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OUTCOMES OF REFORMS IN INDIA'S POWER SECTOR: PROGRESS AND CHALLENGES

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ABSTRACT

The power sector can be pivotal in India's economic growth and development. India has been implementing the electricity sector reform since 1991, aimed at improving efficiency, promoting renewable energy sources, improving distribution, increasing generation capacity, fostering private sector participation, and ensuring reliable electricity supply for economic growth. The outcomes of India's electricity sector reforms are summarised in this study, highlighting the progress and challenges faced during the implementation process. Implementing reforms in the electricity sector in India has yielded significant improvement from 1997-98 to 2021-22. One of the notable achievements has been the increase in installed generation capacity, which has helped bridge the gap between demand and supply of electricity. This has improved operational performance, reduced losses, and improved the financial viability of power utilities. Despite these positive outcomes, India's power sector faces several challenges. The study explores the specific challenges that the Indian electricity sector faces and provides suggestions for how to resolve them to enhance the sector's sustainability and performance.

Keywords: Power Sector, Reforms, Progress, Challenges, India, Electricity

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1. INTRODUCTION

Electricity is essential in modern society and is vital in numerous aspects of our daily lives. Article 246 of the Indian constitution defines "the power sector as a concurrent subject" and assigns the state governments an essential function in power supply (Fukumi,2016). Electricity is a fundamental input for economic activities across various sectors, including manufacturing, services, agriculture, and transportation. Reliable and accessible electricity is a crucial driver of economic growth. Electricity sector reforms were initiated by the Indian government in 1991 to boost the government-owned power utilities' technological and commercial efficiency. Power sector reforms were initiated to tackle the issues in the "Indian Electricity Sector." These reforms are essential for India to meet its energy needs, improve efficiency, ensure financial viability, promote renewable energy, enhance service quality, and contribute to environmental sustainability. To achieve this goal, the state and central government were given the authority to finance and promote resources for projects that focused on increasing generation capacity and the participation of independent

power producers (Ghosh et al., 2021). India is the world's third-largest producer and consumer of electricity (IBEF, 2023) as of June 06, 2023, with an installed power generation capacity of 417.6 GW (Ministry of Power).

The study's objective is to provide an in-depth evaluation of the outcomes, progress, and challenges faced by the "Indian electricity sector." The study aims to shed light on the complex dynamics within the sector through the historical evolution of the electricity sector, the current scenario, targets and achievements of electricity reforms, and ongoing challenges. By highlighting significant challenges, the study also offers solutions and recommendations to promote the sector's transition to a more resilient and sustainable future. The scope of this study includes a comprehensive analysis of how technology developments, incentives, policy reforms, and regulatory frameworks have impacted the Indian power sector. This study will be helpful for policymakers, researchers, and company stakeholders.

The "Indian Electricity Sector" is segmented into Generation, Transmission, and Distribution. In the generation sector, electricity is produced using different fuels, i.e., fossil, and non-fossil fuels. Produced electricity is transported at high voltages via a grid from power plants to distribution utilities. Through a distribution network, distribution utilities provide electricity to users (domestic, agricultural, commercial, and industrial).

In the value chain of the electricity sector, the distribution of electricity is the last and most important link. It indicates the weakest area of the nation's electricity system (Patyal et al., 2023). Distribution utilities provide electricity to both rural and urban customers. The financial performance of these utilities has a direct impact on the power of GENCOs and TRANCOs. So, it is essential to maintain these utilities' efficient and healthy financial position. The financial and technical performance of these utilities is abysmal. These DISCOMs are facing many challenges. These challenges are the poor financial performance of State Electricity Boards (SEBs), high T&D (transmission and distribution) losses, nonproductive tariff structure, the gap between ACS&ARR (average cost of supply and average revenue realized), power subsidy, AT&C (aggregate technical and commercial losses), inefficiency in revenue collection, unmetered electricity in agriculture, dues, power theft, etc. AT&C losses of DISCOMs in India were 22.3 per cent age in FY2020-21. India's power sector reforms are necessary to address these challenges and ensure financial sustainability for the industry's long-term development.

2. LITERATURE REVIEW

Agrawal et al. (2017) critically assessed the critical elements of the "Electricity Act of 2003", as well as the current situation of the "Indian Power Sector," focusing on distribution losses and the sector's trouble spots. The role of the Electricity Amendment Bill 2014 was also anticipated in the study. If accepted, this bill might pave the way for implementing the next round of reforms in the "Indian power sector" required to increase productivity.

Anupama et al. (2018) assessed the outcomes of power sector reforms in 17 non-OECD Asian countries for the period 1990-2013 by using regression techniques. It was found that the conventional reform structure had provided only moderate benefits mainly because of institutional endowments and sectoral heterogeneity.

Ghosh (2021) studied the impact of "Indian power sector" reforms on the performance of "Indian state-owned electricity utilities (SOEUs)." The authors found out the reason behind the inefficiencies of SOEUs. The author used the Data Envelopment Analysis to evaluate the efficiency of utilities in this study. Secondary data was collected from the various CEA and PFC reports.

Kessides (2012) analyzed the effect of reforms in the "Electricity Sector" in developing countries. The author concluded that the process of electricity reforms needed to be revised, consistent, and irregular in developing countries. Some countries had decreased and eliminated the cross-subsidies, and retail prices accurately correlated with the actual cost due to reforms.

Pal (2013) conducted a study on the growth and policies of the electricity sector in India. The authors examined the challenges faced by the Indian power sector. Electricity reforms in pre-independence and post-independence periods were also focussed. It was found that the commercial loss increased from 20860 crores in 1992-1993 to 60334 crores in 2009-2010.

Patyal et al. (2023) focused on evaluating the efficiencies of 48 electricity distribution companies (DISCOMs) from 24 states of India using an integrated approach of Data Envelopment Analysis (DEA), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Interpretive Ranking Process (IRP). This study aimed to classify DISCOMs as efficient or inefficient, propose that DISCOMs be given financial and operational autonomy, and provide DISCOM professionals with information to help them evaluate their performance and develop efficient strategies based on

performance evaluations. The paper concluded that DISCOMs were financially unstable after three decades of reforms in the electricity sector. The authors noted that the distribution was the weakest sector compared to the generation and transmission sectors.

Surdeo (2017) studied India's history and evolution of power sector policies. This study focused on the impact of reforms and analyzed especially the two government schemes named Ujwal DISCOM Assurance Yojana (UDAY) and Deen Dayal Upadhyay Gram Jyoti Yojna (DDUGJY). The author used secondary data for this study. The study revealed that the private sector played a considerable role after reforms. The private sector's installed generation capacity was the highest in the electricity sector. In the transmission field, private investment increased, and power transfer capacity also increased. However, in distribution, despite many reforms, the losses persisted. It was analyzed that the aggregate losses of the State Electricity Boards had increased ten times since 1996-97 because of agricultural subsidies, tampering of meters, electricity theft, inefficient and corrupt administration, etc. This article concluded that UDAY was initiated to reduce the losses of DISCOMs. This scheme took a good start, but many issues remained uncovered. DDUGJY targeted 100 percent age electrification of villages. Despite so many reforms, DISCOMs were still in bad shape, and tariffs were not feasible.

Sheoran (2019) evaluated the impact of the UDAY scheme on the performance of power distribution companies. It was found that the UDAY scheme positively impacted the debt situation of power distribution companies in India. It mentioned that the scheme had led to a decrease in the debt of distribution companies in Rajasthan from 27.3 percent to 23.6 per cent age. The Uday scheme positively affected the loss reduction of DISCOMs in Maharashtra, J.K., Tamil Nadu, Rajasthan, etc. However, the loss of Punjab increased by 19.96 per cent age from 2016-17 to 2017-18. The loss reduction of Rajasthan was -53.67percent age. The debt reduction and increased operational effectiveness were expected to allow distribution companies to serve consumers and farmers with uninterrupted electricity.

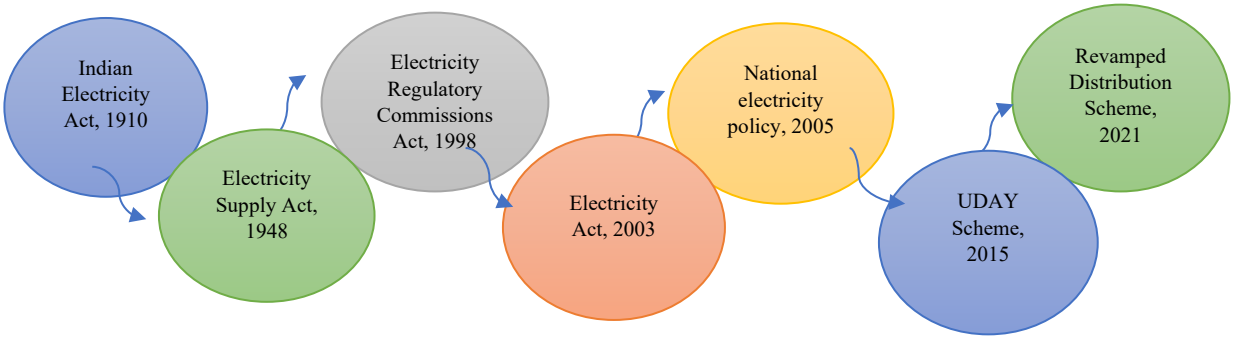
2.1. RESEARCH GAP

It is found that there are many challenges in India's power sector. The Indian and state governments have initiated reforms to enhance this sector. However, even after these reforms, the electricity sector has faced many challenges. Several studies have been conducted on the Indian electricity sector. Most of these are performed on the challenges and growth of the power sector of GANCOMs, TRANSCOMs, and DISCOMs of India. Very few studies have been conducted on the outcomes of power sector reforms in India. This study will evaluate the outcomes of various reforms implemented by the governments of India. The study will analyze the impact of various reforms on the electricity sector's performance. It also will focus on the challenges and progress of the Indian power sector. To my knowledge, there has been no study based on these objectives. It is expected that this study will fill this gap.

3. PROPOSED METHODOLOGY

The study is based on secondary data. The secondary data from the "Power Finance Corporation" (PFC), "Ministry of Power," Central Electricity Authority (CEA), Ministry of New and Renewable Energy, International Energy Agency, and other authentic websites is collected to achieve the objectives. Indicators like plant load factor, energy deficit, peak deficit, aggregate technical and commercial losses, billing efficiency and collection efficiency, and the gap between ACS-ARR are used to evaluate reforms' impact on India's power sector. The period is more than two decades. It is helpful to see the reliable effect of electricity reforms on the performance of DISCOMs.

Figure 1: Various Reforms in the "Indian Power Sector"



4. OUTCOMES OF "POWER SECTOR REFORMS": TARGETS AND ACHIEVEMENTS

4.1. PRE-INDEPENDENCE ERA: -

The electricity generation, transmission, and distribution infrastructure were sparse and concentrated mainly in urban areas. Rural areas had very limited or no access to electricity. The British colonial administration introduced the first few power-generating stations in cities like Calcutta (now Kolkata), Bombay (now Mumbai), and Madras (now Chennai). These stations were primarily set up to serve the interests of the colonial government and industrial needs rather than for the broader population. The development of the power sector began during British colonial rule with the establishment of the first hydropower plant in Darjeeling in 1897. Electricity access was limited to a small percentage of the population, primarily elite or affluent groups residing in urban areas. Rural electrification was nearly non-existent. There was no unified or comprehensive policy framework for developing the power sector during this time. The focus was mainly on meeting the energy needs of British industries and administrative centers. The first electricity act in India, the Indian Electricity Act of 1910, was introduced to give the chance to produce and provide electricity supplied by the state government. After this act, the electricity supply was increased from 363MW in 1910 to 21082 MW in 1915.

4.2. POST-INDEPENDENCE (1947-1990)

After India gained independence in 1947, power generation, transmission, and distribution were still mainly under the jurisdiction of the "State Electricity Board," which operated within the public sector. The "Electricity Supply Act" of 1948 provided the country's legal framework for electricity supply. The Bhakra Nangal Dam, one of the earliest and most significant hydroelectric projects, was initiated in the 1950s to provide water for irrigation and generate electricity. To control and oversee the country's power generation, transmission, and distribution operations, the Central Electricity Authority (CEA) was founded in 1951. The second five-year plan (1956-1961) emphasized the development of the electricity sector to support industrial growth and economic development. The "Electricity Supply Act" of 1948 was replaced by the "Electricity Supply Act" of 1975, which further regulated the electric `supply and introduced the concept of bulk supply tariffs. The government launched rural electrification programs to extend electricity access to remote areas. Initiatives like the National Rural Electrification Program (1978) aimed to provide electricity to villages and rural communities, though progress was relatively slow. Despite development, the power sector faced challenges such as inefficient management, transmission losses, financial constraints of SEBs, and insufficient investment in infrastructure. The government continually introduced policies and made efforts to enhance the efficiency of the electricity sector. However, comprehensive reforms like those seen in the 1990s were yet to be implemented during this period.

4.3. BEGINNING OF REFORMS (1990-2003)

The early 1990s marked a turning point in India's economic policies, including initiating liberalization and economic reforms. The new economic policy of 1991 introduced measures to promote private investment in various sectors, including power. Different states in India implemented the unbundling and restructuring process at different times and through state-level legislation. In India, Odisha was reported as the first state to start the power sector reforms at the state level in 1996. During the 1996 reforms, the Odisha State Electricity Board was unbundled into different divisions for generating, transmission, and distribution. The state constituted the regulatory commission at the state level at the same period. Some states adopted this process. These states were Andhra Pradesh, Haryana, UP, Karnataka, Delhi, Rajasthan, etc. The Electricity Regulatory Commission Act of 1998 was passed, leading to the establishment of "Regulatory Commissions" at the central level (CERC) and state level (SERC). These regulatory bodies are responsible for tariff setting, licensing, dispute resolution, and ensuring transparency and fairness in the power sector.

4.4. THE ELECTRICITY ACT (2003)

The "Electricity Act (2003)" was enacted as a crucial reform in the electricity sector. The "Electricity Act (2003)" was a significant reform in the Indian Electricity Sector that repealed the three existing acts, i.e., the "Electricity Act (1910)," the "Electricity Supply Act (1948)," and the "Electricity Regulatory Commission Act (1998)" (Alok & Chatterjee, 2003). This act aimed to introduce competition in generating and distributing electricity. The act included Open access provisions, giving consumers the freedom to select their electricity supplier. This promoted private sector involvement

and investment by boosting competition in the generating and distribution sectors. The installed electricity generation capacity accounted for by the private sector was 13 per cent. However, in 2023, it is 51 per cent, increasing continuously (Ministry of Power). The act sought to enhance the efficiency of the electricity sector. After implementing the Electricity Act (2003), the Indian power distribution sector experienced an average improvement in technical and operational efficiency (Khetrapal, 2020). It promoted unbundling the state electricity boards into autonomous distribution, transmission, and generation utilities. This act organized the Regulatory Commission at national and state levels to regulate this sector and set tariffs. It also aimed to reduce cross-subsidies in tariffs to promote microgrids and decentralized power generation to extend electricity access to remote areas. Currently, this act regulates the Indian electricity sector.

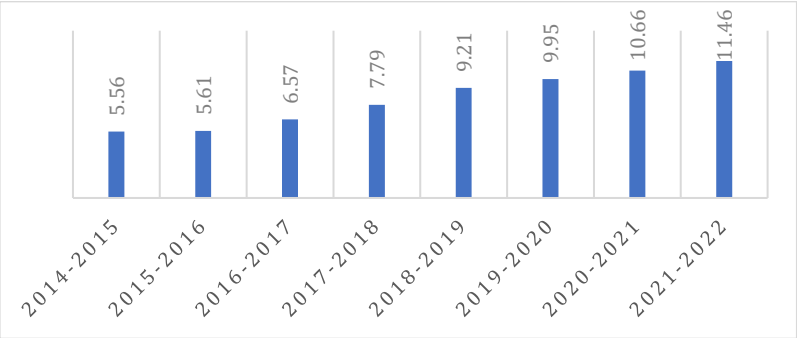
4.5. NATIONAL ELECTRICITY POLICY (NEP) AND TARIFF POLICY (2005)

NEP was introduced in 2005 to guide the development of the power sector. The NEP emphasized rural electrification, quality of supply, and encouraging renewable energy sources. The NEP and TP (2005) played a significant role in shaping the electricity sector in India. It provided a roadmap for the development of the power industry, promoted renewable energy, improved grid infrastructure, and aimed at supplying affordable and reliable electricity to all citizens. However, continuous monitoring, periodic reviews, and necessary amendments are essential to address emerging challenges and sustain the progress in the electricity sector—the tariff policy aimed to ensure transparency, cost, reflectivity, and competitiveness in tariff determination. As a result of the national electricity policy, more significant numbers of rural areas have been electrified. The "Deen Dayal Upadhyaya Gram Jyoti Yojana" and Saubhagya (DDUGJYS) schemes have been introduced to promote rural electrification. It is crucial to note that the issues and challenges still exist despite these positive results. Regulatory Disputes, financial distress in DISCOMs, subsidies, and unmetered power supply are ongoing challenges. In addition, there is still work to be done to fulfill the objective of providing all Indians with reliable and reasonably priced electricity. To solve the issues facing the electricity sector and improve the sustainability and reliability of the electricity supply, the government has persisted in launching new initiatives and regulations.

4.6. RENEWABLE ENERGY (RE) PUSH

The capacity of India's sources of green energy has increased significantly. The government has set high goals for installing renewable energy with the National Wind-Solar Hybrid Policy and the "Jawaharlal Nehru National Solar Mission." Solar power has witnessed remarkable growth. India started focusing on green energy sources to address environmental concerns and diversify its energy mix. Various incentives and policies were introduced to promote solar, wind, and other renewable energy projects. The National Solar Mission, launched by the government in 2008, is the most significant initiative to promote solar power. The primary goal of this mission is to promote India as the world's leader in solar energy. India is fourth globally in installed renewable energy capacity, wind power, and solar power. The installed capacity of renewable energy, which includes large hydro, increased about 2.23 times from 76.37GW in March 2014 to 167.75GW in Dec.2022. The nation's total solar power capacity increased 24.07 times from 2.63GW to 63.30GW between 2014 and 2022(Ministry of New and Renewable Energy, 2022-23). The growth rate of renewable energy generation was 16.07 per cent during the year 2021-22.

Figure 2: Percentage share of renewable energy in total generation



Source: Ministry of Power, Central Energy Authority (report 2021-2022)

4.7. UJWAL DISCOM ASSURANCE YOJANA (UDAY), 2015

The Indian government introduced UDAY in 2015 to help state-owned power distribution companies (DISCOMs) overcome operational and financial challenges. Under the scheme, participation from 27 states and five union territories was included. West Bengal and Odisha did not take part in UDAY. The primary objective of UDAY was to enhance DISCOM's operational effectiveness and financial health. Over two years, the state will pay off 75per cent of the debt due to DISCOMs as of Sept 30, 2015. In 2015-2016, 25per cent of the debt owed by DISCOMs will be taken on, and 50per cent will do so in 2016-2017. Under UDAY, state governments took over a significant portion of DISCOM debt and issued bonds to clear outstanding dues. This debt restructuring helped reduce the financial burden on DISCOMs and improved their balance sheets. UDAY aimed to reduce AT&C losses through various measures such as infrastructure upgrades, metering improvements, and better billing and collection processes. As a result, several states saw a decline in AT&C losses, leading to increased revenue collection. The Ujwal Discom Assurance Yojana has had a mixed impact across different states. While some states have shown significant improvement in their financial health and technical efficiency, others still face challenges in fully realizing the scheme's objectives. As a result, 15 of the 27 states participating in UDAY experienced an overall decrease in net losses from 2014-15 to 2019-20. The net losses increased between 2014-15 and 2019-20 in the 12 states that remained. The gap between ACS-ARR per unit decreased from Rs. 0.77 in 2014-15 to Rs. 0.72 in 2019-20 at the national level. On the other hand, the ACS-ARR gap varies widely across states, growing in some states.

4.8. REVAMPED DISTRIBUTION SCHEME (2021)

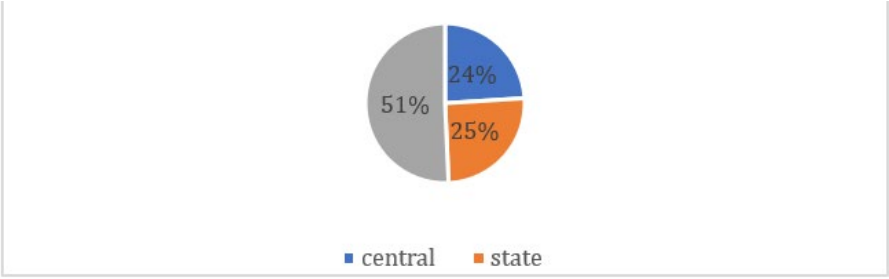
In 2021, GOI launched the Revamped Distribution Scheme in which the government will provide a bailout package of Rs 3 trillion from FY2021-22 to FY 2025-26 to decrease AT&C losses to 12-15per cent and the revenue gap between "ACS-ARR "to zero by FY2024-25 by enhancing the operational efficiency and financial sustainability of the distribution sector. The primary objectives of the scheme are to solarize agriculture feeders and enhance farmers' electricity access by integrating the PM-KUSUM scheme.

5. CURRENT SCENARIO OF THE INDIAN ELECTRICITY SECTOR

India's electricity consumption has steadily risen due to the country's growing industry, middle class, and urbanization. India's energy balance is changing, with a focus on cleaner and more sustainable sources of energy. Although coal-based power generation has historically prevailed, a noticeable trend has favoured green energy sources like solar and wind power. Although the Indian power grid is among the biggest in the world, it has capacity and reliability issues. The infrastructure for transmission and distribution is being expanded and modernized. The power industry is governed by a complicated regulatory framework in which the state and federal governments play significant roles.

The three sectors, i.e., Private, State, and Central, are engaged in electricity generation. In total installed generation capacity, the private sector, state, and central sector shares are 51 per cent, 25 per cent, and 24 per cent, respectively, as of 31.05.2023. The share of fossil fuels in total installed generation capacity is 56.4per cent, in which the share of coal is 48.8 per cent, and the non-fossil fuels share is 43.6 per cent, in which the renewable and the nuclear sources share are 41.8 per cent and 1.8per cent, respectively.

Figure 3: Sector Wise Installed Generation Capacity (31.05.2023)



Source: Ministry of Power

Table 1: Fuel-wise "Installed Generation Capacity" as of 14.08.2023:

Fossil Fuel	Installed Generation Capacity (GW)	Share (Percentage)
Coal	205.895	48.8
Gas	24.824	5.9
Lignite	6.620	1.6
Diesel	0.589	0.1
Total fossil fuel	237.929	56.4

Category of Non-Fossil Fuel	Installed Gen. Capacity (GW)	Share (Percentage)
Solar	700.97	16.6
Hydro	46.850	11.1
Wind	43.773	10.4
Others	15.773	3.7
RES	176.493	41.8
Nuclear	7.480	1.8
Total of Non-Fossil Fuel	183.973	43.6
Total Installed Capacity	421.902	100

Source: Central Electricity Authority (CEA)

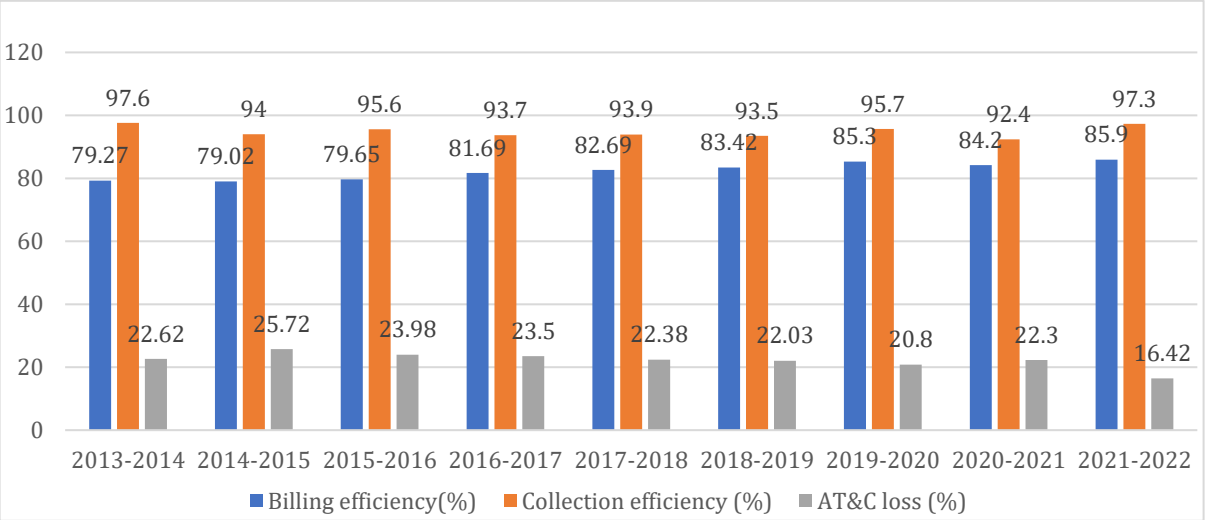
Thermal power plants, primarily of coal, gas, and oil, have traditionally been India's dominant electricity generation source. The thermal power sector accounts for a significant portion of the installed capacity. India has rapidly expanded its renewable energy capacity, including solar, wind, hydro, and biomass. The share of green energy capacity has consistently risen over the years as the country aims to reduce its carbon footprint. Solar energy capacity has grown remarkably, with large-scale solar power plants and rooftop solar installations contributing significantly to the overall capacity. Wind energy has been a prominent renewable source in India for many years. Wind farms are spread across states like Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Telangana, Maharashtra, etc. India has significant hydroelectric potential, and hydropower plants contribute to the country's electricity generation capacity.

6. TRENDS IN FINANCIAL AND OPERATIONAL PERFORMANCE

The financial health of distribution companies in India has been a concern. DISCOMs often face issues related to high AT&C losses and inefficient revenue collection processes and billing. Government initiatives like UDAY aimed to enhance the "financial health of DISCOMs," but challenges persist in some regions. Efforts have been made to enhance billing efficiency by installing advanced metering infrastructure (AMI) and smart meters. These technologies enable accurate recording of electricity consumption, reducing billing discrepancies. Discoms are increasingly adopting IT solutions for billing processes, including automation and digitization of billing systems. This helps streamline operations and reduces billing errors. With the push towards digitalization and cashless transactions, there has been an increase in the adoption of digital payment methods for electricity bill payments. This trend has improved collection efficiency by making payment processes more convenient for consumers. Discoms are implementing improved revenue collection mechanisms such as online payment gateways, mobile apps, and kiosks to facilitate timely bill payments and enhance collection efficiency. Reduction Initiatives: Efforts have been made to reduce AT&C losses through infrastructure upgrades, loss reduction programs, system modernization, and technology adoption. Upgrading distribution transformers, replacing timely infrastructure, and implementing high-efficiency systems have been initiated to minimize technical losses in the distribution network. Promoting energy-efficient appliances and consumer awareness programs to reduce electricity theft and promote responsible usage have contributed to curbing commercial losses. AT&C losses

at the national level decreased from 25.72 percent in 2014-15 to 20.8 per cent in 2019-20. However, in 2020-21, it increased from 20.8per cent to 22.3per cent in 2020-21 (PFC). According to the recent data released by PFC, reforms introduced in the Indian electricity sector have started to show results. DISCOMs' average AT&C losses decreased in India from 22.3per cent in 2020-21 to 16.4 per cent in 2021-22. The ACS-ARR gap for DISCOMs has decreased. Between the FY 2020-21 and 2021-22, the ACS-ARR gap decreased from 0.69/kWh to 0.15/kWh. Billing efficiency increased from 79.27 per cent in 2013-2014 to 85.9 percent in 2021-2022. The collection efficiency also increased from 92.4 per cent in 2020-2021 to 97.3 per cent in 2021-2022. DISCOMs are now in a better financial situation and can guarantee that the customers receive a consistent and high-quality power supply. (Ministry of Power)

Figure 4: Billing Efficiency Vs. Collection Efficiency Vs. AT&C Loss



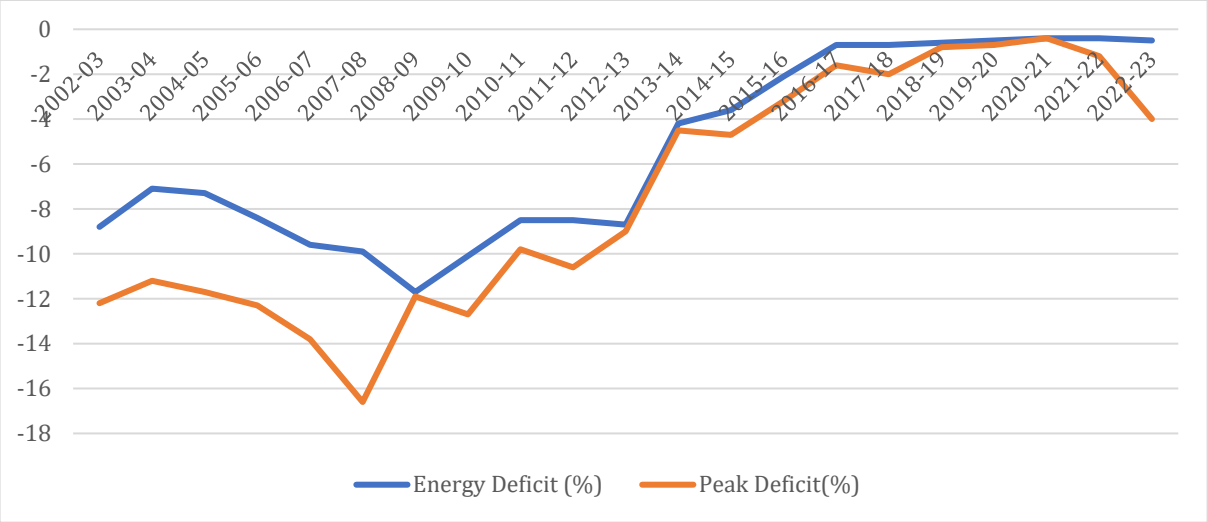
Source: PFC various reports

7. ENERGY DEFICIT AND PEAK DEFICIT

Over the years, India has significantly reduced its energy deficit. The energy deficit measures the shortfall in electricity supply compared to the demand. Policy initiatives, increased power generation capacity, emphasis on renewable energy, and transmission and distribution infrastructure improvements have narrowed the energy deficit. Investments in power generation, especially in green energy sources such as wind and solar, have played a crucial role in reducing the energy deficit. The declining costs of renewable energy technologies have encouraged their adoption, contributing to increased capacity and improved energy availability. The peak power deficit indicates the shortfall in meeting the maximum demand for electricity during a specific period. India has experienced fluctuations in peak power deficit due to varying demand patterns, seasonal changes, economic growth, and available power generation capacity. There have been peak power deficits during high electricity demand, especially in summer when air conditioning usage escalates. However, efforts to enhance power generation capacity, augment transmission infrastructure, and promote demand-side management have helped manage and reduce peak power deficits.

Upgrades and expansions in the transmission and distribution infrastructure have played a crucial role in reducing deficits. Efforts to strengthen the grid, minimize transmission losses, and enhance the efficiency of distribution systems have improved electricity's overall reliability and availability. Overall, India's power sector trends indicate a gradual reduction in energy and peak power deficits. However, managing these deficits remains a continuous challenge, especially considering the country's growing energy demands and the need for further infrastructure development to ensure reliable and uninterrupted power supply across the nation. Ongoing investments in renewable energy, infrastructure upgrades, and policy initiatives will continue to shape the trajectory of energy and peak power deficits in the Indian power sector. In 2003-04, the peak deficit was 12.2 per cent, and the energy deficit was 8.8 per cent. The energy deficit increased continuously from 7.3 per cent in 2004-05 to 11.7 per cent in 2008-2009. The peak deficit also increased from 11.7 per cent in 2004-05 to 16.6 per cent in 2007-08. However, after 2009-10, the energy deficit decreased. It was 0.4 per cent in 2021-22. The peak deficit also declined after 2009-10. It was 1.2 per cent in 2021-22. However, in 2022-23, both deficits increased. The energy deficit is 0.5 per cent, and the peak deficit is 4 per cent.

Figure 5: Energy And Peak Deficit



Source: Ministry of Power, CEA

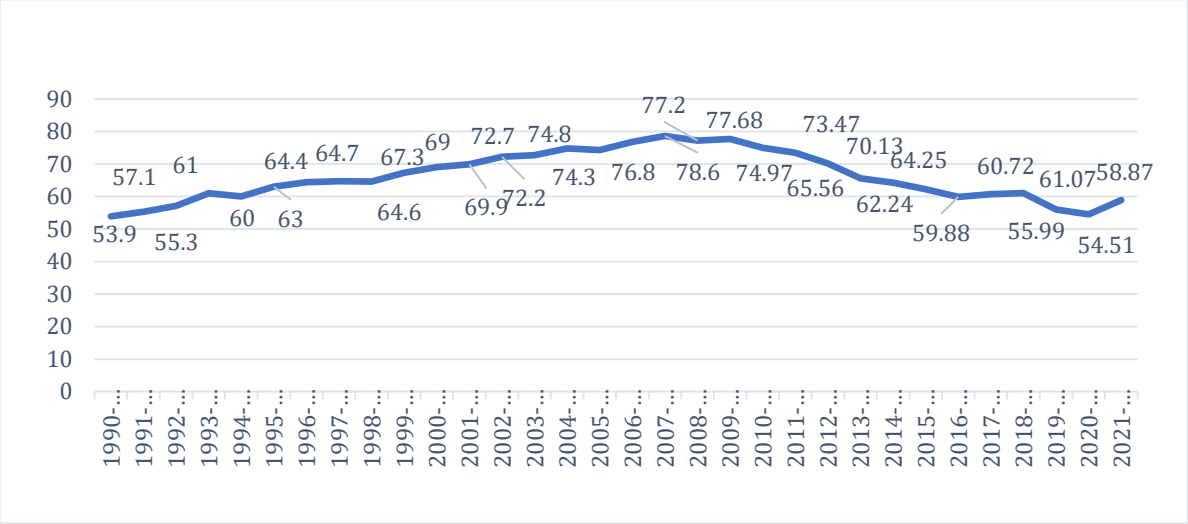
8. PLANT LOAD FACTOR

The Plant Load Factor provides insights into how efficiently a power plant is utilized. It is the "ratio of the actual output of a power plant to its maximum possible output at a given time," expressed as a percentage. A high PLF indicates that the power plant is producing electricity close to its maximum capacity and is operating efficiently. A low PLF suggests that the plant is underutilized and not operating at its full potential.

The average PLF Per cent of Thermal Power Plants had increased from 53.9per cent in 1990-1991 to 78.6 per cent in 2007-2008. However, after FY 2007-2008, the PLF (per cent) started declining. The average PLF (per cent) of Thermal Power Plants in FY 2021-2022 was 58.87per cent. The lower PLF was mainly due to decreased generation loss due to the Reserve Shut Down (CEA,2017)

The details of PLF from the financial year 1990-1991 onwards are depicted in the following chart:

Figure 6: PLF (percentage) of Thermal Power Stations in India



Source: Ministry of Power, CEA (various reports)

9. CHALLENGES

9.1. ISSUES IN THE GENERATION POWER SECTOR

Insufficient Power Generation Capacity: Meeting the growing electricity demand remains a challenge due to inadequate power generation capacity. This gap leads to power shortages and outages in various parts of the country.

High cost of fuel: Coal mining from government-owned issues with land acquisition, a lack of investment in advanced technologies, and delays in obtaining environmental permission have all hampered the growth of coal in India.

Dependency on imported coal: Despite having ample coal supplies, power companies frequently rely on expensive coal imports.

High contribution from non-renewable sources:

Most electricity generation in India is produced thermally, gas and diesel.

Aged power plant: There are a lot of outdated and inefficient power plants in India, which results in inefficiencies. Due to this, the plant load factor is decreasing. The PLF was 58.87 per cent in 2021-22, which was very low.

9.2. CHALLENGES IN THE TRANSMISSION AND DISTRIBUTION POWER SECTOR

High AT&C losses: The distribution companies' AT&C losses are considerable; the national average is 16.42 per cent, but losses are nearly 40 per cent in certain states. AT&C losses are incredibly minimal in nations like the US and the UK. Technical losses are increased due to inadequate equipment. Power theft and pilferage, unmetered in the agricultural sector, and ineffective billing and collection techniques are the leading causes of commercial losses. The main aim of reforms like the "ACCELERATED POWER DEVELOPMENT PROGRAM, UDAY" was to reduce AT&C's losses, but the reduction in AT&C losses has been slower than the target set in reforms.

Uneconomical Subsidies: Subsidies in India's agricultural sector have been both beneficial and controversial. While the subsidies aim to support farmers and boost agricultural productivity, electricity can lead to the overuse of resources, imbalanced crop choices, and inefficiency in resource allocation. After providing electricity subsidies, irrigation by electric tube wells increased. Because of this, the water level is deteriorating continuously. To offset the expenses of agricultural sector subsidies, tariffs have not been raised sufficiently.

Transmission and Distribution Losses: Significant power losses during electricity transmission are caused by inefficient transmission and distribution networks, which wastes energy and raises prices. Transmission and distribution losses in India were 20.66 per cent in the FY 2018-19, the highest in the world. Korea and Japan were 3.47 per cent and 4.04 per cent, the lowest in the same period.

Lack of Private Sector Investment: New investments in the electricity sector have been hindered by the inadequate financial performance of DISCOMs, particularly from the private sector.

Electricity Theft and Losses: Electricity theft is rampant in many areas, particularly in urban slums and rural regions. This includes illegal connections, meter tampering, and bypassing meters. This results in significant revenue losses for Discoms. India faces severe electricity theft issues, including technical and non-technical losses. This impacts the overall financial health of the energy sector and causes revenue losses for electricity distribution companies.

10. CONCLUSION

Significant achievements and persistent challenges have marked the evolution of the electricity sector in India through reforms. The reforms, aimed at enhancing efficiency, sustainability, and accessibility, have resulted in commendable progress in various facets of the sector. Electricity reforms have significantly improved India's power availability, especially in rural and isolated areas. This has raised living standards and facilitated economic growth. Reforms have made it easier to add significant power generation capacity from various sources, including renewable energy, strengthening, and diversifying the energy mix. Several legislative and regulatory measures have been implemented to encourage competition, efficiency, and transparency in the power industry. The efficiency of electricity generation, transmission, and distribution networks has increased due to the reforms' encouragement to adopt cutting-edge technologies. Notably, there has been a substantial enhancement in electricity generation capacity, accompanied by strides in electrification efforts across rural and urban regions. Integrating renewable energy sources has been a

notable success, contributing to a more diverse and sustainable energy mix. Additionally, transmission and distribution infrastructure improvements have been evident, laying the groundwork for a more reliable power supply.

However, the journey of reform implementation has not been devoid of challenges. The financial health of distribution companies (Discoms) remains a critical issue, burdened by high subsidy costs and operational inefficiencies. Transmission and distribution losses persist, impacting the overall viability of the sector. Policy implementation hurdles, regulatory complexities, and technological limitations hinder the sector's optimal functioning. Despite these challenges, the reforms have made a tangible impact on consumers and socio-economic development. Access to electricity has improved, contributing to rural electrification and fostering socio-economic growth. However, concerns regarding affordability, consumer satisfaction, and effective grievance redressal mechanisms necessitate continued attention.

In conclusion, the outcomes of power sector reforms in India showcase a mix of accomplishments and challenges. Policymakers, regulatory bodies, and industry stakeholders must address the persisting hurdles through innovative policy interventions, technological advancements, and robust regulatory frameworks. Learning from past experiences and focusing on sustainable strategies will be pivotal in ensuring a resilient, inclusive, and thriving power sector that meets the diverse needs of the nation's growing economy and population.

11. SUGGESTIONS

The electricity sector is a critical enabler of economic growth and development in India, impacting virtually every aspect of the economy and society. Ensuring an affordable, reliable, and sustainable electricity supply is essential for achieving inclusive and sustainable economic growth, improving living standards, and fulfilling the aspirations of India's growing population. Energy security may be improved, environmental effects can be reduced, and dependency on fossil fuels can be decreased by promoting investment in renewable energy and infrastructure. Renewable energy sources such as solar, hydroelectric, and wind should remain the government's primary objective. In India, rural electrification still needs to improve despite enormous progress. Enhancing livelihoods and fostering economic development can be achieved by increasing access to electricity in rural regions through off-grid possibilities such as microgrids and decentralized renewable energy systems. Improving power sector reforms in India is crucial for achieving sustainable, reliable, and affordable energy access. There is a need for further reforms to improve the electricity sector in India. The government needs to take the initiative and policies to reduce the challenges the DISCOMs face. There is a need to address the issue of cross-subsidies. The government should address the issues of tariffs. DISCOMs need to reduce their AT&C through digitalization. It is recommended that the government rapidly switch over to smart meters from current electrical meters. The government should promote the participation of the private sector to enhance the poor health of the distribution sector.

CONFLICT OF INTERESTS

None.

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REFERENCES

Agrawal, S., Mehta, R., & Sharma, K. (2017). Future of Indian power sector reforms: Electricity Amendment Bill 2014. *Energy Policy,* 491–497.

Fukumi, A. (2016). Power sector reform in India: Status and issues.

Ghosh, S., Banerjee, A., & Ray, S. (2021). Three decades of Indian power sector reform: A critical assessment. *Utilities Policy.*

Garg, V., Viswanathan, B., & Rajagopal, M. (2020). The curious case of India's Discoms: How renewable energy could reduce them. Institution for Energy Economics and Financial Analysis (IEEFA).

Kessides, I. N. (2012). The impacts of electricity sector reforms in developing countries. *The Electricity Journal,* 25(6), 79–88.

Khetrapal, P. (2020). Performance analysis of electricity distribution sector post the implementation of Electricity Act 2003: Empirical evidence from India. *Journal of Advances in Management Research.*

Kumar, S., Jain, A., & Goswami, P. (2012). Electricity sector in India: Policy and regulation. *Oxford Academic.*

Pal, A. (2013). Power sector in India: Growth, policies, and challenges. *International Journal of Emerging Technology and Advanced Engineering,* 3(3), 527–536.

Patyal, R., & Singh, J. (2023). Performance evaluation of Indian electricity distribution companies: An integrated DEA-IRP-TOPSIS approach. *Energy Economics.*

Sen, R., Shinde, M., & Sinha, A. (2018). Have model, will reform: Assessing the outcomes of electricity. *The Energy Journal,* 39(2), 181–209.

Sheoran, S. (2019). Impact of UDAY Yojana on the performance of power distribution companies. *THINK INDIA JOURNAL,* 22(10).

Surdeo, N. (2017). Power sector policies in India: History and evolution. *Jindal Journal of Public Policy,* 3(1), 166–219.

India Brand Equity Foundation. (n.d.). *Power sector in India.* Retrieved from https://www.ibef.org/industry/power-sector-india

Ministry of Power. Retrieved from https://powermin.gov.in/

Central Electricity Authority. Retrieved from https://cea.nic.in/?lang=en

Power Finance Corporation. Retrieved from https://pfcindia.com/ensite

Ministry of New and Renewable Energy. Retrieved from https://mnre.gov.in/