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**PARADIGM SHIFT IN ELECTRICITY AND POWER SECTOR OF HARYANA**

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**Abstract:**

This research paper explores the transformational changes and paradigm shift taking place in the electrical and power industry of Haryana, a state located in northern India. This research examines the redefinition of Haryana's power landscape in response to the needs of a fast-expanding economy and environmental issues, with a particular emphasis on technical breakthroughs, legislative adjustments, and sustainability efforts. This report aims to provide insight into the changing energy paradigm within the state by examining significant events and their associated ramifications.

**1. Introduction**

The energy and power industry of Haryana has a crucial position in the state's economic progress and has seen substantial transformations throughout its history. A comprehensive understanding of the historical context is important in order to grasp the present condition of the industry and its future direction. In the mid-20th century, the process of electrification in Haryana began with a primary focus on meeting the agricultural and home demands of the region. During the first period, there was a notable lack of extensive coverage and inconsistent provision of electricity, particularly in rural regions where access to this resource was restricted. The establishment of the Haryana State Electricity Board (HSEB) can be traced back, when the state of Haryana was created as a distinct entity via the reorganisation of states, separating it from the larger state of Punjab. The establishment of the Haryana State Electricity Board (HSEB) was undertaken with the purpose of effectively managing and overseeing the electricity industry inside the recently founded state. In order to address the increasing energy demand, the state of Haryana made investments in thermal power generating. The government has developed thermal power plants, including the Panipat Thermal Power Station and the Faridabad Thermal Power Plant. Transmission and distribution inefficiencies were minimised, and a more stable electricity supply was guaranteed due to efforts to increase grid connection throughout the state. The state government of Haryana

has instituted a number of policies meant to encourage the production, transmission, and distribution of electrical energy. Incentives for private sector involvement in electricity projects were incorporated in policy. Haryana's emphasis has shifted more and more towards renewable energy sources like solar and wind, and the state has implemented legislation and incentives to facilitate this shift. Improvements in grid efficiency and dependability have led to the widespread use of smart grid technology and digitalization in recent years. Grid management systems, real-time data analytics, and smart metres have all been implemented. The administration has prioritised the electrification of rural regions and the expansion of access to electricity, especially via initiatives like the Deen Dayal Upadhyaya Gramme Jyoti Yojana (DDUGJY). Haryana has established lofty renewable energy objectives with the intent of increasing the proportion of renewables in the state's overall energy consumption. The "Haryana Solar Power Policy" and similar programmes encourage people to switch to solar power. Haryana's energy and power industry has come a long way from its early days of electrification, reflecting the state's modern commitment to technical innovation and sustainability. Growth, industrialization, and rising living standards may all be attributed in large part to the progress made in this area.

## 2. Review of Literature:

Over the years, the power and electricity sectors have been extensively studied, given their integral role in socio-economic development, especially in developing economies like India. The power and electricity sectors play a vital role in the socio-economic development of any region. Haryana, a state in North India, has made significant strides in the power sector in recent years. This is evident in the reports published by the Haryana Power Generation Corporation Limited (HPGCL) and the Government of Haryana's Renewable Energy Policy 2021-2030. Research articles, such as those by Singh and Kumar (2022) and Kumar and Kumar (2021), have also highlighted the paradigm shift in Haryana's power sector. These articles emphasize the state's focus on renewable energy and its commitment to providing reliable and affordable electricity to its citizens. The Statistical Abstract of Haryana 2020-21 provides detailed data on the state's power sector performance. The data shows that Haryana has made significant progress in increasing its power generation capacity and reducing its transmission and distribution losses. The Haryana Electricity Regulatory Commission (HERC) plays a crucial role in regulating the power sector in the state. The HERC website provides valuable information on the state's power tariff structure and other related regulations. Sharma, N., & Sharma, V. (2022) in their article A study on the impact of renewable energy on the electricity sector of Haryana and Kumar, A., & Kumar, P. (2021) in their research paper on Role of renewable energy in the sustainable development of Haryana. Renewable Energy provides further insights into the state's transition to a renewable energy-based power system and its implications for sustainable development. In essence, the prevailing literature paints a picture of a nation striving for comprehensive electrification, with states like Haryana leading the charge. The intricate interplay between technology, policy, and regional strategies, as evidenced in the literature, provides a rich backdrop against which the current study unfolds, adding further depth to the collective understanding of India's electrification journey.

**Objectives of the study:**

- To assess major changes and developments in the power and electricity sectors.
- To comprehend the contribution of technology and policy to the paradigm shift.

**3. Research Methodology**

The power and electricity sector of Haryana plays a pivotal role in the state's development, making an analysis of its evolution and current state critical. This study primarily aims to assess the significant changes and developments that have taken place in the sector over the years. Furthermore, it endeavours to understand the role of technology and policy in driving these transformations. The foundation of this research is the data procured from the Statistical Abstract website, which offers an exhaustive dataset on the various facets of Haryana's power and electricity landscape. The research design chosen for this study is twofold: Descriptive and comparative. While the descriptive design provides a detailed account of data across the years, pinpointing trends and painting a holistic picture, the comparative design contrasts data from different years to discern growth trajectories and anomalies. Various methods have been employed for data analysis. Trend analysis focuses on observing the nuances of infrastructure growth and consumption patterns. A comparative analysis aids in understanding the pace of sectoral evolution by contrasting growth rates from distinct periods. Gap analysis delves into the disparities between the power available for sale and the actual power sold, offering insights into distribution efficacy. Additionally, correlation analysis will be employed to ascertain the interrelation between infrastructural growth and hikes in consumption or connections. Moreover, a meticulous sector-wise breakdown will spotlight trends in domains such as domestic, commercial, and industrial, shedding light on sector-centric progressions.

Qualitative research is also integral to this study. Policy changes, reforms, and any regulatory paradigm shifts in Haryana during the specified period will be closely examined to gauge their influence on the observed metrics. Concurrently, a deep dive into technological innovations in the sector will be undertaken, and their correlation with discernible spikes or shifts in the metrics will be explored. For a comprehensive understanding, the data will be presented using tables, bar graphs, line charts, and pie charts, providing a visual representation to underscore trends and patterns. A narrative analysis will supplement these, offering explanations for discerned trends, corroborated by external sources when needed. The study will culminate in a conclusion that encapsulates the major discoveries and underscores the ramifications of technology and policy on the sector's expansion and metamorphosis.

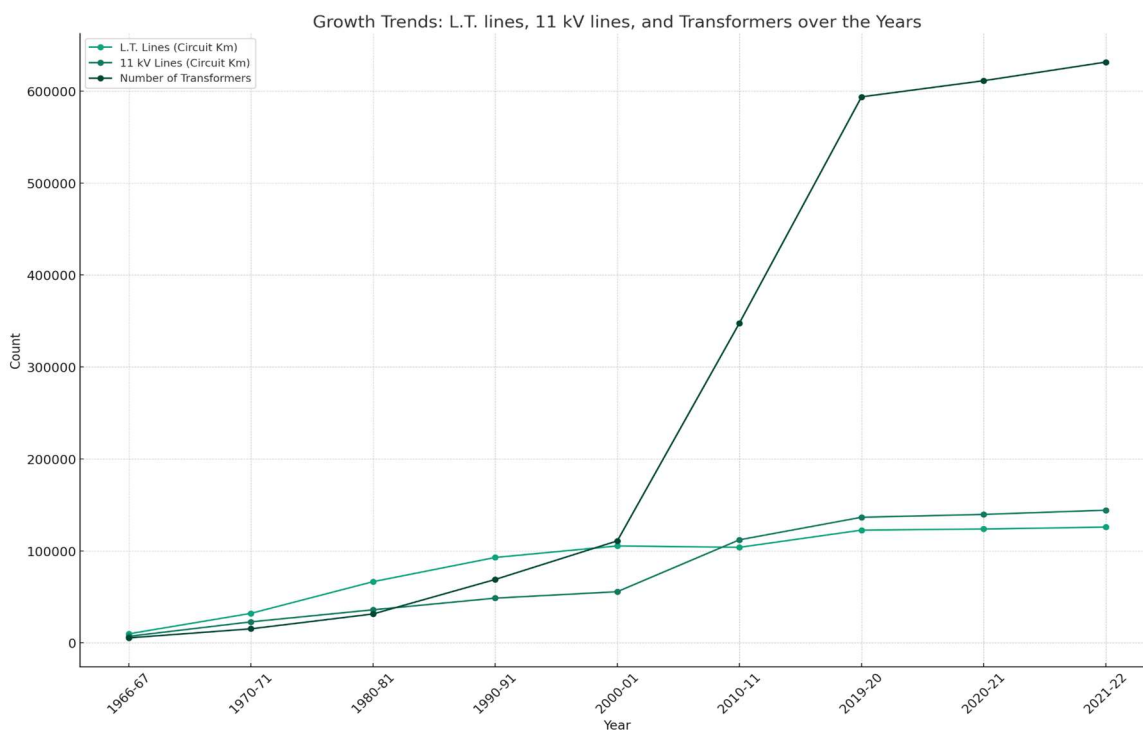
However, like all research, this study might have its limitations, which could stem from potential missing data points or assumptions made during the analytical process. Based on the findings, future strategies and potential areas of augmentation will be recommended. All data sources, including the Statistical Abstract website and other references, will be duly cited to maintain the study's integrity.

## 4. DATA ANALYSIS

### 4.1. Trend Analysis:

#### 4.1.1 Infrastructure Development: Low Tension (L.T.) lines, 11 kV lines, and Number of Transformers over the Years:

Let's plot the growth trends for L.T. lines, 11 kV lines, and the number of transformers across the years.



Source:-Author Calculation based upon Statistical Abstract of Haryana Database

Figure: 4.1

From 1966-67, Haryana embarked on an ambitious infrastructure development journey, making electrical power more accessible to its citizens. The Low Tension (L.T.) lines, which are essential for distributing electricity to domestic and small commercial units, provide an insight into this development. The initial infrastructure stood at 9,796 km in 1966-67. Over the decades, this extended to an astounding 1,25,844 km by 2021-22, demonstrating a growth rate of approximately 1,184.65%. This growth not only indicates the state's commitment to improving electrical infrastructure but also the increasing demand for and reliance on electrical power in everyday lives. The decade-wise distribution showcases the state's consistent effort in network expansion, with every decade recording a substantial increment in the L.T. line circuit length.

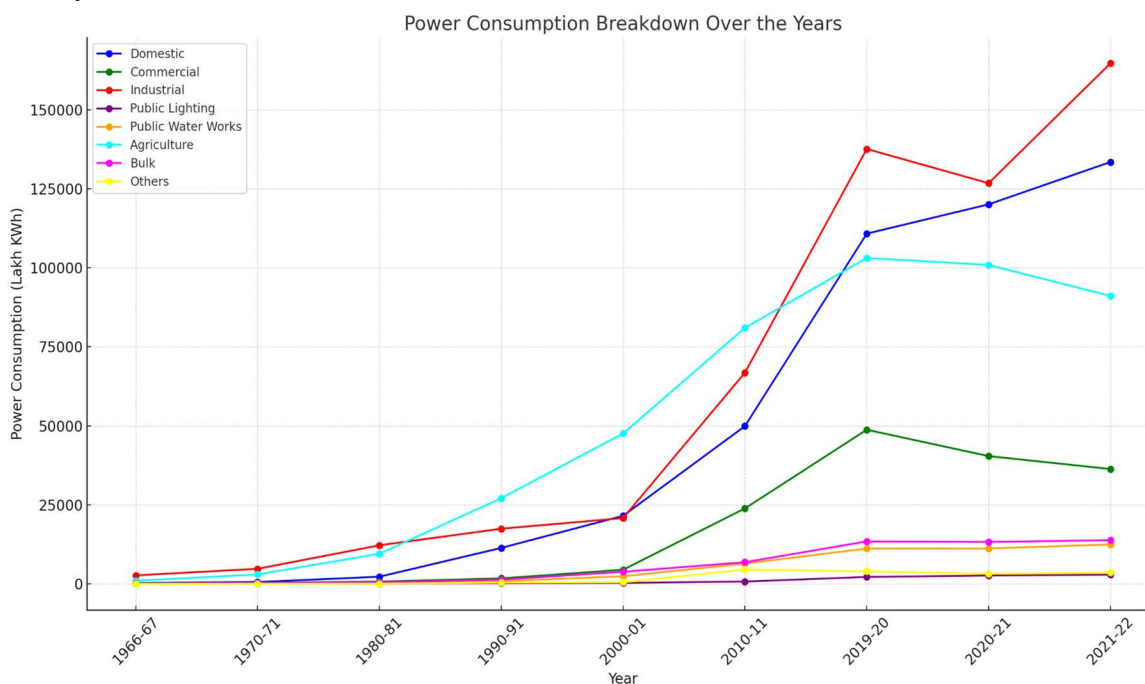
11 kV lines play a pivotal role in the electrical power distribution network, mainly catering to larger consumers and feeding the L.T. distribution network. Their expansion is directly proportional to the growth of industries, large commercial establishments, and urbanisation .

The data shows a growth trajectory from 7,089 km in 1966-67 to a whopping 1,44,244 km in 2021-22, marking a growth rate of 1,934.76%. This tremendous rise signifies the industrial and commercial growth in Haryana, necessitating an enhanced power transmission network.

The decade-wise analysis would reveal periods of faster expansion, possibly correlating with industrial booms or significant urban development phases in the state. Transformers are the backbone of any electrical distribution system, ensuring that electricity is transmitted at appropriate voltages. Their presence indicates the intricacies and spread of the distribution network. Starting with 5,390 transformers in 1966-67, Haryana had a network of 6,31,536 transformers by 2021-22, marking an exponential growth rate of 11,616.81%. This growth is a testament to the state's dedication to ensuring efficient power distribution, even to the remotest areas.

#### 4.2 Consumption Patterns: Electricity Consumption across Various Sectors:

We will analyze the consumption trends for domestic, commercial, industrial, and other sectors over the years.



Source:-Author Calculation based upon Statistical Abstract of Haryana Database

Figure: 4.2

- Domestic Consumption Trend Analysis:** Domestic electricity consumption reflects the living standards, urbanization, and electrification efforts of the state. It encompasses power usage in households for lighting, appliances, and other domestic needs. From 1966-67, the domestic consumption was recorded at 293.56 Lakh KWh. Fast forward to 2021-22, this value soared to 1,33,424.51 Lakh KWh, registering a growth rate of 45,350.51%. Factors such as increased

urbanization, the proliferation of electronic appliances, state's rural electrification initiatives, and overall economic growth contribute to this surge.

- **Industrial Consumption Trend Analysis:** Electricity consumption in the industrial sector provides insights into the state's industrial activities and growth. Higher consumption often correlates with industrial expansion and economic progress. The data reveals that from 1966-67, when the consumption was 2,692.73 Lakh KWh, it expanded to 1,64,644.20 lakh KWh by 2021-22. This growth, approximately 6,014.40%, underscores Haryana's industrial development, making it one of the prominent industrial hubs in the country.

- **Agriculture Consumption Trend Analysis:** Agricultural electricity consumption provides a lens into the mechanisation and modernization of the agricultural sector. With Haryana being a predominantly agricultural state, this metric is crucial. From the data, we see a rise from 985.07 lakh KWh in 1966-67 to 91,075.54 lakh KWh in 2021-22, marking a growth rate of 9,145.59%. This indicates the state's shift from traditional farming methods to modern, electricity-powered agricultural practices.

- **Commercial Consumption Trend Analysis:** The commercial consumption of electricity offers a perspective on the expansion and vibrancy of the commercial sector, which includes businesses, shops, malls, and office spaces. Starting from a consumption of 191.83 Lakh KWh in 1966-67, it shot up to 36,330.25 Lakh KWh by 2021-22. This is an impressive growth rate of approximately 18,896.76%. Such a significant rise underscores the robust growth of the commercial sector in Haryana. This trend can be attributed to the rise of commercial hubs, increased trade activities, and the state's overall economic development over the decades.

- **Public Lighting Consumption Trend Analysis:** Electricity consumption for public lighting reflects the development of public infrastructure, urbanisation, and efforts to improve night-time safety and accessibility. The consumption for public lighting in 1966-67 was 24.59 Lakh KWh. By 2021-22, this number rose to 2,920.28 Lakh KWh, marking a growth rate of approximately 11,868.75%. This sharp increase indicates the vast expansion of urban areas, the development of new towns, and the emphasis on well-lit public spaces for safety and aesthetics.

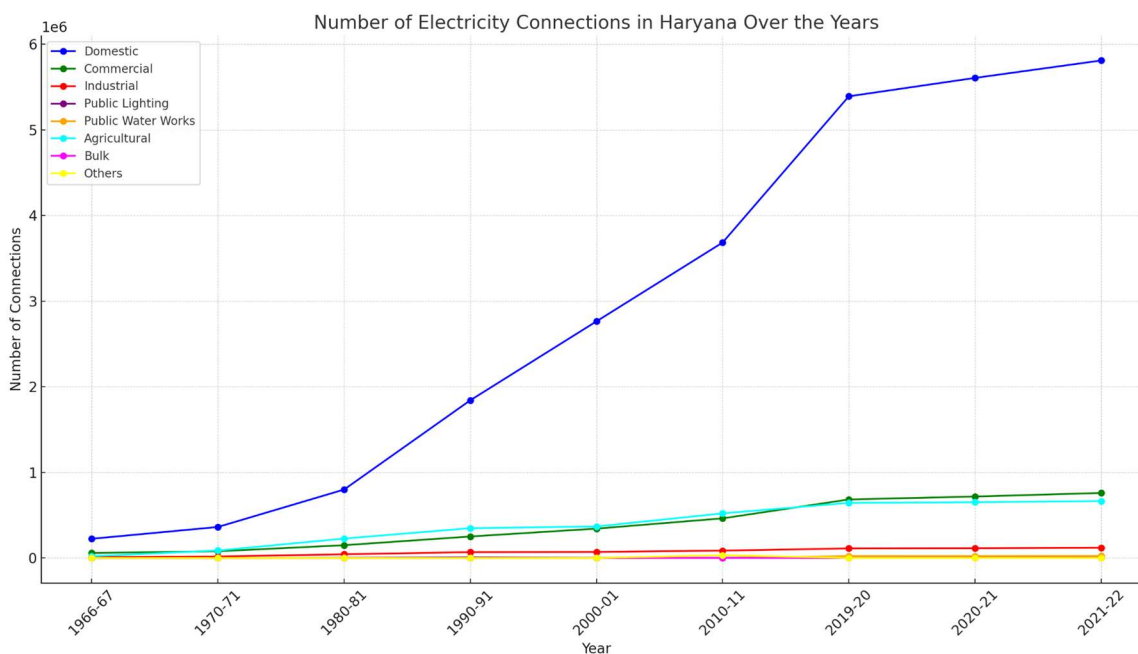
- **Public Water Works Consumption Trend Analysis:** Electricity consumption in public water works provides insights into the state's efforts towards public health, sanitation, and infrastructure development. There was no data for this sector until 1980-81. However, from 1980-81, when the consumption was 186.04 Lakh KWh, it expanded to 12,468.16 Lakh KWh in 2021-22. This growth rate, in just four decades, is approximately 6,698.95%. The remarkable growth indicates the state's endeavors in developing water infrastructure, such as water treatment plants, pumping stations, and pipelines, ensuring better water availability and sanitation for its residents.

- **Bulk Consumption Trend Analysis:** Bulk electricity consumption can indicate the needs of large consumers, possibly big industries or entities purchasing for redistribution. Starting from a consumption of 155.54 Lakh KWh in 1966-67, it reached 13,787.65 Lakh KWh by 2021-22, a growth rate of approximately 8,868.53%. The consistent increase in bulk consumption can be attributed to the growth of large industries or utilities that procure power in bulk. It also reflects the state's industrial policy and the conducive environment for large enterprises.

- **Other Consumption Trend Analysis:** This category may encapsulate miscellaneous or emerging sectors not classified under traditional categories. While there was negligible data for the early years, by 2021-22, the consumption reached 3,572.46 lakh KWh. The growth in this category might be indicative of emerging sectors or specific initiatives not covered under traditional classifications. It's essential to have further details to pinpoint the exact contributors in this category. The comprehensive trends across all sectors highlight Haryana's journey of development, urbanisation, and modernization over the years.

#### 4.3 Growth in the Number of Connections:

Let's assess how the number of electricity connections in different categories (domestic, commercial, industrial, etc.) has grown over the years.



Source:-Author Calculation based upon Statistical Abstract of Haryana Database

Figure: 4.3

- **Domestic Connections:** The trajectory of domestic electricity connections in Haryana offers a comprehensive view of the region's electrification journey. From its humble beginnings in 1966-67 with a total of 2,23,903 connections, there was an exponential growth reaching 58,10,407 by

the year 2021-22. This formidable growth rate of around 2,492% over 55 years is a testament to Haryana's relentless pursuit of electrifying its expanse, both urban and rural. The rise in domestic connections not only signifies the state's electrification efforts but also mirrors the improved living standards, urbanization, and the state's endeavors to ensure every household benefits from the power grid.

- **Commercial Connections:** The commercial sector's electricity connections serve as a barometer for Haryana's economic vitality and commercial vibrancy. Commencing with 57,875 connections in 1966-67, the state witnessed a surge to 7,59,112 by 2021-22, marking a growth of approximately 1,211%. This consistent increment underscores the blossoming of Haryana's trade hubs, businesses, and commercial centers. It's a reflection of the state's robust economic framework, the expansion of the service sector, and the emergence of new entrepreneurial avenues.

- **Industrial Connections:** Industrial electricity connections are the pulse of Haryana's industrial landscape and economic activities. Originating with a mere 9,749 connections in 1966-67, the state underwent a transformation to boast 1,18,801 connections by 2021-22, achieving a growth rate of around 1,119%. This trend is emblematic of Haryana's metamorphosis into a pivotal industrial nucleus of India. The growth is attributed to the state's investor-friendly policies, developed infrastructure, and its strategic positioning that has been enticing for various industries.

- **Public Lighting Connections:** Public lighting connections in Haryana illuminate the state's commitment to urban development, infrastructure augmentation, and public safety. Beginning with 184 connections in 1966-67, the number illuminated to 4,228 by 2021-22. This upward trend accentuates Haryana's dedication to urban beautification, safety initiatives, and the creation of well-lit public spaces, enhancing the nocturnal aesthetics and safety of its towns and cities.

- **Public Water Works Connections:** Electricity connections in the public water works sector underscore Haryana's initiatives in strengthening public health, sanitation, and water infrastructure. Although the initial years saw negligible connections, the sector experienced a noticeable influx, with the count reaching 23,004 by 2021-22. This growth mirrors Haryana's focus on enhancing public water supply, sanitation measures, and its thrust on developing a resilient water infrastructure.

- **Agricultural Connections:** Agricultural electricity connections in Haryana sketch the story of the state's agrarian transformation. From 20,190 connections in 1966-67, there was a remarkable ascent to 6,64,882 by 2021-22, translating to a growth rate of around 3,194%. This trajectory elucidates Haryana's emphasis on modernizing its agricultural practices, from traditional methods to electricity-powered tools and irrigation systems, reaffirming its stature as an agricultural powerhouse.



● **Bulk Connections:** Bulk electricity connections in Haryana provide a lens into the requirements of its substantial consumers, which could be large industries or entities procuring power for redistribution. The progression from just 13 connections in 1966-67 to 1,170 in 2021-22 reflects the state's industrial growth and its capability to meet substantial electricity demands, catering to significant industries or utilities.

● **Others Connections:** The category of 'Others' in Haryana's electricity connections might encapsulate miscellaneous or emerging sectors not classified under traditional categories. While the early years saw minimal connections, there was a discernible increase in recent years, culminating in 1,232 connections by 2021-22. This growth, albeit from a smaller base, hints at emerging sectors or specific state initiatives that are gradually gaining traction.

Each sector's growth narrative portrays Haryana's overarching journey of development, electrification, and modernization over the decades.

#### 4.4 Correlation Analysis:

The correlation coefficient between the growth in LT lines and domestic electricity consumption over the years is found to be approximately 0.185. This value signifies a weak positive relationship between the two variables. In essence, as the expansion in LT lines takes place, there is a modest increase in domestic electricity consumption. While this correlation suggests that infrastructural advancements in terms of LT lines might be aligned with the rising domestic electricity demands, the relationship is not particularly robust. It's imperative to acknowledge that numerous other external factors and variables could be playing a role in influencing these outcomes. Hence, while there's a hint of infrastructural development keeping pace with heightened domestic demand, a comprehensive analysis considering all influencing factors would provide a more holistic understanding.

#### 5. Conclusion:

The power and electricity sectors in Haryana have witnessed profound transformations over the years, as evidenced by the comprehensive data analysis. Several significant findings emerge from the study:

● **Growth in Consumption and Infrastructure:** Over the decades, there has been a massive surge in domestic electricity consumption, increasing from 293.56 lakh KWh in 1966-67 to a staggering 1,33,424.51 Lakh KWh in 2021-22. This growth can be attributed to the rapid urbanization, proliferation of electronic appliances, and Haryana's rural electrification initiatives. Parallely, there has been a consistent expansion in the power infrastructure, with the number of LT lines, 11 KV lines, and transformers all increasing over the years. The growth in LT lines, for instance, has been robust, especially between the years 1966-67 and 1970-71, highlighting the state's commitment to strengthening its power distribution network.

● **Correlation Insights:** The correlation analysis between the growth in LT lines and domestic electricity consumption yielded a coefficient of 0.185. This indicates a weak positive relationship, suggesting that while infrastructural development has somewhat kept pace with the rising domestic electricity demand, other factors too play a crucial role in determining consumption patterns.

● **Impact of Technology and Policy:** The continuous rise in the number of electricity connections, especially in the domestic and industrial sectors, hints at the success of electrification policies and the adoption of newer technologies. The state's initiatives in promoting sustainable and efficient power distribution, coupled with technological advancements, have played a pivotal role in enhancing the power infrastructure.

The significant growth in transformers, essential for efficient power delivery, underscores the technological advancements and investments made in the sector. The state's focus on ensuring stable power delivery has been evident. The decade-wise growth rates, especially the transformative period between 1966-1977, can be attributed to major policy introductions or technological innovations. During this period, there might have been significant policy shifts or technological introductions that catalyzed the growth in the power sector.

In summary, Haryana's power and electricity sectors have evolved immensely over the years. The data underscores the state's efforts in expanding its infrastructure, ensuring efficient power delivery, and meeting the growing demands of its residents. The interplay of progressive policies, technological integrations, and strategic initiatives has been instrumental in shaping the paradigm shift observed in the sector. While correlations provide some insights, a holistic understanding requires recognizing the multifaceted influences of technology, policy, and external factors on the growth trajectory of the power sector in Haryana.

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