INDIA'S ENERGY BASKET AND THE CASE STUDY OF JAITAPUR NUCLEAR POWER PLANT

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In the 21st century, Energy has become the world's most vital commodity and India is one of its largest consumers. The energy world is rapidly changing and this change is driven by increasing demand, changing growth and demographic patterns, finite resources, environmental impact, and the transition from hitherto dominant sources of fuel to newer, cleaner sources of energy. In the coming years, the energy transition and the changes will impact not only the operational ability but also the functioning of nation states and other entities alike. Energy is clearly becoming the currency of the 21st century.

India is a major force in the global energy economy. This primacy could be attributed to two factors—consumption and demand. India has a large population and a fast-growing economy. India currently ranks second on the world population charts and would soon overtake the People's Republic of China (PRC) to become the

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most populous country in the world by 2027.[1] India is also the fastest growing economy in the world according to the Gross Domestic Production (GDP) growth projection by the International Monetary Fund (IMF).[2] India uses 6 per cent of the world's primary energy and its energy consumption stands at one-third of the global average.[3] Considering 2000 as the base year, India has been responsible for a 10 per cent increase in the global energy demand.[4] The last two decades also saw an increase in the per capita energy demand by 60 per cent.[5] An ascending forecasted GDP coupled with a yielding demographic dividend makes a case for a rapidly growing economy. As the economy grows, so will the demand for energy needed to fuel the economy and India's economic growth will continue to drive its energy consumption. Hence, there exists a great potential for an increased energy demand in the coming times.

When looking at India's energy basket in terms of Installed Generation Capacity (IGC), fossil fuels account for the majority of the contribution, accounting for 58.6 per cent of the total share.[6] In it, Coal accounts for 50.7 per cent of total generational capacity, with natural gas coming in second at 6.2 per cent.[7] Renewable energy accounts for the majority of the remaining 39.7 per cent in the non-fossil fuel category.[8] Surprisingly, nuclear energy, which is one

1. Special Correspondent, "India to be Most Populous by 2027", *The Hindu*, at https://www.thehindu.com/news/national/india-to-be-most-populous-by-2027-un/article28067167.ece. Accessed on August 21, 2022.
2. "India to Remain the Fastest Growing Major Economy in the World During 2021-22 as per World Bank, IMF, Says Economic Survey 2022", ANI, at https://www.aninews.in/news/national/general-news/india-to-remain-fastest-growing-major-economy-in-the-world-during-2021-24-as-per-world-bank-imf-says-economic-survey2022020101011933/#:~:text=This%20projects%20India%20as%20the,per%20cent%20in%202020%2D21. Accessed on August 30, 2022.
3. ET Bureau, "India Needs Quadrupling Per Capita Energy Consumption to Get into Upper Middle Income Country Club: Economic Survey", *The Economic Times*, at https://economictimes.indiatimes.com/industry/energy/power/india-needs-quadrupling-per-capita-energy-consumption-to-get-into-upper-middle-income-country-club-economic-survey/articleshow/70070107.cms?from=mdr. Accessed on August 25, 2022.
4. World Energy Outlook Special Report, "India Energy Outlook 2021", International Energy Agency, p. 20. Accessed on September 5, 2022.
5. Ibid.
6. Ministry of Power, "Power Sector at a Glance ALL INDIA", at https://powermin.gov.in/en/content/power-sector-glance-all-india. Accessed on August 29, 2022.
7. Ibid.
8. Ibid.

of the cleanest sources of energy and is a baseload energy source, accounts for only 1.7 per cent of the entire IGC. Nuclear power has the potential to become a major contributor to India's energy basket in the future. It is the world's second largest source for low carbon-power and contributes to 10 per cent of the world's total electricity generation.[9] India's installed nuclear power capacity has grown substantially. It grew 40 per cent in the last 7 years itself.[10] About 650 million tons of CO_2 emissions have been avoided because of nuclear power reactors, which have produced about 755 billion units of electricity to date.

The state-owned Nuclear Power Corporation of India Limited (NPCIL) is in charge of the design, construction, commissioning, and operation of 22 thermal nuclear power plants with a total installed capacity of 6,780 MW. In 1969, two small GE boiling water reactors (BWRs) were commissioned (160 MW each) at the Tarapur Atomic Power Station, Maharashtra. In 1972, one AECL PHWR constructed in Canada was commissioned (100 MW) at the Rajasthan Atomic Power Station. By 2017, two huge Russian-built pressurised water reactors (PWRs) were put into service of 1,000 MW each at Kudankulam Nuclear Power Station, Tamil Nadu.[11] Additionally, Kakrapar 3 which is India's indigenously built PHWR attained criticality in 2020 and is the country's first 700 MW unit.[12]

The Government of India has set ambitious aims to develop India's nuclear energy capacity.[13] The country's 12th Five-Year Plan

9. Worldnuclear.org, "Nuclear Power in the World Today", at https://world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx. Accessed on September 10, 2022.
10. Press Trust of India, "Installed Nuclear Power Capacity Grew by Over 40% in the Last 7 Years: Govt", *Business Standard*, at https://www.business-standard.com/article/economy-policy/installed-nuclear-power-capacity-grew-by-over-40-in-last-7-years-govt-121121500653_1.html. Accessed on September 3, 2022.
11. Nuclear Power Corporation of India Limited, "Plants Under Operation", at https://www.npcil.nic.in/content/302_1_AllPlants.aspx. Accessed on September 3, 2022.
12. Anil Sasi, "What is the Significance of Kakrapar-3?", *The Indian Express*, at https://indianexpress.com/article/explained/kakrapar-atomic-power-project-third-unit-achieves-first-criticality-india-nuclear-mission-6518946/. Accessed on August 26, 2022.
13. United Nations, Nationally Determined Contributions Registry, "India's Intended Nationally Determined Contributions", at https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf. Accessed on August 27, 2022.

in 2010 aimed for total built nuclear capacity of 63 GW equivalent by 2032.[14] India also expects to have 10 per cent of its energy sourced from nuclear energy by 2030.[15] India is currently building seven nuclear reactors, comprising four indigenous 2,800 MW PHWRs, two Russian-built 1,000 MW PWRs, and a 1,500 MW indigenous FBR.[16] The Department of Atomic Energy informed India's parliament that 21 more reactors with a combined installed capacity of 15,700 MW are anticipated to be built by 2031.[17] Additionally, India would start the construction of 10 nuclear plants in fleet mode from 2023.[18]

According to Dr. Jitendra Singh, India's net zero targets are anticipated to be achieved using a combination of several clean energy sources, including nuclear power. In this regard, it is intended to gradually complete projects that are now under construction and receive authorisation which would increase the current nuclear power capacity of 6,780 MW to 22,480 MW by 2031.[19] Nine nuclear power reactors are now under construction and should be finished by 2024-2025. In June 2017, the Government also granted administrative authority and financial sanction to twelve more nuclear power reactors. Thus, 21 nuclear power reactors with a combined installed capacity of 15,700 MW are now being built and are expected to be gradually completed by the year 2031.[20]

14. Pooran Chandra Pandey, "India Expects to Have 10% of its Energy Sourced to Nuclear Power in 10 Years", *Climate Score Card*, at https://www.climatescorecard.org/2021/08/india-expects-to-have-10-of-its-energy-sourced-to-nuclear-power-in-10-years/. Accessed on August 31, 2022.
15. Ibid.
16. Press Release, "Nuclear Power Plants", Press Information Bureau, at https://pib.gov.in/PressReleseDetail.aspx?PRID=1605939. Accessed on September 23, 2022.
17. Press Information Bureau, "Generation of Nuclear Power", at https://pib.gov.in/PressReleasePage.aspx?PRID=1808681. Accessed on September 23, 2022.
18. Worldnuclear.org, "2023 Construction Start for Indian Reactor Fleet", at https://www.world-nuclear-news.org/Articles/2023-construction-start-for-Indian-reactor-fleet. Accessed on August 28, 2022.
19. PIB, "Union Minister Dr. Jitendra Singh says, Government has Accorded Approval for setting up the Largest Nuclear Power Generating site at Jaitapur in Maharashtra with a Total Capacity of 9900 MW. Minister Says, Presently Techno-commercial Discussions to Arrive at the Project Proposal with M/s. EDF, France are in Progress", at https://pib.gov.in/PressReleasePage.aspx?PRID=1782229. Accessed on August 16, 2022.
20. DAE, PIB, "Proposals for New Atomic Power Plants", at https://pib.gov.in/Pressreleaseshare.aspx?PRID=155848. Accessed on September 3, 2022.

CASE STUDY—JAITAPUR NUCLEAR POWER PLANT

The proposed nuclear plant at Jaitapur is set to be the world's largest nuclear power plant with 6 European Pressurised Water Reactors (EPR) and a targeted installed capacity of 9.6 GW in the state of Maharashtra. Accordingly, Government of India accorded its sanction in October 2005 to set up the Nuclear Power Plant at Jaitapur.[21] India has also given an in-principle approval to the site at Jaitapur but the project, despite being in talks for over a decade, has failed to come to fruition till date. If constructed, the plant would produce 9.6 GW of baseload, CO_2 free energy at one spot which would generate enough energy to power 70 million houses—all while reducing more than 50 million tonnes of CO_2 each year. But what has caused a project with major benefits to the country to falter even before it has begun construction?

To understand that, it is necessary to understand the reasons behind choosing Jaitapur as the favourable site for the project, the benefits it would accrue to the country and the local populace, and the trajectory of the project. With the reception of an in-principle approval, the department of atomic energy is actively considering a binding techno-commercial offer submitted by EDF, a French state-owned power company that will be building 6 third-generation EPR reactors in India.

The site for the Jaitapur nuclear power plant (JNPP) was recommended by the site selection committee which is notified by the Government of India. The site selection committee is responsible for selecting the site to set up a nuclear power plant as per the parameters and the requirements which are laid down by the Atomic Energy Regulatory Board (AERB). The factors that were taken into consideration while choosing Jaitapur were majorly pertaining to the availability of land vis-à-vis the population density and availability of the source of cooling water. Apart from this, seismicity, safe grade elevation including flood level analysis, feasibility and accessibility of transportation of heavy equipment to the site along with environmental and anthropogenic impact were also considered. Jaitapur is considered to be a favourable site and was accorded

21. DAE, PIB, "Facts about Jaitapur Nuclear Power Plant", at https://pib.gov.in/newsite/printrelease.aspx?relid=71795. Accessed on September 10, 2022.

government sanction in October 2005 for setting up a nuclear power plant at Jaitapur.

Trajectory of the project

The genesis of the project dates to 2008 during the visit of the former French President Nicolas Sarkozy to India. In a joint statement issued on his visit, France and India decided to give a "… new impetus to their cooperation for the development of nuclear energy for peaceful purposes as an expression of their strategic partnership."[22] The project began with the signing of the Inter-Governmental Agreement (IGA) on cooperation for peaceful uses of nuclear energy signed between India and France on September 30, 2008. Later, in 2009, a Memorandum of Understanding (MoU) was signed between Nuclear Power Corporation of India Limited (NPCIL), and AREVA, a French state-run nuclear power producer. Through the agreement, the NPCIL was made responsible for the construction and the commissioning of each of the six proposed units of the Jaitapur Nuclear Power Plant, as well as for obtaining all necessary permits and consents in India. Later, a General Framework Agreement (GFA) and an Early Works Agreement (EWA) was signed on December 6, 2010. The project also received environmental clearance and Coastal Regulation Zone (CRZ) clearance from the Ministry of Environment and Forests in 2010.[23]

In 2011, Fukushima Daiichi incident sent ripples of caution across the nuclear world. There was a renewed invigoration in the nuclear safety debate. Naturally, the confidence in the Jaitapur nuclear power plant slumped to a low and the project moved at a snail's pace. In 2016, the collapse of the initial French partner AREVA led to a major

22. Joint Statement, Ministry of External Affairs, "India-France Joint Statement Issued on the Occasion of the visit of HE Mr. Nicolas Sarkozy, President, Republic of France, to India", at https://www.mea.gov.in/bilateral-documents.htm?dtl/5152/IndiaFrance+Joint+Statement+issued+on+the+occasion+of+the+Visit+of+HEMr+Nicolas+SARKOZY+President+of+the+Republic+of+France+to+India+on+25+amp+26-+January+2008. Accessed on August 15, 2022.
23. Environmental Safety, NPCIL, "Jaitapur Site", at https://www.npcil.nic.in/content/507_1_JaitapurSite.aspx#:~:text=Environmental%20Clearance%20and%20CRZ%20clerance,as%20per%20EIA%20Notification%202006. Accessed on August 16, 2022.

setback to the project in terms of intergovernmental efforts. Later, AREVA was taken over by the Électricité de France (EDF), France's public electricity producer and supplier. It was not until 2018 that the JNPP gathered pace. On March 10, 2018, with the signing of the Industrial Way Forward Agreement, the project was set in motion. The agreement comprises three parts: project's industrial framework; roles and responsibilities of partners; and a planned time table for the next step. According to the conditions of the contract, it was decided that the EDF would supply India with EPR technology. For the first two reactors, the former would handle the engineering studies and procurement tasks. The engineering studies and the procurement tasks might then be delegated to local authorities for the remaining four units. The lessons learned by the EDF during the development of the EPR reactors would be very beneficial for NPCIL.[24]

Recently, in April 2021, EDF submitted a binding techno-commercial offer to NPCIL. According to an EDF statement, the new offer reiterates the terms in the previous agreement and includes "…the detailed technical configuration of the reactors, taking into account the information provided by NPCIL on the Jaitapur site conditions and the joint comprehensive work performed by EDF and NPCIL", and "the associated comprehensive commercial terms and conditions for the supply of engineering studies and equipment for six (6) EPR reactors."[25] This was a result of intense work between the two countries as the project is an important part of the strategic partnership between India and France. In December 2021, the government granted an in-principle approval for the setting up of six nuclear reactors in the Jaitapur site. This approval is being actively considered as recently as June 2022.

24. EDF, "Industrial Way Forward Agreement Signed between the EDF Group and the Indian Energy Company NPCIL for the Implementation of 6 EPRs in Jaitapur", at https://www.edf.fr/en/edf/industrial-way-forward-agreement-signed-between-the-edf-group-and-the-indian-energy-company-npcil-for-the-implementation-of-6-eprs-in-jaitapur. Accessed on August 20, 2022.
25. Utpal Bhaskar, "EDF Submits Binding Techno-commercial Offer for Jaitapur Nuclear Plant to NPCIL", *Livemint*, at https://www.livemint.com/companies/news/edf-submits-binding-techno-commercial-offer-for-jaitapur-nuclear-plant-to-npcil-11619168867867.html. Accessed on September 2, 2022.

Drawbacks

Jaitapur has always been a highly controversial project. If it gets through, it could be a potential factor in easing India's energy problems and would give a major boost to India's lagging civil nuclear programme. But the task is arduous and the goals seem to be easier said than done. In the last two decades, India's energy scenario has changed drastically. The project which was considered has been languishing for too long. The criticism received mainly ranges on 3 major issues: long construction time and overriding costs; safety; and environmental concerns.

LONG IN THE MAKING

The cost of power has been a major hurdle in the forward movement of the proposed plant. AREVA, which was initially tasked with the construction of the plant, had quoted a price of Rs 9.18 per unit of power. This quotation was vehemently opposed by the NPCIL and the Department of Atomic Energy (DAE). In 2014, with intense discussions and deliberations, the cost of the power per unit was bought down to Rs 6.[26] Although the estimates of the price per unit power are quite high when adjusted with the inflation rate and the time taken for the construction of the plant, it is generally believed that the price of per unit electricity from the JNPP would cost more than the price of per unit electricity of power sourced from renewable energy sources.

Apart from the electricity cost which is an end-user cost, the construction cost of the power plant has also put serious strains on the progress of the project. EPR, the reactor kind that is being considered for the site at Jaitapur, only has a few precedents to look at. A relatively new kind of reactor technology, EPR is being used at Taishan in China, Olkiluoto in Finland and is under construction at Hinkley Point in the UK and Flamanville in France. EPRs are experiencing overriding costs and construction time delays all over the world. In Taishan, the commercial operation of the plant began

26. PTI, "India, France Agree on Cost of Power Generated by Jaitapur Nuclear Power Plant", *The Economic Times*, at https://economictimes.indiatimes.com/industry/energy/power/india-france-agree-on-cost-of-power-generated-by-jaitapur-nuclear-power-plant/articleshow/31734670.cms. Accessed on September 9, 2022.

in 2018, which is five years later than the scheduled date. In addition to the delay in construction timing, the costs of the project were 40 per cent more than the estimated cost. The condition of the plant at Flamanville is not very different; the commercial operation of the plant was scheduled in 2012 but was moved to 2023 alongside an escalated price of 10.9 billion euros from 3.3 billion euros. The two EPRs that are being planned at the Hinkley Point have also come under criticism as the cost of construction has risen to a whopping 20 billion euros even before the construction began. The precedent showcases a certain pattern which has now become synonymous with the EPRs. A similar situation is unfolding in India. The project, which began its trajectory in 2008, is yet to begin construction in 2022. The final cost of the project has not been disclosed but can be roughly estimated from the cost of plants at other places.

SAFETY

The public opinion had turned quite apprehensive in the aftermath of the Fukushima Daiichi nuclear accident. It became necessary for the government to assuage the concerns about nuclear safety by undertaking measures like engaging in information dissemination which would trickle down to the grass roots. When it comes to a nuclear plant, the safety concerns are valid. In addition to the longer construction times and exacerbated costs, there have emerged safety issues with reactors at other EPR sites. In April 2015, the French nuclear safety regulator, Autorité de Sûreté Nucléaire, announced that some sections of the pressure vessel that the French Le Creusot forge had supplied to the Flamanville and Taishan reactors had too much carbon in the steel. The Flamanville project was also found to have substandard welding in the reactor's pipes.[27] In December 2021, tension mounted over the safety aspect of the EPR as damaged fuel rods were reported at China's Taishan nuclear plant.

These safety concerns are worsened by India's existent nuclear liability laws. In the event of an accident, it is the operator rather

27. Jesse Turland, "Safety Concerns Mount over Damaged Fuel Rods at China's Taishan Nuclear Plant", *The Diplomat*, at https://thediplomat.com/2021/12/safety-concerns-mount-over-damaged-fuel-rods-at-chinas-taishan-nuclear-plant/. Accessed on September 11, 2022.

than the vendor who is responsible for the nuclear safety risk and its aftermath. Under international norms, the power producers have an overwhelming liability and in case of the current project, the EDF is liable only for the damage caused by equipment supplied.[28] This means that the NPCIL would become the compensatory party in the case of an accident, largely exonerating EDF of its responsibility. In such a scenario, EDF can exit the situation with little to no consequences.

PUBLIC PERCEPTION

It is well known that Jaitapur has been marred by the perpetual protests by civil society groups whose primary opposition to the project stems from the larger environmental impact that the project would have on the area adjoining the plant. Jaitapur is an environmentally rich region and the local populace is mostly engaged in allied occupations. The plant site is surrounded by small fishing hamlets and farming communities. The creation of a nuclear power plant at the site would mean putting a stop to the occupations which have been carrying on for ages. One of the primary reasons for choosing Jaitapur site was the large availability of water for the plant as a nuclear power plant requires a steady supply of water acting as a coolant in the reactor. The intake of water by the plant is expected to be 52 billion litres. It is alleged that the water from the plant with higher temperature than the sea would force the translocation of marine life from the coast deeper into the sea, changing the entire ecological make-up of the region. There have been contrary views. Anil Kakodkar, former chairman of the AEC, has reiterated time and again that the construction of the plant at Jaitapur would not be a threat to agriculture or marine ecology in the region. The site has been selected after carefully carrying out thermal ecological studies which show no harm to the environment. There are more advantages of the project. The perceived threat of nuclear waste in the region must be debunked as the nuclear waste generated will not be handled at the site but will be done at the re-processing plant. Since civil

28. Ranvir Nayar, "Time for India to Cancel Jaitapur Nuclear Power Project", at https://mediaindia.eu/business/jaitapur-nuclear-france/. Accessed on September 14, 2022.

society opposition remains the single largest cause for the hold-up at Jaitapur, it is important for the government to hasten its efforts in getting the local populace on board with the project. DAE outreach is necessary for information to be disseminated at the grass roots so that such misinformation in the minds of the people could be cleared.

CONCLUSION

Energy security is a very strong arch in India's strategic goals. As of now, India is heavily dependent on fossil fuels which contributes 58.6 per cent of the nation's installed generation capacity followed by renewable energy sources accounting for 39.7 per cent of the total share. A major fault line in the current composition of India's energy basket is that it perpetuates India's crippling reliance on imports. India's economic future and prosperity is dependent on her ability to provide affordable, reliable, and sustainable energy to all. India has a set of strategic goals, and self-sufficiency and development contribute to it in a major way. The existent trend of an excessive reliance on coal needs to be reduced as soon as possible and this requires added efforts in other directions. Solar, wind, and other renewable energy sources along with non-conventional energy sources must be deployed to its full extent.

Although there have been significant improvements in India's energy scenario, certain measures should be employed rigorously to ensure India's energy security. These include the *reduction* of import dependence for primary energy sources; *introduction* and integration of cleaner and sustainable fuels like that of nuclear energy, hydrogen, and biofuels; *integration* of renewables and non-fossil fuel sources of energy in a phased and reliable manner, and reducing emissions in a bid towards adopting sustainable policies to help towards tackling climate change while attaining specified social and economic goals. Given India's humongous electricity requirement, lack of indigenous fuel sources, long-term vision for a sustainable growth, and environmental responsibility, diversifying India's energy basket is the key to ensuring India's energy security. The JNPP is an ambitious project and could help in ensuring India's energy security goals but the project comes with its own set of challenges. Nuclear power plants are long-term commitments with investment deals

running into billions of rupees and in this case, the precedents set by the EPR reactors have not been encouraging. To invest in a project with a reactor with such precedents, treading carefully on this path would be in India's favour. It becomes imperative for India to not fall into any wrong policy as Jaitapur could be another Enron waiting to happen. For a viable alternative which is also sustainable, India needs to accelerate the pace of its ongoing three-stage nuclear programme and push for the construction of indigenous reactors. Given India's expertise and experience, the nation is highly capable of doing so. But to paint a realistic picture, a slow-paced growth in the nuclear energy domain would not be sufficient in meeting the requirements needed to fulfil India's growing energy demands. This could inadvertently lead to India's increased dependence on imports and could hamper India's strategic goal of self-sufficiency.