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Powering Viksit Bharat: The Strategic and Energy Implications of Civil Nuclear Agreements.

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ABSTRACT

India's vision of Viksit Bharat (Developed India) by 2047, hinges on sustainable economic growth, technological advancement, and strategic autonomy. US - India Civil Nuclear Agreements (123 Agreements) signed on 1 August 2008 have played a pivotal role in this transformation by enhancing India's energy security and bolstering its nuclear capabilities. Before this Agreement, India faced restrictions under the Nuclear Suppliers Group (NSG) due to its non-signatory status in the Non-Proliferation Treaty (NPT). The deal removed these restrictions, allowing India to access cutting-edge nuclear technology from countries like the USA, France, Russia, and Canada. Advanced reactor designs, safety mechanisms, and efficiency improvements became available for India's civilian nuclear sector. India aims to increase its nuclear power capacity to 22 GW by 2031 as part of its clean energy transition. Collaboration with foreign companies has led to new nuclear projects, such as reactors being built with Russia (Kudankulam) and France (Jaitapur). Advanced reactor technologies like Pressurized Heavy Water Reactors (PHWRs) and Fast Breeder Reactors (FBRs) are being developed to increase efficiency. This research explores the strategic and energy implications of these agreements, assessing their impact on India's nuclear energy expansion, technological self-reliance, and geopolitical standing. The paper examines how civil nuclear cooperation with global partners has enabled India to access advanced reactor technology, diversify its energy mix, and reduce dependence on fossil fuels. Additionally, it analyzes the broader strategic benefits, including strengthening India's position in global nuclear governance and fostering indigenous innovation in nuclear technology. While civil nuclear deals have accelerated India's progress, challenges such as fuel supply constraints, technology transfer limitations, and regulatory hurdles remain. This study highlights the need for policy interventions and technological advancements to maximize the benefits of civil nuclear agreements in India's journey toward *Viksit Bharat*.

Key Words: Viksit Bharath, Nuclear Suppliers Group, Geopolitical, Non-Proliferation Treaty.

INTRODUCTION

The pursuit of "Viksit Bharat" (Developed India) by 2047 requires a fundamental transformation of India's energy landscape. India, currently the world's third-largest energy consumer, faces the dual challenge of

meeting rapidly increasing energy demands driven by economic growth and urbanization, while also addressing the urgent need to mitigate climate change (India Energy Outlook 2021). This necessitates a shift towards a more diversified and sustainable energy mix.

Nuclear energy, with its potential to provide a stable and low-carbon baseload power, is considered a crucial component of India's energy strategy. However, the development of India's nuclear power sector has historically been constrained by technological limitations and restrictions on international trade, stemming from its non-signatory status under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

Civil nuclear agreements with other countries have emerged as a key mechanism for India to overcome these constraints. These agreements facilitate access to advanced nuclear technologies, fuel supplies, and technical expertise, thereby accelerating the growth of India's nuclear energy capacity. This paper delves into the strategic and energy implications of these agreements, highlighting their significance in powering India's developmental trajectory and its pursuit of the "Viksit Bharat" vision.

1. Energy Security and Diversification

India's energy security is challenged by its heavy reliance on fossil fuels, particularly coal, which accounts for a significant portion of its electricity generation. This reliance exposes the country to the volatility of global fossil fuel markets and contributes to environmental concerns. The transition to a cleaner and more diversified energy portfolio is essential for sustainable development and long-term energy security. Nuclear energy offers a pathway to reduce this dependence and enhance energy security.

1.1. Role of Nuclear Energy in India's Energy Mix

The Indian government has set ambitious targets for non-fossil fuel-based energy generation as part of its commitments under the Paris Agreement and its domestic energy policy objectives. Nuclear power is expected to play a significant role in achieving these targets. The government aims to substantially increase nuclear power capacity in the coming decades (Pib-Nuclear_Energy Mission). Nuclear energy's ability to provide a stable baseload power supply is crucial for balancing the intermittency of renewable energy sources like solar and wind power, which are also key components of India's energy transition strategy. This stability ensures grid reliability and supports sustained economic activity.

1.2. Impact of Civil Nuclear Agreements on Fuel Supply

A major hurdle in the growth of India's nuclear power program has been the limited availability of domestic uranium resources. Civil nuclear agreements have been instrumental in addressing this challenge by enabling India to access uranium fuel from international markets. The 2008 India-U.S. 123 Agreement was particularly significant in this regard. It effectively ended the decades-long nuclear trade embargo against India, paving the way for fuel imports from various countries, including Russia, France, and Kazakhstan (World Nuclear Association India}. This diversification of fuel sources has significantly enhanced India's energy security and ensured a more stable supply of fuel for its nuclear reactors. Furthermore, it has allowed India to pursue its nuclear program without compromising its commitment to non-proliferation.

2. Strategic Partnerships and Technological Advancement

Civil nuclear agreements are not solely focused on fuel supply; they also foster strategic partnerships that facilitate the transfer of advanced nuclear technologies, promote collaborative research and development, and enhance India's indigenous nuclear capabilities.

2.1. The India-U.S. 123 Agreement and its Significance

The India-U.S. 123 Agreement stands as a landmark achievement in India's nuclear history. This agreement, signed in 2008, was the culmination of complex negotiations and marked a significant shift in the global nuclear order. It granted India access to U.S. nuclear technology and fuel, despite India not being a signatory to the NPT. The agreement was based on India's strong non-proliferation record and its commitment to separating its civilian and military nuclear facilities (US Department of State 123 Agreement). Beyond its immediate impact on fuel supply, the 123 Agreement has had profound strategic implications. It has strengthened the strategic partnership between India and the United States, recognizing India as a responsible nuclear power and paving the way for increased cooperation in other areas, including defense, trade, and technology. It also signaled India's integration into the global nuclear order, albeit outside the framework of the NPT.

2.2. Collaboration with Other Nations: Russia, France, and Others

India has also established strong nuclear partnerships with other countries, notably Russia and France. Russia has been a long-standing and reliable partner in India's nuclear program, providing technical assistance and fuel for the construction and operation of nuclear power plants, such as the Kudankulam Nuclear Power Plant (Rosatom India Cooperation). Collaboration with France has been growing, with a focus on developing advanced nuclear technologies, including Small Modular Reactors (SMRs), and enhancing nuclear safety. India also has nuclear cooperation agreements with countries like Canada, South Korea, and Australia, further diversifying its sources of technology and expertise. These diverse partnerships contribute to India's technological advancement in the nuclear field and reduce its dependence on any single country.

2.3. Small Modular Reactors (SMRs) and Future Technologies

Small Modular Reactors (SMRs) represent a promising frontier in nuclear technology. These reactors, typically with a generating capacity of up to 300 MW(e), offer several advantages over traditional large-scale nuclear power plants. SMRs are designed to be factory-fabricated and transported to the site, reducing construction time and costs. They also offer enhanced safety features and greater flexibility in deployment, making them suitable for a variety of applications, including decentralized power generation and integration with renewable energy systems (IAEA SMR Information).

India is actively pursuing the development and deployment of SMRs as part of its strategy to expand nuclear power capacity. The Indian government has recognized the potential of SMRs to meet the country's growing energy demands in a sustainable and cost-effective manner. International collaboration, facilitated by civil nuclear agreements, is crucial for India to access cutting-edge SMR technology and develop its own

indigenous SMR designs. This focus on advanced technologies like SMRs underscores India's commitment to staying at the forefront of nuclear innovation and ensuring a secure and sustainable energy future.

Reactors Operating in India.

Name	Model	Reactor Type	Reference Unit Power (MWe)	Grid Connection
Kaiga 1	Horizontal Pressure Tube type	PHWR	202	2000-10
Kaiga 2	Horizontal Pressure Tube type	PHWR	202	1999-12
Kaiga 3	Horizontal Pressure Tube type	PHWR	202	2007-04
Kaiga 4	Horizontal Pressure Tube type	PHWR	202	2011-01
Kakrapar 1	Horizontal Pressure Tube type	PHWR	202	1992-11
Kakrapar 2	Horizontal Pressure Tube type	PHWR	202	1995-03
Kakrapar 3	PHWR-700	PHWR	630	2021-01
Kakrapar 4	PHWR-700	PHWR	630	2024-02
Kudankulam 1	VVER V-412	PWR	932	2013-10
Kudankulam 2	VVER V-412	PWR	932	2016-08
Madras 1	Horizontal Pressure Tube type	PHWR	205	1983-07
Madras 2	Horizontal Pressure Tube type	PHWR	205	1985-09
Narora 1	Horizontal Pressure Tube type	PHWR	202	1989-07
Narora 2	Horizontal Pressure Tube type	PHWR	202	1992-01
Rajasthan 2	Horizontal Pressure Tube type	PHWR	187	1980-11
Rajasthan 3	Horizontal Pressure Tube type	PHWR	202	2000-03
Rajasthan 4	Horizontal Pressure Tube type	PHWR	202	2000-11
Rajasthan 5	Horizontal Pressure Tube type	PHWR	202	2009-12
Rajasthan 6	Horizontal Pressure Tube type	PHWR	202	2010-03

Name	Model	Reactor Type	Reference Unit Power (MWe)	Grid Connection
Rajasthan 7	Horizontal Pressure Tube type	PHWR	630	2025-03
Tarapur 1	BWR-1 (Mark 2)	BWR	150	1969-04
Tarapur 2	BWR-1 (Mark 2)	BWR	150	1969-05
Tarapur 3	Horizontal Pressure Tube Type	PHWR	490	2006-06
Tarapur 4	Horizontal Pressure Tube Type	PHWR	490	2005-06

Reactors under construction in India.

Reactor Name	Model	Reactor Type	Gross Capacity	Construction Start
Kudankulam 3	VVER V-412	PWR	1000	2017-06-29
Kudankulam 4	VVER V-412	PWR	1000	2017-10-23
Kudankulam 5	VVER V-412	PWR	1000	2021-06-29
Kudankulam 6	VVER V-412	PWR	1000	2021-12-20
PFBR	Prototype	FBR	500	2004-10-23
Rajasthan 8	Horizontal Pressure Tube type	PHWR	700	2011-09-30

3. Economic Implications

The expansion of nuclear energy in India, driven by international agreements, has significant economic implications, creating opportunities for investment, stimulating industrial growth, and generating employment.

3.1. Investment and Infrastructure Development

The development of nuclear power plants and related infrastructure requires substantial investments. These investments contribute to economic growth by creating demand for a wide range of goods and services, including construction materials, heavy machinery, and specialized engineering expertise. The Indian government is encouraging private sector participation in the nuclear energy sector to augment public funding and accelerate the pace of project implementation (pib Nuclear Energy Mission). This infusion of private capital is expected to boost the growth of the nuclear industry and create new economic opportunities.

3.2. Job Creation and Industrial Growth

The nuclear industry is a significant source of employment, generating jobs for a highly skilled workforce in various sectors, including construction, engineering, manufacturing, research, and operations. The expansion of nuclear power capacity creates direct employment opportunities in the construction and operation of nuclear power plants, as well as indirect employment in related industries. Furthermore, it stimulates industrial growth by creating demand for specialized equipment, components, and services, fostering the development of domestic manufacturing capabilities and reducing reliance on imports.

3.3. Impact on Industrial Competitiveness

A reliable and affordable supply of electricity is crucial for industrial competitiveness. Nuclear energy, with its ability to provide a stable baseload power supply at a relatively low operating cost, can significantly enhance the competitiveness of Indian industries, particularly energy-intensive sectors such as steel, cement, and chemicals. By ensuring a consistent and uninterrupted power supply, nuclear energy can help industries to improve their productivity, reduce their operating costs, and compete more effectively in the global marketplace.

4. Policy and Regulatory Framework

The safe and efficient development of nuclear energy requires a robust policy and regulatory framework. India has established a comprehensive framework for the regulation of nuclear activities, ensuring safety, security, and environmental protection.

4.1. Amendments to Existing Laws and Regulations

To facilitate the growth of the nuclear energy sector and encourage greater private sector participation, the Indian government is considering amendments to key legislation, including the Atomic Energy Act and the Civil Liability for Nuclear Damage Act. These amendments aim to streamline regulatory processes, provide greater clarity on liability issues, and create a more conducive environment for investment in nuclear power projects. The proposed changes seek to balance the need for accelerated development with the paramount importance of safety and security.

4.2. Safety and Regulatory Compliance

Safety is the cornerstone of India's nuclear program. India has a strong commitment to nuclear safety and adheres to stringent safety standards and regulations in the design, construction, operation, and decommissioning of nuclear facilities. The Atomic Energy Regulatory Board (AERB) is the independent regulatory body responsible for ensuring the safe operation of nuclear power plants and enforcing safety standards. India also actively participates in international efforts to enhance nuclear safety and security,

including cooperation with the International Atomic Energy Agency (IAEA) and adherence to international conventions.

5. Conclusion

Civil nuclear agreements have played a transformative role in India's energy landscape, providing access to critical technologies, fuel resources, and international partnerships. These agreements are not merely commercial transactions; they are strategic instruments that have enhanced India's energy security, fostered technological advancement, and contributed to its economic development. As India pursues its ambitious "Viksit Bharat" vision, nuclear energy, enabled by these international collaborations, will be a crucial component of its diversified and sustainable energy mix. The continued emphasis on strengthening these partnerships, promoting indigenous technological development, and maintaining a robust safety and regulatory framework will be essential for India to harness the full potential of nuclear energy and achieve its developmental goals.

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