ENERGY TRANSITION IN INDIA: A ROADMAP TO A SUSTAINABLE AND SECURE FUTURE

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I. INTRODUCTION

India's power sector is undergoing a significant energy transition. This means moving away from a heavy reliance on fossil fuels like coal for electricity generation and embracing cleaner, renewable energy sources like solar and wind. This shift is driven by a desire to combat climate change and air pollution, along with ensuring energy security. The transition involves installing a massive amount of renewable energy capacity, but also requires improvements in energy storage and grid management to handle the variable nature of renewables. Success also hinges on policy changes and investments to make renewables more affordable and integrate them effectively into the power grid. This transition holds the promise of a cleaner, more sustainable future for India's energy sector.

India is a major energy consumer in Asia, but heavily reliant on fossil fuels (over 90% of its energy mix). This dependence is straining the economy and environment, as fossil fuel consumption has risen significantly in the last decade. Despite this national trend, there's a large gap between urban and rural areas. While urban areas have access to commercial energy sources, a large portion of the rural population relies on traditional biomass fuels and lacks access to electricity. This highlights the challenge of balancing development goals with reducing emissions. As India strives for economic growth, its energy consumption is expected to rise further, making low-carbon development strategies crucial for the future.

II. FACTORS AFFECTING ENERGY TRANSITION

Countries transition their energy mix for various reasons. Political decisions for energy transition are mostly influenced by a nation's social, economic, geopolitical, and environmental goals. The goal of the transition process is to achieve a newer mix of cleaner sources and technologies through supply side and demand side energy management strategies:

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1. Political shifts, like Japan's post-Fukushima focus on renewables, can drive change. Additionally, governments may seek to create jobs through promoting new energy sources like solar or wind. India's biomass program is a good example, generating employment in rural areas. These transitions can also aim for energy independence, as Japan hopes to achieve with renewables.
2. A country's economic growth drives its energy needs. India's goal of high GDP growth necessitates a significant increase in energy availability. But there are challenges: a high import bill for fossil fuels and the difficulty of supplying energy to a large rural population. These factors push India towards alternative energy sources to meet its economic targets and reduce its dependence on expensive imports. This need for alternative energy sources is a major driver of India's energy transition.
3. Geopolitical instability, especially around oil supplies, can be a major driver of energy transition. The 1970s oil crisis is a prime example. Countries like Brazil and the US boosted biofuel production, while others like Japan and South Korea ramped up nuclear power to lessen dependence on volatile oil supplies. This trend faded in the 1970s when oil prices normalized, but regained momentum in later decades due to continued instability. India's recent focus on alternative energy sources is partly driven by a desire for long-term energy security in the face of geopolitical challenges. Their policy initiatives like the Energy Conservation Act and Draft Renewable Energy Policy reflect this shift.
4. Environmental concerns are a major driver of energy transition. Many countries, including India, are realizing the long-term economic costs of pollution and are prioritizing cleaner energy sources. India's rising carbon emissions, fueled by its dependence on fossil fuels and economic growth goals, highlight this challenge. The government acknowledges the need for clean energy but also sees economic growth as essential for poverty reduction. Balancing these priorities requires significant investments in infrastructure, technology, and clean energy access. Climate change mitigation is becoming a more prominent factor in India's energy policy.

While all four factors (political, economic, geopolitical, and environmental) influence India's energy transition, environmental concerns are currently the strongest driver. This is because India, like many countries, is facing pressure to reduce greenhouse gas emissions. To meet its commitment of a 20-25% reduction in emissions intensity by 2020 (compared to 2005 levels),

India must prioritize developing alternative energy sources and implementing energy-saving measures. This will allow them to achieve economic growth while still lowering emissions.

III. LEGAL FRAMEWORK IN INDIA

Though there is no specific framework that exclusively provides any mandatory legal direction for energy transition, various Policies, Acts and regulations pertaining to energy sector promote and positively contribute to transitioning to a low carbon energy mix in the future.

1. The Electricity Act unifies laws pertaining to the production, transmission, distribution, and use of electricity. It also provides general guidelines for actions taken to support the growth of the electricity sector, including fostering competition, safeguarding consumer interests, and ensuring universal access to electricity. Other objectives include streamlining electricity tariffs, establishing transparent policies regarding subsidies, encouraging the adoption of environmentally friendly and efficient policies, and establishing the Central Electricity Authority, Regulatory Commissions, and Appellate Tribunal, among other things.
2. The Energy Conservation Act stipulates provisions for conservation and efficient use of energy sources. As per the directions set under the Act, the Bureau of Energy Efficiency was formed subsequently. It paved the way for the establishment of the Bureau of Energy Efficiency (BEE), a crucial organization tasked with implementing the Act's provisions. The BEE plays a central role in driving India's energy transition by setting standards for appliances, buildings, and industries, promoting energy audits and labeling programs, and creating awareness about energy efficiency practices. This two-pronged approach – legal framework and dedicated enforcement body – signifies India's commitment to a more sustainable energy future.
3. Integrated Energy Policy: India's five main governmental agencies are in charge of directing the country's energy industry. The Department of Atomic Energy is one of these organizations, along with the Ministries of Coal, Power, Petroleum and Natural Gas, and New and Renewable Energy. Given the significance of India's long-term economic objectives and energy demands, it has been noted that policy integration at all levels is required, and an integrated framework that includes the five government agencies that handle the energy sector must be developed.

IV. ENERGY TRANSITION

The concept of energy transition signifies a shift from high-carbon fossil fuels towards energy sources and technologies that minimize carbon emissions per unit of energy consumption. This transition aims to reduce the overall carbon intensity of energy use. While complete replacement with zero-carbon sources might seem ideal, the reality is a gradual move from high-carbon to lower-carbon options. Achieving complete decarbonization presents a significant challenge due to disparities in technological advancement, socio-political landscapes, and economic development across nations.

In the Indian context, energy transition is intricately linked to long-term energy security. Factors such as projected energy demand and supply imbalances, poverty alleviation goals, environmental and climate concerns, and socio-political considerations all influence the country's energy security strategy. Energy transition emerges as a key policy response, encouraging a shift away from imported hydrocarbon fuels. However, it's crucial to acknowledge that a formal, centralized energy transition policy is currently lacking in India. Instead, the concept is manifested in a fragmented manner, gradually becoming a core element within policies targeting long-term economic objectives.

The Integrated Energy Policy's projections for commercial energy demand act as a major impetus for energy transition. Estimates suggest that by 2031-32, with a projected GDP growth of 9%, import dependence for primary energy demand could reach a staggering 58-67%. This scenario presents a two-pronged challenge for India. Firstly, increased reliance on fossil fuels will directly impact the country's emissions profile. Secondly, the growing import burden will place a significant strain on the economy.

In essence, India's energy transition journey necessitates a delicate balancing act. The nation strives to decarbonize its energy sector while simultaneously addressing developmental goals and ensuring energy security. The fragmented nature of current policy approaches reflects this complexity. Moving forward, a more comprehensive and coordinated approach to energy transition will be crucial for India to navigate these challenges and achieve a sustainable energy future.

V. CHALLENGES TO ENERGY TRANSITION IN INDIA

The process of energy transition necessitates the coordination of numerous policy and governance initiatives, some of which may provide formidable implementation obstacles. Various obstacles could potentially impede a nation's energy transition initiatives, such as the influence of interest groups, regulatory barriers, a deficiency of robust institutional frameworks, and the belief that switching to a more modern fuel mix would not be economically feasible.

Despite its environmental drawbacks, coal remains crucial for India's energy needs. Currently, it makes up over half (52%) of the country's energy mix. Several factors contribute to this reliance:

- Domestic availability of coal
- Concerns about potential disruptions in oil supplies
- Lack of readily available alternative sources
- Existing power plants designed for coal

Coal is expected to be India's primary energy source until at least 2032. To address the environmental impact, the government and Coal India Limited are exploring cleaner coal technologies like gasification and liquefaction. An example is a proposed coal-to-liquid project by Coal India Limited.

Further, India's heavy reliance on fossil fuels, particularly coal and petroleum, presents a challenge for its energy transition. Here's a breakdown of the key issues:

- Fossil Fuel Lobby Influence: Powerful lobby groups representing the coal and petroleum sectors can influence government decisions, potentially hindering energy transition efforts. This is a global phenomenon, with examples like fossil fuel companies lobbying against climate change legislation in the United States.
- Competing Priorities: Short-term political cycles may prioritize policies with immediate economic or political benefits over long-term energy transition plans, which may face opposition from established energy industries.

- Economic Concerns: Transitioning away from fossil fuels could threaten the economic interests of companies and workers in these sectors, leading to potential resistance.

Moreover, effective institutions and legal frameworks are crucial for implementing energy transition policies. Here's a look at the institutional challenges India faces:

- Lack of a Dedicated Framework: Currently, India's energy transition efforts lack a strong legal and administrative backbone. Disparate initiatives exist, but a unified approach is missing.
- Conflicting Institutional Interests: Existing institutions may have conflicting goals. For example, a coal ministry might resist promoting clean coal technology or reducing coal consumption, as these measures could impact the coal sector and government revenue.
- Transition vs. Existing Institutions: Energy transition policies often rely on existing institutions for implementation, but these institutions may prioritize the interests of the conventional energy sectors they were built to support.
- Shifting Policy Landscape: While India previously lacked a strong framework, recent years have seen increased policy focus on the energy-climate change connection. This shift offers hope for a more coordinated approach to energy transition.

VI. THE WAY FORWARD

India's successful energy transition hinges on a robust policy framework and well-defined long-term strategies.

- Complementary Targets: Develop policies that reconcile energy security goals with climate change mitigation targets.
- Climate Mitigation with Legal Backing: Provide legal support for climate mitigation policies to ensure effective implementation and maximize socio-economic and environmental benefits, including addressing energy poverty.
- Focus on Rural Energy Needs: Design long-term energy plans that address the growing energy demands of rural areas, which currently lack access to modern energy sources.

- Decentralized Approach: Leverage market mechanisms and encourage greater participation from state governments in developing long-term energy security, environmental, and energy transition policies. This may be more effective than solely relying on top-down central government policies.
- Public-Private Partnerships: Explore public-private partnerships to enhance private sector involvement in renewable energy generation, energy efficiency improvements, and energy conservation efforts.
- Education and Awareness: Integrate energy efficiency, conservation practices, and the importance of clean energy options into educational curriculums to build public awareness and long-term support for the transition.

By implementing these comprehensive strategies and fostering collaboration between various stakeholders, India can navigate a successful energy transition path.

VII. CONCLUSION

From the standpoints of growing rural energy demand, rising energy-related emissions, and energy security, India must strategically implement an energy transition. India is susceptible to both the geopolitical volatility in the petroleum-producing countries and the variations in fuel prices in the global market because it is a net importer of petroleum. But because so many important economic sectors rely heavily on fossil fuels, the reliance on them will persist. However, when the US and its allies showed that they were prepared to use military force to defend their petroleum interests from the Persian Gulf, a shift in mindset started to emerge among the developing economies in the last several decades. The concept of "use of power to secure energy security" should be applied to the use of force to intervene in Persian Gulf affairs during Kuwait-Iraq wars and the later military actions against the Saddam regime. Unlike the Anglo-Saxon economy, developing economies have never been able to utilize military force to secure their energy supplies. This has shown to be one of the main justifications for developing policy ideas, making investments, and strengthening domestic supply capacities—especially with regard to alternate sources.

The efforts to shift to an energy mix that rely more on domestic supply capabilities have also been sparked by worries about rising energy bills due to the unpredictability of petroleum prices in the global market and growing reliance on finite fossil fuel sources. Approximately 68% of

India's population currently resides in rural areas, where the majority lacks access to modern energy sources. Among the 809 million people living in rural areas in 2005, 364 million did not have access to electricity, and 726 million did not have modern cooking fuels. This is a significant obstacle to India's long-term economic goals of nearly double-digit GDP growth.

There are three major obstacles in using traditional fossil fuel supply to meet the increasing energy demand in rural areas. First, it is challenging to have an adequate infrastructure for the provision of fossil fuels or power due to the geographic location of the majority of rural communities. Second, using traditional fossil fuels to cover the energy needs of rural areas will increase the nation's fuel imports, which will raise energy costs. Third, the country's energy-related emissions would rise dramatically as a result of the increased fuel usage in rural areas. These issues make the long-term transition of the nation to a fresh fuel mix that leans more on alternate sources necessary.

India has among of the lowest per capita emissions of all the major economies, but over the past several years, the country's overall emissions due to fuel usage have increased. Between 2000 and 2009, the total amount of carbon dioxide emissions resulting from energy consumption increased from 1002.95 million metric tons to 1591.12 million metric tons.45 Even though, given current technological capabilities, no major economy could realistically achieve a full transition to non-fossil fuel energy consumption, an energy transition would mean moving away from a conventional energy mix that heavily relies on fossil fuels and toward a low-carbon fuel mix and technology alternatives.

However, in the current Indian context, energy transition should be understood as reducing incremental reliance on fossil fuels and using cleaner technologies and methods to meet a portion of the demand. The climate mitigation agenda has been crucial in bringing together the disparate policies and actions towards transition, even though energy transition has not yet become the dominant policy in India. The shift to a clean energy economy will become essential to India's domestic policy in light of the long-term benefits to the country's economy, society, politics, environment, and energy security. It is crucial that the nation raise the proportion of non-fossil fuels in its energy mix in this scenario.

India’s pledges to reduce emission intensity will also instrumental in enabling the transition from conventional fossil fuel-based economy to a cleaner energy mix in the future.

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