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ELECTRICITY ENERGY REQUIREMENT AND GENERATION IN INDIA: PREDICTIONS FOR NEXT FIVE YEARS

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Abstract. In this study, demand and production forecasts for India's electricity energy during the following five years are given. It forecasts future power demand and the matching generation capacity required to meet the rising energy needs of the nation by utilising historical data, current trends, and numerous factors affecting the electrical sector. This study focuses on projections for India's energy production and demand over the next five years. In order to provide insight into the anticipated power energy environment in India, the study analyses various sources of electricity generation as well as major drivers such population increase, industrial expansion, urbanisation, and governmental regulations. To maintain a dependable and sustainable electricity supply for India's economic growth and social development, policymakers, energy planners, and stakeholders can use the findings to help them make educated decisions on infrastructure investments, renewable energy deployment, and grid management.

1. Introduction

The production, distribution, and use of electrical energy in a way that satisfies current demands without jeopardizing the ability of future generations to satiate their own energy needs is referred to as sustainable electricity energy. Throughout the entire electrical supply chain, it includes the utilisation of renewable energy sources, energy-saving techniques, and ecologically friendly procedures. Environmental effects, greenhouse gas emissions, resource conservation, energy security, and social and economic advancement are all goals of sustainable electricity energy.India is one of the economies in the world that is expanding the fastest, with one of the fastest-rising populations and rising energy needs [1]. There are several opportunities and problems in meeting the nation's growing and populous electricity needs. For efficient energy planning, infrastructure development, and policy formulation over the next five years, accurate estimates of electricity energy requirement and generation are essential. Policymakers, energy planners, and stakeholders may decide how to assure a dependable, cheap, and sustainable electricity supply for India's economic growth and social development by having a thorough grasp of the predicted growth in demand and necessary generation capacity [2].

2. Literature Review

The Indian electrical industry is essential to fostering sustainable development, raising living standards, and sustaining the nation's economic expansion. The industry includes the production, transmission, distribution, and use of electricity, and it caters to a wide range of stakeholders,

including individuals, businesses, and even public services and agricultural operations. This is a summary of the Indian power market.

2.1. Hydro Electricity

Hydroelectricity, commonly referred to as hydropower, is a method of generating electricity that makes use of the force of moving or falling water. One of the first and most popular renewable energy sources worldwide. The kinetic energy of moving water is used by hydroelectric power plants to produce electricity. Typically, they are made up of a dam, reservoir, and turbine. A dam is built over a river to produce a reservoir or made-up lake. To provide a constant supply of water for the turbine, the dam regulates the flow of water. Penstocks are the broad pipelines that carry water from the reservoir to the turbine. The turbine rotates as a result of the force of the flowing water. The generator, which is attached to the rotating turbine, transforms the mechanical energy produced by it into electrical energy. Power lines are then used to deliver the generated electricity to consumers' homes, places of business, and industries [3].

India is capable of producing a lot of hydroelectric power. About 46.35 GW of the nation's installed power capacity was hydroelectric as of September 2021, making up about 12% of the overall installed power capacity [4]. Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh, and Sikkim are major hydropower-producing states in India. Large-scale hydroelectric power stations can be found throughout India. A few noteworthy initiatives include:

- Tehri Dam and Power Complex (Uttarakhand): With a 1,000 MW installed capacity, this hydroelectric project is one of India's biggest.
- SardarSarovar Dam (Gujarat): In addition to providing irrigation benefits, it also has a 1,450 MW power capacity.
- Bhakra-Nangal Dam (Himachal Pradesh): This multifunctional undertaking has a 1,325 MW electricity capacity.

2.2. Thermal electricity

Electricity produced by burning fossil fuels, chiefly coal, oil, and natural gas, is referred to as thermal electricity. Thermal power plants are the primary source of electricity in India. The majority of India's installed electricity capacity comes from thermal power plants [5]. About 236 GW of installed thermal power capacity existed as of September 2021, making up about 62% of the nation's total installed power capacity. The majority of the thermal capacity installed is contributed by thermal power plants using coal, followed by those using gas and oil [6].

Coal-Based Thermal Power Plants:

- The primary fuel utilised to generate thermal energy in India is coal. Coal-based power plants are positioned adjacent to coal mines or coastal areas to facilitate shipping.
- With a capacity of 2,000 MW, NTPC's Singrauli Super Thermal Power Station (Uttar Pradesh) is one of the biggest coal-fired power plants in India and a remarkable example of a coal-based thermal power plant.

- Adani Power's Mundra Thermal Power Station in Gujarat, which has an installed capacity of 4,620 MW, is one of the biggest privately owned thermal power plants in the country.Gas-Based and Oil-Based Thermal Power Plants
- Oil- and gas-based thermal power plants make up a far lower portion of India's total installed thermal capacity.
- Natural gas is the main fuel for gas-powered plants, whilst diesel or fuel oil is used in oil-powered ones.
- States with access to LNG ports or natural gas supplies tend to have a concentration of gas-powered power plants.

2.3. Nuclear Electricity

Nuclear power plants, which use the energy released during nuclear reactions to generate electricity, are known as nuclear power plants. In India, nuclear energy is a key component of the nation's overall energy mix. The nuclear power industry is expanding in India. Approximately 6.78 GW of nuclear generating capacity was installed nationwide as of September 2021, making up 2% of India's total installed power capacity. Nuclear Power Corporation of India Limited (NPCIL), a state-owned company, runs nuclear power stations in India [7].

Several nuclear power stations are currently in operation in India, and they are spread out across the nation. In India, notable nuclear power plants include:

- The largest nuclear power station in India is the Tarapur Atomic Power Station (Maharashtra), which has two active units with a combined capacity of 1,400 MW.
- Two operational units with a total capacity of 2,000 MW make up the Kudankulam nuclear power facility in Tamil Nadu. It is the outcome of cooperation between Russia and India.

3. Research Methodology

The research design employed in this study is a qualitative approach. It involves a comprehensive examination of past and current years statistics related to India’s need for and production of power. The Trend Analysis tool is used to predict the India’s need for and production of power for electricity generation for next five years in India. This trend analysis will help to forecast the predictions for future energy generation in India. The study focuses on projections for India's energy production and demand over the next five years. The study utilizes the secondary data sources to analyze the future energy requirement in India predictions. Here, researcher used Systematic Literature Review (SLR) to forecast future energy requirements and how much energy generation from different sources available in India. In order to provide insight into the anticipated power energy environment in India, the study analyses various sources of electricity generation as well as major drivers such population increase, industrial expansion, urbanisation, and governmental regulations. Here, the researcher used facts from the Economic Outlook website to address the goal.

4. Data Analysis

Insights and forecasts about India's need for and production of power over the following five years are provided by this study. The results can help decision-makers in the energy sector and policymakers build policies and provide an affordable, dependable, and sustainable electricity supply to support India's socioeconomic development and environmental goals.

Table 1. Requirement and Availability of Electricity in India (source : https://economicoutlook.cmie.com/).

Cumulative	Energy requirement	Energy availability	Energy surplus/deficit (-)	Energy surplus/deficit (-)	Peak demand	Peak demand met	Peak energy surplus/deficit (-)	Peak energy surplus/deficit (-)
	Million kwh	Million kwh	Million kwh	%	MW	MW	MW	%
2002-03	545,674.00	497,589.00	-48,085.00	-8.81	81,492.00	71,520.00	-9,972.00	-12.24
2003-04	559,264.00	519,398.00	-39,866.00	-7.13	84,574.00	75,066.00	-9,508.00	-11.24
2004-05	591,373.00	548,115.00	-43,258.00	-7.31	87,906.00	77,652.00	-10,254.00	-11.66
2005-06	631,757.00	578,819.00	-52,938.00	-8.38	93,255.00	81,792.00	-11,463.00	-12.29
2006-07	690,587.00	624,496.00	-66,091.00	-9.57	100,715.00	86,818.00	-13,897.00	-13.8
2007-08	739,345.00	666,007.00	-73,338.00	-9.92	108,866.00	90,793.00	-18,073.00	-16.6
2008-09	777,039.00	691,038.00	-86,001.00	-11.07	109,809.00	96,785.00	-13,024.00	-11.86
2009-10	830,594.00	746,644.00	-83,950.00	-10.11	119,166.00	104,009.00	-15,157.00	-12.72
2010-11	861,591.00	788,355.00	-73,236.00	-8.5	122,287.00	110,256.00	-12,031.00	-9.84

2011-12	937,199.00	857,886.00	-79,313.00	-8.46	130,006.00	116,191.00	-13,815.00	-10.63
2012-13	998,114.00	911,209.00	-86,905.00	-8.71	135,453.00	123,294.00	-12,159.00	-8.98
2013-14	1,002,257.00	959,829.00	-42,428.00	-4.23	135,918.00	129,815.00	-6,103.00	-4.49
2014-15	1,068,923.00	1,030,785.00	-38,138.00	-3.57	148,166.00	141,160.00	-7,006.00	-4.73
2015-16	1,114,408.00	1,090,850.00	-23,558.00	-2.11	153,366.00	148,463.00	-4,903.00	-3.2
2016-17	1,142,928.00	1,135,332.00	-7,596.00	-0.66	159,542.00	156,934.00	-2,608.00	-1.63
2017-18	1,212,462.00	1,203,866.00	-8,596.00	-0.71	164,066.00	160,752.00	-3,314.00	-2.02
2018-19	1,274,914.00	1,267,531.00	-7,383.00	-0.58	177,022.00	175,528.00	-1,494.00	-0.84
2019-20	1,291,355.00	1,284,766.00	-6,589.00	-0.51	183,804.00	182,533.00	-1,271.00	-0.69
2020-21	1,275,880.00	1,270,986.00	-4,894.00	-0.38	190,197.50	189,395.10	-802.5	-0.42
2021-22	1,380,146.00	1,374,352.00	-5,794.00	-0.42	203,014.00	200,539.00	-2,475.00	-1.22
2022-23	1,511,214.00	1,503,650.00	-7,564.00	-0.5	215,888.00	207,231.00	-8,657.00	-4.01

4.1.Requirement and Availability of Electricity in India

India now has much more installed power generation capacity. The total installed power capacity was approximately 379 GW as of September 2021, making it one of the largest power markets in the world.Table 1 shows the required and available electricity energy as well as the percentage of a deficiency. It details the demand for power and how much of that gap demand hasn't been met during the past 20 years. In the past, India experienced power shortages caused by an imbalance between demand and supply, which frequently caused power outages in some areas. However, major efforts have been undertaken to close the supply-demand gap in electricity [8]. The Ujwal DISCOM Assurance Yojana (UDAY) and other government programmes are aimed at reducing power shortages and enhancing the overall reliability of the electricity supply.

Table 2. Electricity Generation: % share in total: 2003-04 to 2027-28 (source: https://economicoutlook.cmie.com/).

Year	Electricity energy	Hydro electricity	Thermal electricity	Nuclear electricity
2003-04	100	13.21	83.61	3.18
2004-05	100	14.38	82.75	2.87
2005-06	100	16.4	80.52	2.79
2006-07	100	17.11	79.63	2.81
2007-08	100	17.52	79.35	2.38
2008-09	100	15.62	81.53	2.03
2009-10	100	13.52	83.36	2.43
2010-11	100	14.09	81.98	3.24
2011-12	100	14.88	80.83	3.68
2012-13	100	12.47	83.4	3.6
2013-14	100	13.94	81.94	3.54
2014-15	100	12.32	83.76	3.44
2015-16	100	10.96	85.19	3.38
2016-17	100	10.55	85.7	3.27
2017-18	100	10.46	85.97	3.18
2018-19	100	10.8	85.82	3.03
2019-20	100	12.45	83.37	3.72
2020-21	100	12.17	83.63	3.49
2021-22	100	11.48	84.39	3.57
2022-23	100	11.44	84.86	3.22
2023-24	100	10.52	85.93	3.05
2024-25	100	10.37	85.73	3.4
2025-26	100	10.2	85.78	3.52
2026-27	100	10.09	85.79	3.63
2027-28	100	9.57	86.17	3.77

In India, a variety of energy sources, including coal, natural gas, hydroelectric power, nuclear power, and renewable energy sources like solar and wind, are used to generate electricity.The majority of the nation's electricity is generated by thermal power plants, which are typically coal-based. The researcher deduced from table 2 that the generation of energy will increase over the next five years and will become more dependent on thermal and nuclear electricity than on hydroelectricity. In order to fulfil its rising electricity demand, solve environmental issues, and lessen reliance on fossil fuels, India is actively encouraging renewable energy sources. With a concentration on solar and wind power, the nation has established renewable energy capacity targets, including 450 GW of renewable energy by 2030. In spite of regional variations in the availability of renewable energy sources like solar and wind, attempts are being made to properly utilise these resources. India has made significant strides towards electrifying its rural areas. The

Pradhan MantriSahajBijliHarGharYojana (Saubhagya), the government's most visible initiative, aims to link all rural households to the electrical grid. There are ongoing efforts to raise the standard and dependability of the electrical supply in rural areas, ensuring uninterrupted power for domestic usage, rural businesses, and agricultural operations [9].

4.2. Future Plans and Investments

To increase the country's access to energy, the Indian government has detailed a number of programmes and projects. This entails stepping up investments in grid modernisation, energy efficiency promotion, and infrastructure for electricity generation. To promote the growth and expansion of India's electrical sector, the private sector and international investments are also encouraged. Even though India's access to electricity has greatly improved, issues including infrastructure development, funding, grid stability, and ensuring that everyone has access to dependable and reasonably priced electricity continue to be problems. It is anticipated that these issues will be resolved and the nation's increasing electrical needs will be met by the government's sustained emphasis on reforms, the integration of renewable energy sources, and the strengthening of the power sector [10].

5. Conclusion

Insights and forecasts about India's need for and production of power over the following five years are provided by this study. The analysis aids in anticipating the difficulties and opportunities in supplying the rising demand for energy by taking a variety of drivers, trends, and other factors into account. The results can help decision-makers in the energy sector and policymakers build policies and provide an affordable, dependable, and sustainable electricity supply to support India's socioeconomic development and environmental goals. This study helps India improve its infrastructure, formulate policies, and achieve sustainable growth by providing insights on the future demand and generation of power. It addresses the difficulties in supplying the rising demand for power while promoting the shift to a clean and reliable energy future.

6. Future Implications

India's energy sector and overall development would be significantly impacted by the demand for and supply of electricity in the country. Due to population expansion, urbanisation, and economic development, India's energy demand is anticipated to continue growing. The long-term effects include making sure there is enough electrical generation capacity to fulfil this expanding demand. Power infrastructure, such as power plants, transmission lines, and distribution networks, must be continuously improved.

The next important implication is of energy security for the nation to have adequate energy security, there must be a sufficient supply of electricity. Future repercussions include increasing renewable energy sources like solar, wind, and hydroelectric power as India works to lessen its reliance on fossil fuels and diversify its energy mix. By reducing reliance on imported fossil fuels

and boosting the share of domestic and renewable energy resources, this will improve energy security. Addressing environmental sustainability is one of the future effects of India's electricity availability and demand. There is an increasing focus on switching to cleaner and more environmentally friendly types of power generation as the nation works to battle climate change and cut greenhouse gas emissions. To reduce the environmental impact of electricity generation, it will be essential to increase the proportion of renewable energy and enact stronger environmental standards for thermal power plants [5].

Having access to electricity has a big impact on inclusive development. Although there has been progress in rural electrification, it is still difficult to guarantee that all remote and underserved areas can obtain dependable and inexpensive energy. The consequences for the future include expanding electrical infrastructure to these locations, encouraging renewable energy options, and utilising technical breakthroughs to close the rural-urban electricity gap [8]. It focuses on Industrial and economic growth. The ability to get electricity is essential to fostering both of these types of development. In order to grow its economy and establish itself as a global manufacturing centre, India must ensure that enterprises have a consistent and dependable supply of power. Future ramifications include bolstering the electrical system, enhancing grid stability, and using cutting-edge technology like smart grids and energy storage to support industrial growth.

India's ongoing energy transition and policy reforms are necessary given the future consequences of its demand for and access to power. The future of the electrical industry will be shaped by the government's sustained emphasis on boosting renewable energy, enhancing energy efficiency, luring investments, and enacting market-oriented reforms. The facilitation of a supportive policy environment, the simplification of laws, and the promotion of innovation and study in the area of electricity generation, transmission, and distribution are some examples of these effects [9]. In order to address the long-term effects of India's electricity availability and demand, a thorough and multifaceted strategy is needed. It involves long-term investments, legislative support, technical developments, and public-private partnerships. It also incorporates strategic planning. India can contribute to its overall socio-economic development and maintain a sustainable, dependable, and inexpensive electrical supply for its expanding population by addressing these consequences. The Indian electrical industry is well-positioned for future expansion and change [11]. Demand-side management, grid upgrading, the deployment of energy storage, and the increase of renewable energy sources are anticipated to remain the primary priorities. The sector would be essential in helping India meet its climate and sustainable development commitments.

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