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India's Energy Security: An Evolution of Conventional to Sustainable Energy Sources

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Abstract

Energy is a crucial element for the development of any nation. India is one of those nations whose energy security is a key foundation for its development. India's understanding of energy security has evolved since independence, from traditional energy sources to sustainable energy sources today. This is perhaps a key reason why a comprehensive discussion on the conceptual understanding of India's energy security has become necessary. This research paper is an attempt to examine the concept of energy security, the formulation of energy policy, and its evolution from independence to a future based on sustainable or renewable energy. Conceivably this is why India has included it as a key foreign policy goal. In today's unstipulated times, energy security has once again come to the vanguard of discussion. However, infrastructural weaknesses and geopolitical risks remain a key hindrance in India's pursuit of energy security. Therefore, it has become necessary to re-examine its concept, formulation of policies accordingly, and consider measures to maintain it in the near future. Therefore, this research paper is divided into two parts. The first part discusses the concept of energy security, while the second discusses the current state of energy security and its future.

Key Words: Energy Security, India, Concept, Renewable Energy, energy Policy.

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Energy security for India, viewed holistically, is defined as the uninterrupted availability of energy sources at affordable prices to sustain economic and social development. It is well known fact that India is the world's third-largest energy consumer, and for it, this concept is crucial to its very existence. With a population of over 1.25 billion and an average GDP growth of 8% over the past decade, India's primary energy demand is projected to double by 2030, reaching 1921 million tonnes of oil equivalent (Mtoe) by 2040 (Prajapati et al. 2025). Additionally, if we see at the past few decades, it reveals that India has frequently been vulnerable to global price unpredictability and supply chain disturbances due to its dependency on import. Perhaps this is one reason why the Integrated Energy Policy (IEP) of 2006 (Parikh et al., 2006) defined energy security as meeting large demands through indigenous resources, efficient use, and strategic imports, balancing all three dimensions as availability, affordability, and sustainability. These three dimensions play a key role in India's understanding of energy security. Subsequent policies, such as the 12th Five-Year Plan, attempted to describe it as "uninterrupted supply that supports economic growth while minimizing environmental impact." And now, amid the growing climate crisis and geopolitical tensions such as the Russia-Ukraine war and instability in the Middle East, India's overarching energy goal integrates the ambition of net-zero by 2070, emphasizing renewable energy and energy diplomacy. Therefore, to understand the concept of India's energy security, we have to analyse the major energy availability events from independence or even before that till now so that its gradual development can be easily understood.

India's concept of energy security is very ancient. Since Vedic times, the preservation and cultivation of all natural elements that nourish the human body, and a sense of gratitude towards them, have been an integral part of the Indian consciousness. Abundant examples of this are found in timeless texts like the Vedas, Upanishads, and Puranas. However, the development of the concept of energy security in India today begins with independence in 1947. The post-Partition period was a period of profound economic and political restructuring. Until then, energy was not yet an independent strategic necessity in nation-building, but rather an inherent component of industrialization, self-reliance, and socio-economic equality. Furthermore, the inherited energy

infrastructure was extremely rudimentary. After the independence total installed power generation was only 1.36 gigawatts which was concentrated in the private and urban sectors only. (Saini, 2018) At that time, oil production and refining were very limited, or confined to Digboi, Assam. When we talk about coal, it accounted for over 80% of primary energy supply for the country. (Energy World, 2022) During this period, most energy security policies were reactive and state-centric. This was due to the social vision of Prime Minister Jawaharlal Nehru.

Usually, the concept of energy security was not formally defined at that time. However, energy security indirectly revolved around affordability for the public and reliability of supply for industrial development. To understand the evolution of the concept of energy security, we need to analyse the major events and policies related to energy security from independence to the present. So, from the beginning we will analyse the nationalization of major industries and centralized planning of infrastructure; then, the construction of large hydropower projects, nuclear testing, the oil crisis, liberalization, and a unipolar world. Finally, we will analyse the events leading up to the Rio Climate Conference and understand how India's energy security has evolved from conventional to sustainable energy.

After independence energy policies laid the foundation for India's coal based energy backbone, while also initiating imports to meet its own needs. Both remain integral to India's concept of energy security even today. The years, following independence were defined by a passionate pursuit of self-reliance, reflected in the Industrial Policy Resolution (IPR) of 1948. (Industrial Policy, 2013). The 1948 IPR prioritized the development of petroleum products and related industries as a resource of national importance. Subsequently, the 1956 resolution classified mineral oils under Schedule (A) of the Constitution. (Industrial Policy, 2013, p. 221) This also delegated state control over energy sources, with some exemptions for private entities. Afterward, India's First Five-Year Plan (1951–1956) provided initial attention to energy security, allocating 27.2% of the total budget to power and irrigation combined (Poojari, 2012, p. 2). During the Plan, large hydroelectric power projects were considered essential for energy supply, and as a result, hydroelectric projects like the Bhakra Nangal Dam came into existence. The objective of such large projects was to fully utilize the hydroelectric potential of the Himalayas and ensure uninterrupted power supply to Himachal Pradesh, Punjab, Delhi, and Rajasthan.

Continuing with the availability of coal, it was known as "black gold" in the Indian economy

at the time. Coal production was carried out by private firms, and the target production was 38 million tons (MT) per year. (Bardhan et al., 2019) Besides, if we consider the challenges of that time, there were many, such as technological backwardness, central-state tensions, and the rural-urban energy divide. Additionally, private power operators prioritized profitability and distributed power erratically, resulting in uneven rural electrification. This was likely a major reason why, by 1956, nine years after independence, only 15% of villages had access to electricity. (Government of India et al., 1986) At this time, energy security was defined as a necessary element for promoting industrialization and easy availability.

Now, if we look at the Second Five-Year Plan, it was inspired by the Mahalanobis model, in which India began moving towards heavy industries. At this time, 20.5% of the budget was allocated to power and transportation. (Rana, 2012) Thermal power plants were also promoted along with hydroelectric projects. Coal production also increased to 54 MT and in 1956 the Oil and Natural Gas Commission (ONGC) was established as a statutory body to undertake new research for energy security (Rana, 2012). All these represent independent India's initial efforts towards energy security. Additionally, the establishment of the Atomic Energy Commission (1948) and the Department of Atomic Energy (1954) were significant steps towards energy security. Perhaps this is why, following the Department's research, India approved a three-stage thorium-based program in 1958 to ensure long-term energy security, given the uranium shortage. In the Third Five-Year Plan (1961–1966), energy security began to be understood as a "mineral and oil" sector (Tyner, 1978). By this time, the target for power capacity addition was 7 gigawatts, but the India-China War of 1962 and the India-Pakistani War of 1965 hindered this goal. Furthermore, domestic oil production remained stagnant at 5MT and imports accounted for 30% (Banerjee, 2022, p. 632).

This period also saw serious contradictions between the energy policies of the center and the states. Rural dependence on biomass masked the differences between urban and rural areas. Key initiatives undertaken during this period were through passing of the Electricity (Supply) Act of 1948 followed by the creation of State Electricity Boards (SEBs) to build vertically integrated monopolies. Thereafter Oil India Limited (OIL) was established as a 50-50 joint company with Burmah Oil, thus increasing the oil production in Assam. All in all, most policies over this period had the advantage of national sovereignty rather than India's energy security. However, with low technological development and lack of capital the increase in energy production was negligible. By

1966, coal production reached 70 MT and total capacity of hydropower supply was 4 GW. In the oceans oil crisis of 1970-1980 this marked the 1970s as a demoralizing time for India's energy security. India had largely sourced its need for oil by imports till then. The advent of the oil crisis around the world also added a new dimension of defensive security to the concept of energy security.

The Organisation of Petroleum Exporting Countries (OPEC) Embargo in 1973 induced a due surge in the price of oil (Trivedee et. al., 2025). Consequently, the import bill of India had risen by about US$1.2 billion. This crisis revealed the shortcomings of the Fourth 5 Years Plan of India (1969-1974) that was previously 70% dependent on oil imports. Consequently, despite the integration of oil into the mineral plan, the Five-year plan did not meet its targets amid drought, war and refugee crises.

India's response to energy security concerns at the time was swift. The Oil Coordination Committee (1975) planned supplies and promoted energy conservation through a 20-point program. (Moulik, 1988) This also led to a 10% reduction in energy consumption through measures such as carpooling. (Moulik, 1988) The Indian Oil Corporation (IOC) was given control over 75% of refining by the end of the decade. Additionally, the Coal Mines Nationalization Act of 1973 centralized production under Coal India Limited (CIL). (Khanna, 2016, p. 78) It was at this time that the demands of the Green Revolution in power generation were addressed for the first time.

In this mean time, the ONGC's Bombay High discovery in 1974, with Soviet assistance, promoted self-reliance in the energy sector. As a result, domestic production increased to 10 million tonnes (MT) by 1980. (Panagariya, 2005) By this time, the dimensions of India's energy security had begun to change. While until now India had been comfortably meeting its energy needs through oil imports, during the oil crisis, it included oil storage and the search for alternatives. This, in turn, led to a growing demand for green energy.

In its Fifth Five-Year Plan, India adopted the slogan "Garibi Hatao" (Remove Poverty) and emphasized self-reliance in agriculture and energy. That’s why it allocated 25% to electricity, including subsidies for farmers. However, cross-subsidies paid by industries to pay agricultural bills reduced the SEB's revenue. The Sixth Five-Year Plan (1980–1985) devoted a full chapter to energy, projecting the addition of 1,000 MW per year in the following years. (Srivastav, 2021). However, the Iranian Revolution of 1979 drove oil prices to $40/barrel, leaving India on the verge of depleting its

foreign exchange reserves as the document the Economic Situation in 1979-80 quoted. Furthermore, geopolitical turmoil in South Asia, including the 1971 Indo-Pak War, disrupted oil supplies, prompting India to opt for rupee-ruble trade in oil imports with the Soviet Union. In response to the oil crisis, India accelerated its switch towards alternative energy sources, such as nuclear, and conducted the Pokhran nuclear tests (Pattanaik, 2021, p. 631). Subsequent nuclear isolation, resulting from global sanctions, led to India's dependence on the Soviet Union for Tarapur fuel. Now, India also began to view energy as a strategic security concern. This policy shift emphasized strategic flexibility and the administered price mechanism implemented at the time, stabilized domestic energy prices.

Overall, energy security policies during this period were developed in response to imminent crises. By this time, the concept of energy security had also expanded to include the peaceful use of nuclear energy. Looking ahead, the 1980s were a decade of stagnation in terms of energy security. This was due to the Seventh Five-Year Plan (1985–1990) allocating 30% to energy. (NIEPA et al., 1985). However, public sector undertakings inadequacies and ONGC's costs, which were significantly higher than global standards, resulted in oil imports increasing by 60%. Meanwhile, India added another dimension to its energy needs: the use of natural gas. As the beginning of the national gas grid, the Gas Authority of India Limited (GAIL) built the Hazira-Vijaipur-Jagdishpur pipeline. (Kadam et al., 2024, p. 3). At that time, natural gas accounted for only 5% of India's energy balance. During this period, tensions arose between the central and state governments over a number of issues, including energy security.

Meanwhile, the 1990–91 Gulf War crisis depleted India's reserves by $1 billion, leading to a balance of payments crisis. (Cerra & Saxena, 2002) The Eighth Five-Year Plan (1992–1997) saw liberalization reforms open up production to private power producers through the 1991 policy. This resulted in production reaching 5,000 MW by 2000. (Prayas, 2001) It also addressed sustainable energy for the first time and integrated environmental protection with energy security. Internationally, India's participation in the 1992 Rio Climate Conference led to the formulation of energy security from a climate-friendly perspective and opposition to mandatory cuts. The Ninth Five-Year Plan (1997–2002) placed greater emphasis on private sector participation in energy security. Subsequently, the New Exploration Licensing Policy (NELP, 1999) brought about a uniformity in the terms and conditions for public and private power generation, eliminating the

differences that existed until then. Subsequently, the Electricity Regulatory Commissions Act (1998) gave rise to separate central and state ERCs for tariff rationalization, and the SEBs were bifurcated into generation-transmission-distribution units (Ahn et al. 2012). Overall, the concept of energy security has undergone significant changes since independence, laying the foundation for conceptual developments over the next two decades.

The twenty-five-year period from 2000 to the present can be divided into three sub-phases: the first decade can be considered reform-driven expansion. The second in which, India made a rapid shift to renewable energy, and the third in which, it saw a reconciliation between conventional and non-conventional energy sources. During this period, India did pace with some great achievements in electrification, and was about to boost its energy production capacity. Over nearly 25 years, India achieved 99.9 percent coverage in electricity and over the same period it was able to reduce transmission losses from 22 percent in 2010 to 16.5 percent. India looks forward but tackles the issues such as changing workforce in the fossil fuel industry and the cyber threats to the digital grids (Parul, 2025). Moreover, approaches to energy security policy have changed from Integrated Energy Policy (IEP) in 2006 that sought to emphasize energy availability, affordability, and sustainability and to the National Energy Policy (NEP) in 2017 which further incorporated equity and sustainable energy pathways into the energy distribution framework. A lot has been accomplished as reflected in the Green Hydrogen Mission of 2023 which is in line with net-zero goals by 2070 (Bhati et al., 2024). By 2025, energy security does not only focus on the consideration of the supply but also in terms of just transition from conventional to non-conventional energy sources.

Taking into account the impetus of reform drive and integration, the early 2000s saw a time of transformation, capitalising on the liberalisation that had taken place in the 1990s. The key objective was to inject market dynamics into the hitherto state dominated sector. During this time period, the installed capacity has risen from 105 GW to 167 GW in 2010, which is coupled with a huge growth in thermal power generation (Shivarajappa, 2015, p. 271). However, the Electricity Act, 2003 revolutionary changes in energy policies - the Electricity Act, 2003, broke up the SEBs into competitive, enabled access, and private investment. Although the Act was inspired by the 2002 power sector reforms and had a target of 100 per cent electrification by 2012, only 67 per cent of villages were electrified till 2010 (Shivarajappa, 2015, p. 272). This was also the period of diversity

in energy security policies.

Consequently the Jawaharlal Nehru National Solar Mission (JNNSM) 2010 set a total solar target to 20 GW by 2022 and Integrated Energy Policy (2006) formalised the energy security by defining it as "adequate, affordable and reliable energy for development", blending coal (480 MT production by 2010) produced domestically and imports (Srivastava 2009). Furthermore, nuclear power generation doubled to 4.8 GW; via India-U.S. Civil Nuclear Agreement of 2008 (PIB, 2014). This agreement with the US ended India's three-decade nuclear isolation. Subsequently, 70 blocks were discovered for oil exploration under the New Exploration Licensing Policy (NELP-VII) (2009), but domestic production remained stagnant at 0.75 million barrels per day (mbpd). (PTI, 2013) Along with these achievements, challenges also increased. Transmission and distribution losses increased to approximately 25% due to theft and aging infrastructure. Meanwhile, low coal quality also led to an increase in CO2 emissions. This resulted in a significant decline in foreign direct investment (FDI). However, the 26/11 terrorist attacks was also considered a major reason for the decline in FDI during this time. By 2010, energy security policies shifted from monopoly to competition.

The 2010-2020 decade of rapid shift to renewable energy sources, combining global climate agreements and domestic ambitions, saw power generation capacity increase to 249 GW in 2014. (PIB, 2025) The phase-I of JNNSM boosted the manufacturing ecosystem. The Green Energy Corridor-2013 addressed multiple problems in an integrated manner, with an investment of Rs 43,000 crore. (WCI, 2013) Through the UDAY-2015 scheme, the government reduced losses by 19% by restructuring SEB loans worth Rs 4.3 lakh crore. Electrification under the Saubhagya Yojana-2017 ensured electricity access to 99.9% of villages by 2019. This scheme connected 26 million households and empowered 280 million people. (Niti Aayog & CRISIL, 2019) India also attempted to improve energy security policies.

In line with the Paris Agreement, the NEP-2017 envisioned 40% renewable energy production by 2030. By 2020, generation from renewable energy sources reached 39 GW (solar) and 38 GW (wind). (PIB, 2025). Coal production reached 716 MT in 2020. (PTI, 2021) Furthermore, while oil imports remained stable at 82%, the government introduced ethanol blending. But despite all these efforts, grid failures caused by the shift from conventional to non-conventional energy during this period affected millions of people. Additionally, protests erupted in Jharkhand, resulting

in the displacement of people. Besides all these, cyber-risks related to smart metering plans also emerged. In the following years, several power distribution companies were also subjected to ransomware attacks. Moreover, geopolitically, US sanctions on Iran led to a 20% increase in oil prices, prompting India to seek oil and gas deals with Russia.

Reflecting on the past five years, India has rapidly transitioned from conventional to unconventional energy, reaching 487 gigawatts of power generation capacity by October 2025 including 226 gigawatts came from renewable energy sources (125 gigawatts solar and 47 gigawatts wind). (EnergyWorld, 2025) Driven by government schemes, the modules also attracted substantial FDI. Additionally, the Green Hydrogen Mission (2023) launched a pilot project of 1 GW electrolyzers, with a target of 5 MMT per year by 2030. (PIB, 2024). Just last year, the PM Surya Ghar Free Electricity Scheme (2024) installed 10 million rooftop systems. (PIB, 2025). At the same time, Kerosene use declined significantly over these five years. Over the past decade, India's energy security scenario seems to be balancing the twin pressures of growing economic growth and increasing pressure from climate change.

Today, the country's installed power capacity has quadrupled from 105 GW in 2000. More importantly, renewable energy (solar, wind, biomass, and small hydropower) accounts for nearly 50% of this energy generation growth. However, import dependence in the energy sector remains. This means that India's energy security is still vulnerable to the threat of global instability amid geopolitical turmoil such as the Russia-Ukraine conflict and tensions in the Middle East.

All the above observations confirm one approach that while India's understanding of energy security was limited at the time of independence, today, in its vision of a developed India @ 2047, it is committed to sustainable energy development, keeping both energy security and environmental considerations in mind. Additionally, India is also integrating AI into the grid, aligning its energy development with changing technologies. India is now very close to universality in electrification. However, according to the International Labour Organisation, 5 million coal jobs are at risk because workers are either not being reskilled or they do not want to get reskilled. From a geopolitical perspective, while the Quad's mineral agreement secured lithium, China's dominance in its exports could pose a risk in the future.

Overall, India's understanding of energy security is shifting from diversification to equity and imperatives that will establish it as a leader in the Global South in the future The question now arises

- what is the future of the energy development of India. Reflecting on the path of energy development so far, India is far ahead on the path towards sustainable energy security. Today, that journey has reached a transformative turning point with ambitious net-zero commitments due to urbanization and electrification - combined with an expected 7 percent to 8 percent annual growth in GDP through 2070. The exact nature of how sustainable energy will unfold in India will become clear in the next three to four decades, but no doubt it will show that India will be not just accelerating its own sustainable energy path, but also leading many other countries in the years to come.

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