed how much progress we have achieved in nuclear emergency management. The Fukushima-Daiichi plant was almost five times as big in terms of power generation and contained about nine times the nuclear fuel. Yet, with better emergency management, the maximum radiation was less than 0.4 per cent of that released during the Chernobyl disaster.

On 6th November 2011, both of us visited the much talked about 2000 MW Kudankulum nuclear plant to understand the plant's safety features and how it is addressing the concerns of the people which have inflated as an aftermath of the Fukushima Nuclear Event. We spent the whole day there meeting scientists and experts, meeting the local people and also studying the various facilities of the plant first hand. At the end we were absolutely satisfied to understand that this plant is equipped with the latest technologies when it comes to safety.

There are four important aspects of safety in a nuclear power plant which have been addressed in the plant.

1)Structural Integrity Safety: The structure of the plant has been made with the highest safety standards which doubled containment and hermetically sealed to be safe against earthquakes. To counter any risk from Tsunami and cyclones, the plant is elevated, to a minimum height of 6 meter (pump house) and the auxiliary diesel sets are at a height of 9.3 meter with a redundancy of four times in the diesel generators. In the case of Fukushima, one of the primary reasons for structural collapse was the explosion in the hydrogen which got out of control. To counter this, Kudankulum plant has installed 154 Hydrogen recombiners across the plant which can absorb any leaked hydrogen and prevent any structural damage.

2)Thermal Hydraulic Safety: The most advanced safety feature in the Kudankulum plant is the installation of the Passive Heat Removal System (PHRS) which is latest in technology to ensure rapid cooling of the reactor in the event of a reactor problem. The PHRS is a unique steam recirculating system which can continue to cool the plant in the event of the failure of AC power and even when the worst possible scenario of coolant malfunction has occurred, without leaking any radiation in the atmosphere. There is also mechanism to rapidly cool the reactor in emergency situation using an elaborate system of showers which are installed in redundancy across the plant.

3)Neutronic Safety: In any nuclear plant the most important cause of failure can be the loss of ability to control the neutrons being generated which is done by a system called control rods. Besides the control rods, the Kundankulum Plant has uniquely implemented the latest technology in this domain – The Core Catcher. This is basically an underlying structure with Gadolium oxide which would “catch the neutrons” in the event of a highly unlikely meltdown. The core catcher is the ultimate defense which would, without any human intervention, or need of external power supply, cool down the fuel and reactor.

4)Waste Management: A popular myth is that nuclear waste is dumped into the oceans which kills marine life and contaminates water. This is completely false. Yes, many decades ago, some of the nations used to dump nuclear waste in deep oceans away from habitat but that practice is over now. With the closed loop cycle the waste generated per year from 1000 MW plant is less than 3% and that, after vitrification would not occupy a space of about 6 cubic meters.

Another argument is that the nuclear accidents and the radiation fallout would not only harm the exposed generation but also continue to impact generations to come. Post the Hiroshima and Nagasaki bombing in 1945, the U.S. government established the Atomic Bombing Casualty Commission (ABCC) in 1946 which in 1974 was reconstituted as a joint venture between the U.S. and Japan as the Radiation Effects Research Foundation (RERF). The ABCC and the RERF have extensively studied the long-term impact of radiation and nuclear disaster across generations for over six decades. Contrary to popular belief, the findings clearly state that the effect of such exposure is limited only to the exposed generation.

In the wake of the recent natural disaster impacting the Daiichi plant in Fukushima, two concerns are prominent. The first is that of safety against the plant's disaster, and the second relates to the environmental impact and the nuclear waste which the plant generates.

Let us consider the second issue first.

Opportunity cost of nuclear energy

a) Abstinence from nuclear power is an incomplete response without the logical alternative. Some part of the future need, although only a small fraction, would come from solar and wind sources, with great unpredictability. A part would be offset by hydro-power too. But in all probability we will continue to increase our reliance on fossil-based fuel power generation methods.

Every year, human activities are adding about 30 billion tonnes of CO2 into the atmosphere. The IPCC estimates that 26 per cent of this emission (about 7.6 billion tonnes) is a direct consequence of electricity generation requirements. The WHO estimates that about 1.3 million people lose their lives as a result of urban outdoor air pollution alone, and about 140,000 are causalities to adaptation challenges of climate change. Thus, the pollution caused by power generation activities, and the associated climate change are directly or indirectly responsible for about 481,000 deaths every year. Comparatively, in the case of the worst civilian nuclear disaster ever at Chernobyl, the United Nations Scientific Committee on the Effects of Atomic radiation (UNSCEAR) predicted up to 4,000 cancer cases (often curable) due to the accident, besides 57 direct causalities.

Safety issues of nuclear power

b) Throughout the history of nuclear power generation there have been four major incidents of plant failure — the Kyshtym accident in fuel reprocessing in 1957, the relatively smaller Three Mile Island meltdown (United States), the much bigger Chernobyl accident (USSR, 1986) and the recent Japanese incident at Fukushima. The first accident was purely due to underdeveloped technology, and much of the blame for the next two disasters is attributed to human error. Even in the case of the Fukushima disaster of 2011, there were extraordinary natural forces in action — the rare occurrence of the tremendous stress load of an earthquake coupled with the unprecedented shear load of a tsunami. The occurrence of four failures in six decades cannot be made out as a case for completely disbanding the technology.

Let us take a few examples. In 1903, the Wright brothers translated into reality the remarkable dream of controlled human flight. In 1908, the first flight disaster occurred, which severely injured Orville Wright and killed his co-passenger. Today air accidents kill more than 1,500 people every year. Imagine whether we would be flying between distant cities, across oceans and continents, if the incident of 1908, or the ones later, were used as a reason to disband human flight?

The Indian space programme, which is now ranked among the best in the world, started with a failure in 1979 when our first rocket, instead of putting the satellite into a near-earth orbit, went into the Bay of Bengal. I was the Mission Director of the launch, and we were accused of putting a few crores of rupees into the sea. We did not wind up our dreams. The mission continued and the next year we were successful. The argument is that all failures and accidents propel us to think and develop better and safer technologies. Improvement, and not escapism, should be our step forward.

Nuclear fuel of the future: Thorium

Let us introduce a lesser-known member among radioactive materials — Thorium. Thorium is far more abundant, by about four times, than the traditional nuclear fuel, Uranium, and occurs in a far purer form, too. It is believed that the amount of energy contained in the Thorium reserves on earth is more than the combined total energy that is left in petroleum, coal, other fossil fuels and Uranium, all put together. And information revealed in an IAEA, International Atomic Energy Agency Report (2005) on Thorium fuels indicates that India might have the largest reserves of Thorium in the world, with over 650,000 tonnes. This is more than one-fourth of the total deposits of Thorium; in comparison, we have barely 1 per cent of the world's Uranium deposits. Thorium has many other advantages. It is estimated that Thorium may be able to generate (through Uranium-233 that could be produced from it) eight times the amount of energy per unit mass compared to (natural) Uranium. In the much debated issue of waste generation also, Thorium has a relative advantage. It produces waste that is relatively less toxic.

Being the largest owner of Thorium the opportunity is for India to vigorously pursue its existing nuclear programs with a special focus on research and development on the Thorium, which we are already undertaking. The power of the nucleus is mighty and the future of humanity lies in harnessing it in a safe and efficient manner. Affordable, clean and abundant energy provided by nuclear sources is our gateway to a future that is healthy, learned and connected — a future that will span deep into space and crosses the boundaries of current human imagination.

Conclusion: History is written by those who stood for their ideas

I was asking myself “What did I learn from great thinkers who have brought transformation?” From them I learnt no crowd mongers and no easy routes have ever brought progress and change to the nation. It is only the individual, the mighty mind and soul, which have transformed the world, brought the innovative transformation and he and she had the courage to stand alone for their idea and contribute which in course of time has been respected by the masses. I always cherish how Prof. Satish Dhawan can build a high performance space organization which has today sent so many satellites in the orbit or how minds like Dr. C. Subramaniam and Dr. M.S. Swaminathan brought the green revolution which today has enabled us to produce 235 million tonnes of food from 50 million tonnes in 1960s. They stood against the fear of failure, didn’t they? Our nuclear program is one of the indispensible keys to our future and our technological leadership, political leadership and every citizen of the nation must realize this.