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A Case for Expanding Nuclear Energy in India

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Introduction

Energy has been key for the growth of human civilisation from a long time now; with time, humans moved towards fossil fuels for meeting their energy needs. However, with the advent of cheap renewable electricity, electric vehicles, and electric based technologies, fossil fuels are being increasingly replaced, be it in industry or otherwise. This implies that the future form of energy is mainly electric.

India had a considerably low electricity consumption of approx.1208 kwh per capita per annum in 2020[1], as compared to USA which had approx. 12,235 kwh or even the world average of approx.3,316 kwh per capita per annum for the same year.[2] As India grows economically, its electricity consumption is bound to increase manyfold. Electricity

Key Points

- India is expected to witness a sharp rise in power demand in the next two decades owing to an expanding economy and increasing electrification of transport and industrial sectors.
- How such rising power demand is met will directly affect India's contribution towards global efforts against climate change.
- Nuclear Energy makes a compelling argument for a clean and efficient baseload capacity solution, helping in achieving a reliable and practical energy mix.
- Maturing technologies like the small modular reactors can hold the key to nuclear energy's future in India with possible rectifications to the problems faced while working with large conventional reactors.
- Government support by way of improved funding and better policy in terms of exploring different financing methods like the Mankala model of Finland, allowing greater private sector involvement and a carbon tax, can provide the needed thrust to the nuclear industry in India.

consumption per capita per annum doubled from 672 kwh in 2007 to 1208 in 2020.[3] This may further increase by another 35 per cent by 2030.[4] As India has also taken emission pledge at the 2015 United Nations Climate Change Conference, how India meets its energy demand is crucial for the fight against. Nuclear energy can serve as an important tool in meeting India's power needs while supplementing renewable energy solutions. The aim of this paper is to highlight the many advantages of nuclear energy and the need for increasing its share in India's energy mix.

The Future is Electric

In 2014, the energy sector in India accounted for 68.7 per cent of the total greenhouse-gas (GHG) emissions.[5] The energy sector's contribution to the global GHG emissions stood at 73 per cent in 2016.[6] Considering India's growing economy, the energy sector's contribution to the country's emissions is going to increase too. This increase may be at a slower rate than in the past given the massive renewable energy capacity addition that has taken place in the country in the past few years, reaching 24.5 per cent of the total installed capacity,[7] however, the energy sector's contribution to the total GHG emissions will continue to rise as the demand for power grows.

There that are bound to impact GHG emissions contribution: transportation and industrial sectors. How fast these sectors can adopt the transition to electricity as their primary energy source will determine India's fight against climate change; thus, ensuring energy security. This is so because the electricity produced has considerable proportion of renewable energy involved, even if it is with its own set of limitations, which will bring down the total emissions attributable to these sectors. Nevertheless, it is vital to understand the kind of impact transitioning to electricity can have on a country's energy security mainly through the following two sectors.

- ***Electric Vehicles.*** As highlighted, India's energy demand is set to increase with economic growth in the country. One of the factors that can variably boost this demand is the use of electric vehicles (EVs) space. India has high ambitions regarding sales of electric vehicles in the country. According to a joint report by NITI Aayog and Rocky Mountain Institute, EV sales in the country could reach as high as 30 per cent for private cars, 70 per cent for commercial cars, 40 per cent for buses and 80 per cent for two and three-wheelers by 2030.[8] This would result in an increased demand for electricity as the primary source of energy for transportation.

- ***Increased Power Consumption by Industries.*** The falling renewable electricity prices and cost of industrial electrical equipment along with increasingly stringent GHG emission regulations, is expected to produce several opportunities for the industrial sector to go electric. According to McKinsey, currently only 20 per cent of the energy used in industrial sector is electric. While 35 per cent of the fuel used in various industrial processes are used as raw materials, the remaining 45 per cent is used for various processes like cracking, melting, and drying.[9] The McKinsey publication further highlights the added benefits of adopting electric energy including lower maintenance and investment costs, better efficiency and reduced emissions. Nearly half of the fuel used for energy can be substituted with available electrification technologies available. Such developments could very well push the demand for electricity by a significant proportion. This transition is expected mainly due to either anticipated declining electricity prices especially led by renewables, or carbon tax levy by governments as they strive to combat climate change.

Why Nuclear Energy

- ***A Good Baseload Source.*** A baseload is the minimum power demand that is required to be met from a grid. It is essential to maintain an energy mix that can always provide an uninterrupted baseload supply. According to a study by POSOCO[1], an optimum baseload capacity should be about 70-80 per cent of the load duration curve.[10] A load duration curve represents the number of hours a particular load level is required in 24 hours. This means that even if the peak load is 1000 MW but for 70 per cent of the time the load is only 600 MW, then the baseload generation capacity should be only 600 MW. Renewables unfortunately could not be considered a source of good baseload capacities because of their intermittent supply, for instance solar energy cannot provide electricity in the evening and 74 per cent of the total wind power is generated in just 4 months of the year.

  In 2016, India's baseload capacity was about 150 GW, higher than optimum where it should have been approx. 115 GW, according to POSOCO.[11] This indicates a problem of over-supply using mainly the highly polluting coal/lignite/gas fired plants; however, in last five years, there has been considerable improvement in substituting thermal plants (used as baseload capacity) with renewables. The share of thermal

[1] POSOCO: Power System Operation Cooperation.

and renewables has changed from 73 per cent and 12.62 per cent respectively in the year 2015-16 to 61.5 per cent and 24.5 per cent respectively as on 14 March 2021.[12]

Although, the share of thermal capacity has come down in the last few years, but it still needs to be substituted by other sources to bring down carbon emissions and safeguard public health. Non-renewable baseload capacity would still be needed in the absence of cost-effective energy storage solutions which is the biggest limitation of renewable energy. Within that baseload capacity, there is a need for a less emission-intensive mix of power sources. Already, India ranks the highest in terms of the emission intensity of every unit (kwh) of electricity produced, standing at around 750 gCo2 per unit (2020). This is far above the world average of around 275 gCo2 per unit.[13] This is where nuclear energy can play an important role in helping India meet its Intended Nationally Determined Commitment (INDC) submitted before the COP21 by supplementing the baseload capacity in a balanced way.

Nuclear energy is significantly cleaner and more efficient than coal based power plants. While the average plant load factor (PLF) {a measure of its operational time in a year} of coal fired plants in India was 56 per cent for FY 2019-20, the same for nuclear energy was 85 per cent making it a more consistent and reliable source of energy.

The argument for using solar energy for baseload capacity is weak considering the total cost of switching over to solar energy completely. Currently, even without the possible reductions in cost of building a nuclear reactor due to SMR designs, India manages to build conventional reactors at the cheapest rate in the world – about USD 2000/kw[14] —this means that a 1000 MW reactor would cost around USD 2 billion, potentially operating at 85-90 per cent PLF. For solar energy, while the capital investment is less that is about USD 800/kw (2018),[15] the capacity utilisation factor can be as low as 18 per cent and an average of about 20 per cent.[16] This means that to match the electricity output from a 1000 MW nuclear plant, about 4500 MW of installed solar capacity would be needed, offsetting the initial lower capital investment. In addition to this, to be able to provide reliable power supply when the sun is not shining, solar energy would require feasible grid scale battery storage. Currently, the cost of lithium-ion battery is around USD 150/kw,[17] which further adds to the total cost of solar energy as a complete or partial baseload source.

- ***Energy Security.*** India is an energy dependent country. It imports a large portion of its fossil fuel demand. While high import bills may be understandable for oil and

natural gas, what is unfortunate is the import cost of coal for India considering it has one of the largest coal reserves in the world. In the financial year (FY) 2019-20, India imported nearly USD 21.28 billion worth of coal, around 80 per cent of which was of thermal grade used to generate electricity.[18] India's thermal grade coal imports have hovered above the 20 per cent mark of the total demand between FY 2014-15 to FY 2019-20.[19] According to CRISIL analysis, this trend is expected to continue and pose financial stress on the country. This implies that being dependent on external sources for coal with higher price volatility compared to nuclear fuel which is cheaper, requires refuelling in every 18-24 months and has a much lesser price volatility. According to the US Nuclear Energy Institute, the cost of fuel in a coal fired power plant stands at 78 per cent of total costs, while for nuclear power it is only 14 per cent.[20] The longer refuelling cycle in nuclear plants and steady prices of nuclear fuel will ensure that India is less exposed to price and political risks involved with importing fuels. The only shortcoming of using nuclear energy in India was the shortage of fuel supply since it is not a member of Nuclear Suppliers Group (NSG), however, India got a NSG waiver in 2008.

- ***New Technologies.*** There have been some valid concerns about nuclear energy around the world. These mainly comprise of capital costs, safety issues and proliferation. There have been some developments in the nuclear industry which offer solutions to some of these problems. One such solution is the Small Modular Reactors (SMRs). SMRs are reactors rated equal to or below 300 MWe, designed with modular technologies that is the civil works are done on-site and small modules containing the reactors are manufactured in a factory and then transported to the plant site. NuScale, a company based in the US, offers extremely high safety standards. According to James Conca, "the small size and large surface area-to-volume ratio of the reactor core, that sits below ground in a super seismic-resistant heat sink, allows natural processes to cool it indefinitely in case of a complete power blackout",[21] that is drastically reducing the chances of a reactor meltdown and thus reducing the risk of radiation leak and contamination. NuScale reactors are around 5 per cent the size of conventional large-scale reactors. This further reduces the nuclear fuel and waste at the plant size at any given time compared to large nuclear plants. All the factors highlight another advantage of SMRs - the need for a much smaller exclusion zone around the plant. According to NuScale calculations, the exclusion zone could be limited to just 40 acres from the plant boundary.[22] Currently, this figure stands at nearly 78 sq. km for India.

Another advantage of SMRs compared to traditional large reactors is it's reduced costs. Since, the modules containing the reactors are to be manufactured at a factory, therefore, it can potentially allow significant economies of scale. Due to their modular construction, the construction time can be reduced from five years to three years. The shorter construction times will further reduce the financing costs since utilities would not have to wait long periods before the plant can begin generating revenue. India already possesses the capability to build reactors at a lower cost when compared to America and Europe. SMRs can also help with capacity decentralisation as well as reducing the risks of mistakes prevalent at a large under-construction plant having major consequences in terms of delayed timelines and escalated costs.

- ***Environmental Impact.*** One of the biggest objections to nuclear energy is its potential impact on the surrounding environment with respect to radiation leaks and contamination in case of an accident and the other being nuclear waste management. Nuclear accidents like the Three-Mile Island, Chernobyl and Fukushima which left an indelible impact on the minds of the public and policy makers globally have contributed to this fear of nuclear energy. However, with times, nuclear energy has evolved in terms of safety standards with significant improvements made based on part experiences. To make a point, the death toll related to the Fukushima Daiichi nuclear accident was zero. An immediate report submitted to the International Agency (IAE) highlighted no immediate adverse health effects were found in 195,345 nearby residents who were screened by May 2011 end.[23] On 09 March 2021, a United Nations (UN) report highlighted how no adverse health effects were noticed among the Fukushima residents which could be directly attributable to the disaster.[24]

  In the Indian context, there have been 'zero' direct fatalities related to seven nuclear accidents that have occurred in India till date. However, maximum deaths in India have been caused due to air pollution and fossil fuelled power plants are one of the main reasons for air pollution. While on one hand, nuclear disaster related deaths can be much more graphic and harder to comprehend, on the other hand statistics reveal that fossil fuelled power plants remain the silent killers, evoking little fear in the people or the government.

Nuclear waste disposal issue remains more of a political one rather than technological. Several technologies exist today than can recycle 90 per cent of the 'used fuel', while the remaining can be stored safely in sealed concrete-steel dry casks on existing plant sites. India is a topographically diverse country with large deserts and mountains that can be used for constructing permanent repositories for nuclear waste, especially the transuranic waste that can last for 100,000s of years.

Recommendations and Way Ahead

- ***Better Funding.*** In India, the nuclear sector is completely reliant on the central government for its research and development, operating expenses and capital expenditure for new capacity. For FY 2020-21, the budget allocation to the Nuclear Power Corporation of India Limited (NPCIL) was INR 3000 crore and INR 3560 crore in FY 2021-22.[25] Owing to the capital-intensive nature of the industry and denial of access to the private sector, the central government must take the responsibility of providing timely and adequate funding, for enabling the nuclear power industry in India to grow more rapidly. Apart from government funding via the debt-equity route, financing options involving private companies can lead to competitive financing. India could also explore the Mankala Model in Finland which has been followed since the 1970s to finance major power plants in the country.[26] The model is based on a cooperative form of financing wherein the risk associated with large capital investment is shared by a group of companies. These companies may in turn sell the power generated from these plants or use it themselves. India can explore using the same model for its nuclear sector.

- ***Policy Support.*** Capital support needs to be complemented with policy support for nuclear energy as well. There is a need to allow and encourage the private sector to take a lead role in the nuclear sector with necessary regulations and government oversight considering the sensitive nature of the technology. Along the lines of the National Solar Mission launched in 2010, India needs a National Nuclear Mission to unlock growth in this sector. NPCIL could play the role along the lines played by the Solar Energy Corporation of India (SECI), enabling competitive bidding through tenders with set parameters for quality control of the equipment. The government could also provide tax benefits for research and development projects undertaken by companies, productivity- linked incentives in terms of timelines for project completions, tax breaks for necessary equipment imports and providing subsidised funding in cooperation with foreign partners like Japan. Increasing nuclear power's

share in India's current electricity generation capacity, which today stands at around 1.8 per cent, would also require carbon tax on fossil fuel based power plants. India could also tie-up with companies like NuScale which have already been working on new technologies to get a head start on the technological curve.

Conclusion

Like all energy sources, there are advantages and disadvantages to nuclear energy. However, it is important to attain a balanced energy mix that can provide affordable and reliable power to growing industries and societies. The argument is not to completely replace coal with nuclear. Nuclear power's own constraints in terms of long construction timelines and high costs prohibit that. But it is equally important to understand that renewables are not a cure all either in the absence of affordable long-duration storage technologies and therefore cannot supply round the clock power. Given the urgency to fight climate change, coal cannot be allowed to retain a lion's share in India's energy mix either. The goal should be to strive for a balanced supply mix that manages the affordability, reliability, public health and fight against climate change. Nuclear power's merits far exceed its potential downsides, making it the perfect hedge between the fossil fuels and renewables.

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