Public Energy Infrastructure Development in India: An Empirical Analysis

A thesis submitted to the University of Hyderabad

in partial fulfillment of the requirements for the award of

DOCTOR OF PHILOSOPHY
IN
ECONOMICS

By
MOHAMMED SHAMEEM P
Registration No. 17SEPH09

SCHOOL OF ECONOMICS

UNIVERSITY OF HYDERABAD

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DECLARATION

I, Mohammed Shameem P, hereby declare that this thesis entitled "**Public Energy Infrastructure Development in India: An Empirical Analysis**", submitted by me under the guidance and supervision of Dr. Krishna Reddy Chittedi of the University of Hyderabad, is an original work of research, for the award of the Doctor of Philosophy degree. Furthermore, I declare that it has not been submitted previously in part or full to this University or any other University or Institution for the award of any degree or diploma. I hereby agree that my thesis can be deposited in Shodganga/INFLIBNET.

Date: 12/06/2023

Place: Hyderabad

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CERTIFICATE

This is to certify that the thesis entitled "**Public Energy Infrastructure Development in India: An Empirical Analysis**", submitted by Mohammed Shameem P bearing registration number 17SEPH09 in partial fulfilment of the requirements for the award of Doctor of Philosophy in the School of Economics, is a bonafide work carried out by him under my supervision and guidance. The thesis is free from plagiarism and has not been submitted previously in part or in full to this or any other University or Institution for the award of any degree or diploma. The candidate has satisfied the UGC Regulations of publications and conference presentations before the submission of his thesis. Details are given below.

A. Publications:

1. Shameem P, M., & Chittedi, K. R. (2022). Strides for aberrations: The Electricity (Amendment) Bill, 2021 of India. Energy Policy, 165, 112957. DOI: https://doi.org/10.1016/j.enpol.2022.112957.

B. Presentations at conferences:

1. "Public Infrastructure Development and Energy Consumption: A Study on The Indian Transport Sector" at Singapore Economic Review Conference (SERC) co-organized by Nanyang Technological University held from 1 to 3 August 2022 at the Hilton Orchard, Singapore.

2. "Emprising Revival of Telangana Power Sector: Analysis from an Indian state", 4th APEEN Conference on Energy Demand-Side Management and Electricity Markets. Organized by the Department of Management and Economics and GAPEER in association with the International Association of Energy Economics at the University of Beira Interior, Covilhã, Portugal from 17-18 October 2019.

Further, the student has passed the following courses towards the fulfilment of the coursework requirement for Ph.D. He was exempted from doing coursework (recommended by the doctoral committee and the Dean) on the basis of the following courses passed during his M.Phil. program at the School of Economics, University of Hyderabad.

Course Code	Course Title	Credits	Pass/Fail
EC-701	Advanced Economic Theory	4	Pass
EC-702	Social Accounting and Database	4	Pass
EC-703	Research Methodology	4	Pass

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Public Energy Infrastructure Development in India: An Empirical Analysis

ABSTRACT

The endeavours to enrich the infrastructure entitlements of people are associated with development planning in India. The endorsement of the centrality of energy infrastructure as an imperative structure for the operation and development of the economy opens different realms of research and discussions. This thesis is a collection of independent articles which studies different fundamental aspects of energy infrastructure development in India with different orientations. The second chapter examines all key aspects of the public sector-led development of Energy Infrastructure in India, including trends in public spending of union government and states, sector-wise evolution, capacity addition and growth for Coal, Electricity, Petroleum and Natural gas sectors from 1990 to 2020. The study reveals that the country recorded a significant and steady improvement in energy infrastructure in the study period. After the slow growth of public spending in the first decade, at the cost of simulating private investment, an increasing trend was attained by all three major energy sources, which was accelerated in the 11th five-year plan period. The study argues that the shift from capital expenditure-led growth in energy infrastructure development expenditure to a revenue-driven trend is cautious.

The third chapter provides a sectoral analysis to validate the economic output's reliance on the power sector in India. Based on the combined co-integration test and Frequency domain causality techniques, uni-directional causality from three sectors to economic growth has been observed at least in a frequency of short- to medium-run and states the Growth hypothesis in India. The negative relationship between agriculture consumption and GDP growth raises multiple questions, where the productivity-enhancing role for the industrial and service sectors was expected. The fourth chapter discusses the existing regulatory framework of the Electricity sector and the long-standing demand for holistic reform. The provisions of the proposed Electricity Amendment Bill (EAB) 2021 by the government of India are examined based on potential implications for different stakeholders. The paper found that persisting crisis in the operations of the current regulatory paradigm in the electricity sector deserves a comprehensive renovation, but the abortive approach of the Bill on certain critical issues of the sector needs to

be addressed, especially regarding electricity pricing, subsidy system and limits of the existing quasi-federal system in India.

The underlying purpose of the fifth chapter is to dissect the transport infrastructure performance, public spending in transport infrastructure development and the manufacturing sector in determining the transport sector energy consumption in India. The study employed the ARDL bounds test approach along with FMOLS, DOLS, and CCR methods to explore the interdependencies among the sectors. The results of the ARDL bounds test established the presence of the long-run and short-run relationships among studying the study variables. The results of FMOLS, DOLS, and CCR methods show that transport infrastructure performance reduces transport energy consumption. Further, the inference of the positive impact of value added in the manufacturing sector on transport energy consumption validates the higher energy demand of the manufacturing sector from a mobility perspective.

The state-level assessment of energy infrastructure development was the central theme of the last two chapters. The electricity consumption of the agricultural sector in the state of Telangana is discussed at the macro level in the sixth chapter. Trend analysis of energy infrastructure development in the state, the trends in agriculture electricity demand and supply situations with evidence from all India input survey and econometric analysis (co-integration test and causality tests) of a long-run equilibrium relationship between agriculture output and electricity use in the state endorsed the state government's effort in the electricity sector since state formation. Against this backdrop, an appraisal of 24 hours free electricity program in Telangana reassesses preconceived notions about farmers' attitudes towards the habituated production input subsidies. The study concludes that farmers initiated the structural changes needed to implement the program from their side by changing their equipment and found significant changes in the attitude of farmers towards the freebie, like free electricity, along with concern for the sustainability of the program.

JEL: H1, H5, H7, Q4, R4

Keywords: ***Energy infrastructure, Electricity consumption, Transport Energy consumption, Electricity sector reform, Freebies, Telangana.***

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
ARDL	Autoregressive distributed lag
AT&C	Aggregate Technical and commercial
DISCOMs	Distribution Companies
EAB	Electricity (Amendment) Bill, 2020
ECEA	Electricity Contract Enforcement Authority
FMOLS	Fully Modified Ordinary Least Square
GDP	Gross Domestic Product
GSDP	Gross state domestic product
IEBR	Internal and Extra Budgetary Resources
MW	Megawatt
NDA	National Democratic Alliance
ONGC	Oil and Natural Gas Corporation
PCA	Principal Component Analysis
SEBs	State Electricity Boards
TSGENCO	Telangana State Power Generation Corporation Limited
UDAY	Ujwal DISCOM Assurance Yojana
UPA	UPA United Progressive Alliance
WDI	WDI World Development Indicators

Chapter 1

INTRODUCTION

1.1. Introduction

The basic provisions to rejoice real development of any region are primarily based on the infrastructure entitlements of those in that region. Based on the broader classification of infrastructure into social and physical, the existence of superior infrastructure facilities will facilitate the holistic development of the people. Physical infrastructure, including transportation, power, communication, etc., serves as the basic physical structure for the functioning of the economy. In contrast, social infrastructure, such as health, education and other community services, nurtures people to attain a higher quality of life. The direct and indirect effects of these Infrastructures on the economic activities of a region will determine the level of glory that can be attained. Physical infrastructure generally contributes to the output directly as part of the production process as an intermediate public good. The quality and availability of reliable infrastructure will indirectly motivate individuals and firms to choose that particular region for their activities (Lall, 1999). The existing literature endorses the impact of infrastructure on different economic development and well-being indicators. The direct and indirect role of infrastructure in determining the level of macro-economic growth and industrial investment (Dutta et al., 2007), agricultural productivity (Jha & Acharya, 2011), human capital development (Agrawal, 2015), poverty reduction (Ravallion & Datt, 1996) and economic recovery post-crisis like covid-19 pandemic (Krishna & Mukherjee, 2021) are even observed for emerging economies like India at both national and sub-national level.

Realising these influences, infrastructure development always stays a top priority for modern economies beyond their ideological dissimilarities on the concept of welfare. The infrastructure investment possesses distinctive characteristics that incite different questions on its governance, impact and institutions involved. The macroeconomic impact of infrastructure investment is basically through providing enhanced infrastructure services and demand-side endowments. Nevertheless, the features like high initial fixed investment, prolonged construction, planning, payback period, or generally long gestation period make them financially non-viable in countries like India in its developmental phase. Here the role of public infrastructure investment emerges, and planning for them becomes critical. Indian experiments with these infrastructure investments evolved over the years from a socialist approach to an aggressive liberalisation phase since 1991. The decline in infrastructure performance and development post-liberalisation impelled policymakers to mould the existing system where public and private investment contribute concurrently (Patel & Bhattacharya, 2010).

Energy infrastructure is a sub-sector in the physical infrastructure that is imperative for the operation and development of all other sectors. A broader definition of energy infrastructure will be the physical installations and assets involved in a region's production, transportation, transmission, and distribution of energy. From providing reliable energy services to reducing energy poverty, the objectives of energy infrastructure are broad, and it functions with a complex and multi-layered set of institutions, regulations and policies (Majumder et al., 2022). The dependence of economic activities on modern forms of energy like coal, oil and electricity intensifies as the economy transforms to a higher level of development. Thus, the development of energy infrastructure attracts the continuous attention of policymakers to serve the ever-growing energy demands of the economy. Since independence, the development of energy infrastructure in India includes enhancement of energy supply infrastructure, demand-side management through different programs, and evolution of regulatory framework which thrives for an efficient and competitive market. The energy infrastructure development and planning need a polycentric approach that can simultaneously serve the needs of struggling rural agrarian households and cater to aspirations of a five trillion-dollar economy.

1.2. Context of the study

The theoretical and practical propositions of operation, development, and different stakeholders in the energy infrastructure sector are complex where contextualisation is essential. Placing energy infrastructure in the restrained scope of infrastructure in the growth theories as an input in the production function and explicitly recognising it as a common pool resource is the starting point of this complexity. As one of the world's largest democratic countries with quasi-federal governance established by a written constitution, the holistic governance of energy infrastructure has become intriguing. The independence achieved due to decades of anti-imperial nationalist movement ensured India's core sectors, including energy, were under state control. The publicly owned and operated energy infrastructure was an ingrained feature of the state-led economic development approach. The changes in domestic and global factors related to the sector in the mid-1980s compelled the government to reshape the existing system. The period from 1990 to 2020 is thus marked by the efforts of the Indian government to redefine and restructure the energy infrastructure in the country. This offers an exciting research context for studying a rapidly evolving sector.

Despite different energy sources, this study mainly concerns electricity, coal, oil, and gas based on their relative higher importance in India. The interdependence among these energy sources also brings a new investigation arena. These three sources' significant stakeholders in the energy sector are Central government ministries and corporations, State government departments and corporations, private sector licensees, and independent players.

The context of this research will be based on three major threads. It begins by examining energy infrastructure development in India's last 30 years of planned liberalisation. The energy infrastructure sector needs more attention from academia and the public policy domain for the long term. The complexities in and around the sector can be a reason for the absence of comprehensive studies. This study will be a comprehensive attempt to understand the existing energy infrastructure in India at both macro and micro levels.

The second strand is with an objective to track the evolution of the energy sector in the last 30 years with a particular focus on transformation guided by the economic restructuring policies since 1991. This will be based on the argument that the developmental trajectory of the sector did not follow a monotonous division by the liberalisation policies of the early 1990s. Instead, it experienced a failed phase of private financing propelled by the liberalisation policies, which later evoked high public spending in the sector, concurrently encouraging private investment. Here the final thread in the context of the study begins. The predominant role of the public sector in energy infrastructure was not seriously altered or challenged in the last 30 years. However, the sector's public spending level has significantly increased over the year. Considering the growth of public expenditure, both current and capital expenditures, the final 12th five-year plan was multi-folded than the one before. This increased spending is mainly driven by different programs in the sector to enhance supply capacity, rural electrification, and other demand-side management. Public expenditure growth always opens discussion in a dynamic domain where different components, such as productivity, sustainability etc., are relevant (Marjit et al., 2020). Beyond the natural progression in the public expenditure level, the programs led by populism also enter the discussion as subsidies and freebies are inevitable in energy policy in India. The government's growing involvement in these endeavours will result in an increase in the amount of public spending.(Seshaiah et al., 2018). This study will incorporate this aspect also where a state-level analysis is conducted.

1.3. Research Questions

1. Did the energy infrastructure develop significantly after the 1991 economic reforms?
2. What kind of relationship exists between the output of India's basic economic sectors and the use of electricity?
3. How will the proposed Electricity Amendment Bill (2021) will change Indian power sector?
4. What is the level of interdependence between public transport infrastructure investment performance of transport infrastructure, and manufacturing sector on transport sector energy consumption in India?
5. Are the electricity and agricultural sectors significantly related in Telangana state?
6. What is the farmers' perception of Telangana state's 24-hour free electricity program?

1.4. Objectives

1. To analyse the key aspects of India's energy infrastructure development since planned liberalisation in 1991.
2. A sectoral analysis to provide additional validation for the reliance of economic output on the power sector in India.
3. To evaluate the proposals of the newly proposed Electricity (Amendment) Bill, 2021, by the government of India.
4. To analyse India's transport sector energy consumption based on interdependence between transport infrastructure performance, public expenditure in infrastructure development, and manufacturing sector output.
5. To analyse trends and the future of Agrarian electricity needs development in Telangana.
6. An appraisal of 24 hours free electricity program in Telangana state of Southern India from the perspective of farmers at the receiving end.

1.5. Data and Methodology

1. Examines all significant aspects of public spending in India's Energy infrastructure growth, such as trends in public spending of union government and states, sector-wise capacity addition and growth for Coal, Electricity and Petroleum and Natural gas from 1991.
2. The combined co-integration test and Frequency domain causality techniques are used on annual data of real GDP per capita and sectoral level power consumption from 1971 to 2019.
3. An interpretive policy analysis of five provisions in the proposed Electricity (Amendment) Bill, 2021 and a Policy field analysis to identify major players and the relationship between them in the sector after the full implementation of the amendments.
4. An examination of India's transport energy consumption in connection to the transport infrastructure performance, public investment in the infrastructure, and manufacturing sector production was carried out using annual data from 1987 to 2019.
5. Trend analysis of energy infrastructure development in the state of Telangana post state formation, the trends in agriculture electricity demand and supply situations with evidence from all India input survey and econometric analysis (Johansen's co-integration test) of a long-run equilibrium relationship between agriculture output and electricity use in the state.
6. Assessment based on a primary survey conducted in the Nalgonda district of the state after the completion of three years of the program.

1.6. Structure of Study

The thesis is structured as a collection of independent articles which studies different aspects of energy infrastructure development in India with different orientations. Thus, each chapter will have its independent structure, including an introduction, review of literature, analysis and discussions and finally, the conclusion and policy discussions.

The introduction chapter is followed by the study of public spending in energy infrastructure development in India after 1991. The second article will discuss the demand side perspective of the energy sector in India at a sectoral level. The third chapter discusses the institutional framework of the electricity sector management in India, where the upcoming electricity amendment bill is extensively examined. The final chapter in this series with the macro-orientation is the fourth article, where the dynamic relationship between transport sector energy use, performance of transport infrastructure and public investment in transport infrastructure is studied. The second set of articles in the thesis is focused on the energy sector of Telangana, the youngest independent state of India, formed in 2014. The fifth article comprehensively assesses the agrarian power demand of the state. The following chapter's objective is to appraise Telangana's much-celebrated 24-hour free electricity program, a first-of-its-kind program in independent India. The final chapter will briefly summarise each article with concluding remarks.

1.7. Limitations

Analysing the growth of India's energy infrastructure since 1991 is the fundamental objective of this study Energy infrastructure development is one of the most complex sectors in India in terms of its institutional existence, management and operation, from the constitutional placement as a subject in the concurrent list where both union government and state government shares responsibility for diversity and differentiated evolution of different energy sources. Against this backdrop, this study had to pitch research gaps from areas not excavated and areas with future orientation. Secondly, the electricity sector has been predominantly the area of discussion in this study as it is the most popular and common form of energy used by people. Thus, despite the importance of other energy sources like coal in the Indian energy sector, this study must focus on electricity in most articles.

Thirdly, the third article in the thesis is based on the Electricity (Amendment) Bill, 2021, as the legislative efforts for electricity sector reforms in the form of amendments to the existing Electricity Act failed multiple times. This bill also may get altered by the time of implementation. Thus, this study intended to become part of the literature as a reference for the 2021 version of the Electricity (Amendment) Bill for future studies. Further, each chapter incorporates future studies' objectives, limitations, and scope for better conception.

Chapter 2

A REVIEW OF PUBLIC SPENDING ON ENERGY INFRASTRUCTURE DEVELOPMENT IN INDIA SINCE 1991

2.1. Introduction

The infrastructure entitlements will serve as the foundation for prosperity and will be multi-dimensional. The economic perspective of infrastructure development of a region is essentially related to improved growth and efficiency, thus, a better quality of life in the long run (Han et al., 2021). The positive impact of higher infrastructure facilities on macroeconomic variables such as growth, employment, productivity etc., to poverty reduction and rural development, are found empirically significant for developing countries like India (Dash & Sahoo, 2010; NCAER, 2007). Beyond formal classifications into physical (such as roads, transport, energy, telecommunications) and social infrastructure, the development of these basic structures will deliver in the short run as well as long run (mostly for social infrastructure like health and education) in terms of efficiency, saving of input costs, enhanced productivity and stimulates economic activities (Lall, 1999) (Lal, 2007).

The endorsement of the centrality of infrastructure initiates the discussion on who will provide this in an economy. Public infrastructure investment and development occupy a crucial position in policy-making tables as they will shape the long-run behaviour of an economy (Ghosh & De, 2005; Saxena et al., 2018). Even though the theoretical and empirical debate on the size and composition of public infrastructure spending continues, it is considered a major productivity expenditure of the Government of India after the 1991 Economic reforms. Most macroeconomic stimulus packages also incorporated infrastructure spending as a significant booster to stimulate the economy (Ramey, 2020). The National infrastructure pipeline (NIP) project of the Government of India for the period of 2020-25 FY to boost infrastructure development in the country and a post-Covid recovery measure. The infrastructure sectors hold a major share in the NIP, such as roads 18%, railways 12%, urban infrastructure 17%, and energy 24% in the total plan.

The energy infrastructure possesses a distinct importance by its nature as the universal application of energy input in all economic activities. The complementarity with other infrastructures also makes energy infrastructure pivotal. The physical structures involved in the production, transportation, transmission and distribution of energy are included in the broader definition of energy infrastructure (Majumder et al., 2022). The literature and public policy discussions confined to energy infrastructure are limited to demand and supply management, project development, pricing mechanism and distribution which is also conditioned by the level of development in the study region.

In theoretical discourse, it is noteworthy that development economist Hirschman explained the significance of energy infrastructure as expanded access to transport infrastructure and electric electricity are necessary prerequisites for economic development almost everywhere. In the Indian context, the major infrastructure development impelled by the government of India after independence was in the energy infrastructure sector during the late 70s in response to repercussions of the second oil shock by increased oil production and related activities (De, 2008). The evolution of public investment and administrated energy infrastructure development in India has passed different episodes, striving to challenge many supply and demand barriers. The economic restructuring efforts since 1991 have redefined the instrumental role of government in developing infrastructure in the country (Nagesha, 2018). The economic reforms expected more influx of private investment in infrastructure development, but the delivery needed to be better, as infrastructure investment - GDP ratio and rural infrastructure development slackened. Thus, even though India moved from a socialistic approach of pure public-driven infrastructure development, the proactive responsibility of the government was persuaded over the years (Patel & Bhattacharya, 2010). The achievement in terms of access (rural electrification), availability (generation capacity) etc., in these years is the result of this public expenditure in the energy infrastructure development. The present study is to review the main features of energy infrastructure developments in the planned liberalisation of the Indian economy since 1991. In the post-liberalisation period, domains of public expenditure have been restrained to many sectors, including infrastructure development. But the underdeveloped energy infrastructure in the country was in need of public investment to develop and serve the energy requirements for private sector-led economic growth (Agrawal, 2015). In this context, a comprehensive appraisal of public spending in the energy infrastructure of India is attempted.

The study is structured as the next section reviews the major literature in the domain. The following sections will discuss the appraisal criteria of public spending, trends in public spending in energy infrastructure and sector-wise development since 1991 in separate sections. The final section will conclude the significant findings of the study.

2.2. Review of Literature

The inviolable role of infrastructure development has fostered significant research in the area, but public energy infrastructure development remained an under-focused field in theoretical and empirical research. The failure of both energy (as an input) and energy infrastructure (as an institution) as a self-standing factor in traditional growth theories can be the reason behind this (Carlsson et al., 2013). Considering that, a deductive approach is needed to institute the existing literature for the current study. This will include studies on the relationship between public expenditure and economy, infrastructure development and economy and finally, public infrastructure development and economy. The major theoretical proponents of the relevance of public expenditure were Adolf Wagner and John Maynard Keynes. Wagner's proposition on the increased extension of state activity and Keynesian expansionary fiscal policy signifies the public expenditure for the economy. The endogenous growth theory (Romer, 1994) incorporated the public spending on infrastructure investment, human capital and technology has a positive impact on economic growth (Tanzi & Zee, 1997). Based on endogenous growth theory (Barro, 1990) explained that government expenditure enhances economic output by improving labour productivity. But the empirical evidence about the impact of public expenditure needs to be more conclusive as there are studies countering the positive effect (Devarajan et al., 1996; Evans & Karras, 1994). In the case of India, most of the studies validate the positive effect of public spending on economic growth. For the period 1973-2012 (Srinivasan, 2013) found evidence for Wagner's law using the co-integration and error correction model. The study concluded both the short and long-run relationship between public expenditure and economic growth in India. Unidirectional Granger causality was estimated from total public expenditure (TPE) and Gross Domestic Product (GDP) per capita (Gangal & Gupta, 2013) for the period of 1998 to 2012. The vector error correction model was employed by (Medhi, 2014) using annual data from 1974-2010, validating the applicability of Wagner's law in India. The study by (Seshaiah et al., 2018) examined this relationship, including two dummy variables to capture the nature of the relationship between the financial crisis of 2008 and the economic reforms in 1991. According to the study, general government spending had a favourable and considerable impact on economic growth, but after the 2008 financial crisis, this link shifted to the downside. To conclude, in the discussion about the effect of government spending on the economy, there is a conscience that public spending on infrastructure development like roads and railways, power generation, irrigation, telecommunication, etc., is imperative for emerging economies to accelerate economic growth (Sasmal & Sasmal, 2016).

Here the second layer of literature related to this study is pitched. Employing different empirical methodologies, types of data and forms of infrastructure, the impact of infrastructure on macroeconomic variables is studied. Based on the state-level analysis, (Agarwalla, 2011; Dutta et al., 2007) explained that the development of economic infrastructure determines the level of investment and productivity of the industrial sector in 14 states. The impact of infrastructure development on agricultural productivity was confirmed by (Zhang & Fan, 2004) in their study applying a dynamic GMM estimator district-level panel data from 1971 to 1994. These findings were further substantiated by the study (Dash & Sahoo, 2010) that examined how India's physical and social infrastructure influenced economic output from 1970 to 2006 using the Two-Stage Least Squares (TSLS) and Dynamic Ordinary Least Squares (DOLS) methodologies. The estimated results found that infrastructure supplements rural development, poverty reduction, agriculture development, and regional development. Additionally, Kumari and Sharma (2017) showed that India's social and economic infrastructure is positively connected with economic growth using vector autoregression and Granger causation models. The poverty reduction effects of infrastructure development were examined by Chotia & Rao (2017). The results of the Autoregressive distributed lag (ARDL) bound test indicate that economic growth and infrastructural development mitigate poverty in the short and long run. The causality test reveals that, between 1991 and 2015, infrastructure development and poverty reduction have a positive and unidirectional causal relationship. R. K. Mohanty & Bhanumurthy (2019) used Principal component analysis and created two indices of physical infrastructure and financial development, and the correlation between them was calculated from 1980 to 2016 using Autoregressive distributed lag and the Toda-Yamamoto causality techniques. The empirical findings point to a causal relationship that runs in both directions, with physical infrastructure having a favourable both a long- and short-run significance for economic growth.

The integration of these two disparate discussions in the literature was forwarded by the seminal work of Aschauer (1989), in which the argument favouring the positive influence of government investment on the economy was empirically estimated. Aschauer (1989) studied the US economy's annual data for the years 1949 to 1985 and revealed that investments in public infrastructure, such as roads, airports, and water management systems, are crucial for determining productivity and growth. Following this conclusion, Munnell (1990) estimated the effects of total public capital on the output and productivity of the private sector. He found that a 1% increase in public capital stock would result in a 0.34 % increase in output, estimating the marginal productivity of private capital to be around 30%. The fundamental purpose of public sector involvement in infrastructure development can be explained in many ways such as Hirschman's idea of "Backward and Forward Linkages". He asserts that building any infrastructure will result in an increase in the demand for labour, land, and other "heavy" capital products like cement, iron, and steel, among other things. The second wave of employment creation and income generation will happen when this infrastructure supports economic activities (Krishna & Mukherjee, 2021). From a public policy perspective, the welfare state objective of any government will push for infrastructure developments as they are treated both as social equaliser and market failures. The first is connected to the goal of redistribution, which penalises efficient individuals. The second rationale for government intervention, especially in LDCs, is from the possibility that markets may not result in an efficient solution (Ghosh & De, 2005). In operation, this public capital expenditure positively affects the provision of infrastructure in the region, and further, the impact will be multi-phased. In the Indian context, Marjit et al. (2013) found that capital expenditure on infrastructure significantly impacts per capita income. In addition, public capital expenditure will attract private investment into the infrastructure sector (Mallick, 2013; Okolo et al., 2018) and thus will correct regional imbalances (Mohanty et al., 2017).

The New Economic Policy of 1991 marked the transition of the Indian economy to an era of liberalisation where the government started withdrawing from many sectors. The central role of the public sector in the development and operation of many sectors, including infrastructure, was compelled to be compromised because of inefficiency, mounting fiscal deficit and inability to provide adequate infrastructure services for the economy. Nevertheless, this reform period did not follow a monotonous path as such a withdrawal of government was not easy because of many factors. The effects of the reforms of 1991 on public expenditure in 15 central States were evaluated by Chakraborty & Zhang (2009). Using panel data from 1987–88 to 2002–03, the study estimated fixed effects models to examine both the pre- and post-economic reforms era. The study concluded that public investment spending on infrastructure declined steadily across States post-1991. Starting from the early 1990s, the capital spending to GDP ratio decreased and levelled off in the second half of the decade. But that began to rise from 2002–2003.

Infrastructure sectors, including national highways, ports, airports, power, and urban infrastructure, have lured private sector investments through PPP models during the liberalisation period. However, government participation was inevitable because PPP investments were concentrated in high-value locations. At the same time, less lucrative regions like the North East and project types like water and wastewater and other social sectors still needed to attract sufficient private sector participation. (Patel & Bhattacharya, 2010; Planning Commission, 2008, 2013) The vector error correction model (VECM) and Johansen's co-integration test-based analysis by Unnikrishnan & Kattookaran (2020) for 1961–1962 to 2016–2017 found that both public and private infrastructure investments significantly impact the Indian economy.

The discussion on public spending in India is incomplete without understanding the evolution of the nature of public expenditure shaped by concurrent governments and revamped planning objectives. A study on capital expenditure and revenue expenditure in India Marjit et al. (2013) found that capital infrastructure development spending boosts economic growth, while revenue spending has a detrimental effect on per capita income. This conclusion is further supported by Giri & Mohapatra (2016), who claim that revenue spending and non-developmental spending have no discernible impact on India's economic growth. Marjit et al. (2013) also explained the rise of public borrowing in India to finance unproductive populist schemes has reduced fiscal space for capital spending like infrastructure development.

In the trend analysis for the period 1986–1987 to 2018–2019, Karnam (2018) observed that revenue expenditures had increased faster than revenue receipts, which resulted in high revenue deficits. This study also points out that the size of capital expenditure has been shrinking over the years as the share in GDP has declined sharply from 7.09 to 1.6%. The quarterly data-based Structural Vector Auto-Regression (SVAR) model estimated by Goyal & Sharma (2018) analysed capital and revenue expenditure multipliers. The estimated results showed that the long-run capex multiplier remained significantly greater than the equivalent revex multiplier in all of the estimations. Additionally, capex significantly impacts output and, over time, mitigates inflation, whereas revex pushes the price level. The state-level evaluation of the composition of public expenditure and its impact on per capita income by Marjit et al. (2020) also followed similar conclusions. The results reiterated the significance of public spending on infrastructure and capital expenditure as they exert positive effects on per capita income. Despite having a negative impact on growth, the study also revealed that all states have seen a rise in the proportion of revenue expenditures in overall government spending.

As mentioned, the literature on public spending on energy infrastructure development in India is very limited. Even though in the discussion on infrastructure development, Hirschman validated the need for energy infrastructure development; the literature is not rich enough. Most of the existing empirical studies are on the modelling of broader infrastructure development (mostly based on developing indexes) where the energy sector is included as one variable. The relationship between energy infrastructure and macroeconomic variables can be deducted from these studies. In order to inquire how India's economic growth and physical infrastructure development are related, Sahoo & Dash (2009) developed a comprehensive infrastructure stocks index. According to the estimated results, energy is one of the key infrastructures contributing most to growth. The findings of the causality tests revealed a one-way causal relationship between infrastructure development and output growth, with infrastructure development significantly contributing more to economic growth than both private and public investments. Based on annual data from the six key infrastructure-related subsectors of transportation, education, sports, the arts, and culture, energy, health care, telecommunication, and water supply and sanitation, Saxena et al. (2018) explored the effects of public infrastructure investment on 28 state economies of India. The study based on state-level public spending in these sectors and revenue generated found that the state of Gujarat is the most energy-efficient state.

The evolution of energy infrastructure development after 1991 was assessed by Patel & Bhattacharya (2010), who stated that despite encouragement by the governments, private sector growth in the sector has been below expectations. However, the time period featured significant investment in captive generation; from 1986–1987 to 2006–2007, the average annual growth rate for captive facilities was above 16%. According to Majumder et al. (2022), the huge lump sum investment and long gestation period in the development of energy infrastructure like power plants, distribution lines, and transmission structures, thus necessitates long-term planning and state presence.

The present study attempts to evaluate the nature and trends in public spending for the development of energy infrastructure in India after 1991. The contribution of this study to the literature will be primarily the precise focus given to energy infrastructure from a public finance perspective. The novelty of this study is in its approach of appraisal by both dissecting the public expenditure in state and union finance and the sector-wise assessment. The analysis of three major energy infrastructures (i.e., Electricity, Coal, Petroleum and Natural gas) based on different parameters of structural development and achievements since 1991 will open up a new realm for future studies.

2.3. Trends in Public Spending on Energy Infrastructure

The first elemental question in any appraisal activity is regarding the appraisal criteria. It basically decides on what criteria the study variables are analysed and judged. Understanding the structure of developmental planning in India will be the foundation for this exercise. India, after its independence in 1947, adopted the socialist model of centralised planning by forming a Central Planning Commission. This Commission was assigned to formulate five-year plans which will serve as an underline structure for development planning in the country. India, as one of the largest democratic countries, has elected government for five years at both the sub-national level as a state government and the national level as a union government. This government works on budget and other scheme-based development planning. Thus, there are two streams of policy formulation for economic development in the country, where governments are guided by people's mandate as periodic elections and planning commission, which exist as an arm for the union government for designing long-term growth paths. In 2014 the planning commission was replaced by NITI Ayog, and the system of the 5-year plan has been moved to annual planning.

In the study period of this study, six governments completed their 5-year tenure and six 5-year plans were completed (See Table 2.1). There were three short-lived governments formed between 1996 and 1999, and instead of a 5-year plan, annual plans were adopted between 1990 to 1992 period and post-replacement of the planning commission. Even though in operation, government policies and five-year plans are interrelated and the distinction in principle notion is thin, their independence is relevant. In the study period, mainly two alliances led the union government in India, the centre-left United Progressive Alliance (UPA) from 2004 to 2014 and the rest by centre-right National Democratic Alliance (NDA). It should be noted that only 11th Five-Year Plan (2007 to 2012) was the only plan that was under the supervision of one government, whereas the rest of all five-year plans were managed by different governments.

Table 2.1 Appraisal Criteria

GOVERNMENTS			FIVE-YEAR PLANS	
Lok Sabha	**Commenced date**	**Prime minister**	**Five-year plan**	**Duration**
Tenth	June 1991	P. V. Narasimha Rao	Annual Plans	1990-92
Thirteenth	October 1999	Atal Bihari Vajpayee	Eighth Plan	1992-97
Fourteenth	May 2004	Manmohan Singh	Ninth Plan	1997-2002
Fifteenth	May 2009	Manmohan Singh	Tenth Plan	2002-2007
Sixteenth	May 2014	Narendra Modi	Eleventh Plan	2007-2012
Seventeenth	May 2019	Narendra Modi	Twelfth Plan	2012-2017
			Annual Plans	2017-2019

Sources: Author's compilation

The foundational evaluation of public spending in energy infrastructure in India can be based on the combined budget transaction of the union government and state government (combined revenue and capital expenditure). The public expenditure on the energy infrastructure comes under the category of development expenditure (Source: Various editions of Indian public finance statistics published by Ministry of Finance Department of economic affairs, Government of India). The government expenditure on the socioeconomic development of the country is listed under these categories, such as housing, education, agriculture, transportation and communication. To begin with an abstract assessment, it is evident from Figure 1 that both on the basis of the five-year plan and year-wise data, an expansionary growth path has been followed by public spending in energy infrastructure development since 1991. Figure 1(A) shows that from 1991-91 to 2000-01 there is a stable trend which started increasing thereafter. The 2000-2010 decade experienced steady growth, which includes a surge in 2002-03 and 2007-08. This growth trend entered an acceleration path from 2014-15, which can be attributed to increased public spending through new infrastructure development programs. Figure 2(A) shows steady growth in energy infrastructure development spending in each five-year plan. The 10th five-year plan marked the new chapter of increased public spending in the sector. This reached the highest level with the 12th Five Year Plan, where macro-economic stimulus spending post-global financial. The crisis of 2008 was included.

Figure 2.1(A):Public Spending in Energy Infrastructure (Annual)

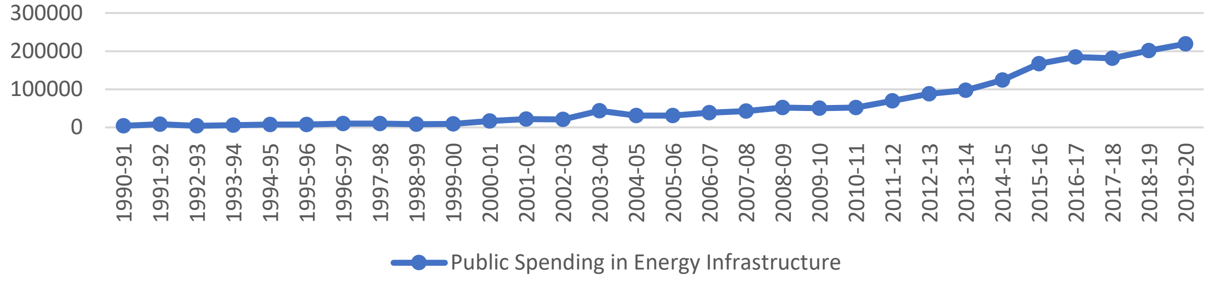
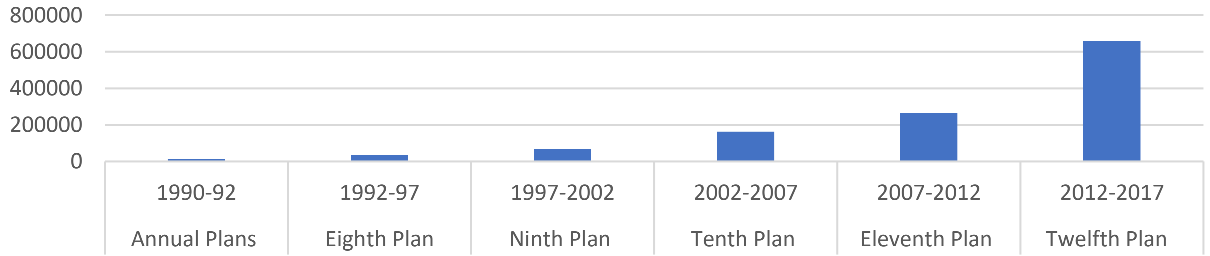


Figure 2.1(B): Public Spending in Energy Infrastructure (Under Five-year plans)



The expenditures shown are "actual" expenditures, not "budget" or "revised" estimates, as those phrases are used in Indian government budgets to describe actual expenditures that were made, not estimates.
Source: Indian Public Finance Statistics (various volumes)

The 1999-2000 decade began with a crisis phase for the Indian economy like never before. The minority government led by Narasimha Rao had to launch structural reforms for the economy to come out of the crisis. The repercussions of this new approach were there on infrastructure development also. In the first decade of the post-economic reforms, the government focused on efforts to attract private investment. A five-year tax holiday, low equity requirements, allowing 100 per cent foreign ownership of power-generating assets, and counter-guarantees against State Electricity Boards (SEBs) failing to pay dues was the notable steps in this direction in the energy infrastructure sector. The corporatisation of Oil and Natural Gas Corporation (ONGC) was the major step in the petroleum sector; with the disinvestment of 20% equity by 1994, along with that the import and distribution of domestic LPG and kerosene was opened to private players to attract private investment. The promotion of joint ventures of private and foreign companies with ONGC or Oil India Limited for oil exploration and production was also aimed at both higher operation efficiency and lower public sector participation which is visible in the low level of public spending in Figure 1 (A). But this phase gave mixed results in the electricity sector bad financial health of State Electricity boards resulted in the failure of many contracts. As a monopoly buyer, the financial difficulties of

SEBs affected thus affected the independent power producers also. The 2000-10 period witnessed a revamp in public spending on energy infrastructure development as the government introduced different programs for different areas of the sector. The Accelerated Power Development Programme (APDP) was launched in 2001 to give the States financial support for the renovation and modernisation of thermal and hydroelectric power plants as well as for the development and strengthening of the sub-transmission and distribution network. In accordance with the APDP, SEBs and ED received funds worth Rs. 978 crores in 2000–01 and Rs. 1,500 crores in 2001–02. In 2002–2003, the funding for the Accelerated Power Development and Reform Programme (APDRP) totaled Rs. 3,500 crores. Rural electrification was identified as an area where government efforts were imperative. The Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) was introduced in April 2005 with a cost of 6241.86 crore to 22 States. The RGGVY gave a boost in power supply infrastructure in the time of the UPA -1 government. The acceleration in public spending on energy infrastructure from 2014-15 can be attributed to a series of new schemes launched by the newly elected NDA government. Notable among them are the Integrated Power Development Scheme (IPDS) to reinforce sub-transmission and distribution networks in urban areas with an outlay of 32,612 crores. 'Rajiv Gandhi Grameen Vidyutikaran Yojana' (RGGVY) was replaced by a new scheme, the 'Deendayal Upadhyaya Gram Jyoti Yojana' (DDUGJY), to focus on rural energy infrastructure. The estimated outlay for the scheme is 43033 crores. Additionally, the 39275 crores approved outlay from the preceding Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) has been transferred to this programme. With support from the Central Government totalling 60% in "General Category" States and 85% in "Special Category" States, the States and their discoms have implemented the scheme. Other programmes, including The UDAY scheme (2015), The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) launched in October 2017 with an outlay of 16320 crores, the National Smart Grid Mission in the power sector with a budget allocation of 30 crores for 2017-18 also contributed to this accelerated growth phase.

In terms of the five-year plan, as explained earlier, five five-year plan was operated along with annual plans in the study period. The first four five-year plans of independent India failed to consider the energy sector as a top priority sector, where the proportion of expenditure ranged from 10% to 15%. The infrastructure investment gap and severe shortage compelled the policymakers to increase the allocation for the sector in the fifth and sixth five-year plans, which varied between 10 to 20%. The energy sector gained its prominence in the 7th five-year plan as top priority infrastructure, where 30.6% of the total outlay was allocated. As explained in the previous section, the major update in the period of annual plans for the sector was the encouragement for private investment. The 8th five-plan envisaged “long-term integrated planning with emphasis on energy end-use as well as an efficient strategy of long run energy supply”. Thus, the Planning Commission endorsed the objective of energy conservation along with supply-side concerns in the plan. The Eighth Plan featured an investment of Rs 6,16,750 crores in the Indian electricity sector. The government approved an outlay of Rs. 26,552 crores for the Eighth Plan in the petroleum sector. The enhancement of power generation capacity was the thrust area of the ninth five-year plan, which started operating amidst the political instability in the union government. This can be visible in the end outcome of the plan also as the investment target achieved was less than 50% and capacity addition was only 19,015 MW against the target of 40,245 MW. In the Tenth Plan (2002-07), the outlay to the energy sector, including power, petroleum, coal and non-conventional sources combined, was Rs. 403927 crores which were 26.5% of the total outlay.

The 11th five-year plan was distinct from other plans as it was designed and implemented under one government. Infrastructure development was identified as a central objective for this five-year plan for a fast-growing economy. About 27% of the total allocation was allocated to the energy sector. The recognition of electricity as a basic human need in the National Electricity Policy of 2005 also motivated to set higher targets for the sector in the five-year plan. A capacity addition of 78,577 MW was proposed with an estimated investment of about Rs. 9 75,000 crores for the Eleventh Five Year Plan. In the plan period, the contribution of public and private sector investment resulted in overachievement against targets in the oil & gas sector. Actual expenditure in the ten infrastructure sectors during the first three years (2007–2008 to 2009–2010), which included investments in gas and oil pipelines, was approximately 10,65,828 crores against the projected 9,81,119 crores. In the 12th five-year plan, the energy sector had objectives of universal access to electricity, Aggregate Technical & Commercial losses to be reduced by 20%, power generation capacity addition over 88000 MW with 52% share of private sector etc. The planning commission projected an investment of Rs.51 lakh crores for the plan period, of which about 53% through budgetary support and the rest from private sector investment.

The second stage of analysis of public spending for a closer understanding can be based on capital expenditure and revenue expenditure. This can go further by dissecting them into expenditures of the union government and state government. By definition, capital expenditures are expenses made to acquire, upgrade and maintain fixed assets. These expenditures are long-term in nature and thus enhance the productive capacity of the country. Revenue expenditure refers to expenditure incurred for the normal running of government departments and services, which are recurring and short-term in operation. Both revenue and capital expenditures have developmental and non-developmental components. The distinctive characteristic of capital account expenditures is that they are incurred at one point in time while the benefits are achieved throughout the course of the following years at various points in time. Thus, compared to revex, it has a larger long-run positive impact on output. As it eliminates structural bottlenecks, capex exerts smaller short-run pressure on inflation and reduces inflation volatility. Ashima Goyal and Bhavyaa Sharma (2018). It should be noted that all grants received by state governments are listed as Revenue expenditure

The trend analysis attempted in the present context for the period 1990–1991 to 2017–2018 reveals that the composition of total expenditure in energy infrastructure is skewed in favour of revenue expenditure. In the case of capital and revenue expenditure of union government, till 2005, capital expenditure was higher than revenue expenditure. With the target of reducing the fiscal deficit, measures of expenditure control and fiscal tightening were followed by the union government. This directed government to slash capital expenditure as it was difficult to curb revenue expenditure. Fiscal Responsibility and Budget Management (FRBM) Act implementation in 2003 also contributed to this reformed path of public expenditure of the union government. The period between 2001 to 2005 marked a higher level of capital expenditure. The advancement of the PPP model, along with increased participation of private investment in the infrastructure, also contributed to the withdrawal of public capital expenditure to the back foot thereafter. It is quite interesting that revenue expenditure started increasing from this point which included the grants to states. The Global financial crisis of 2008 recovery exercises based on expansionary fiscal policy was also part of this upward trend of revenue expenditure.

The diagram reveals that the accelerated path of public spending in the sector under NDA 1 from 2014-15 was also predominantly based on Revenue expenditure growth. As the benefit of capital expenditure is not harvested immediately, it is a commonly accepted notion that political parties are hesitant to expand them in pre-election and election years. The spike in revenue expenditures around general election years such as 2004, 2009, and 2014 can support this notion in the case of India. The NDA government led by Vajpayee dealt with a period where capital expenditure was higher than revenue expenditure which was shifted to a new phase by the UPA government with greater revenue expenditure, which was carried forward by the NDA government from 2014 onwards.

Figure 2(b) also shows an increasing trend in both revenue and capital expenditure in public expenditure of the state after the low-level phase in the first decade after the post-economic reforms of the early 1990s. The centralised planning character of energy infrastructure results in higher revenue expenditure compared to capital expenditure throughout the years. As a subject in the concurrent list of constitutions of India, the state governments are mainly involved in the day-to-day affairs of energy sector establishment, which also play a part in higher revenue expenditure at the state level. Along with the significant rise in revenue expenditure post-2014-15 capital expenditure also grew in the public expenditure of the states.

Figure 2.2(a): Expenditure of Centre

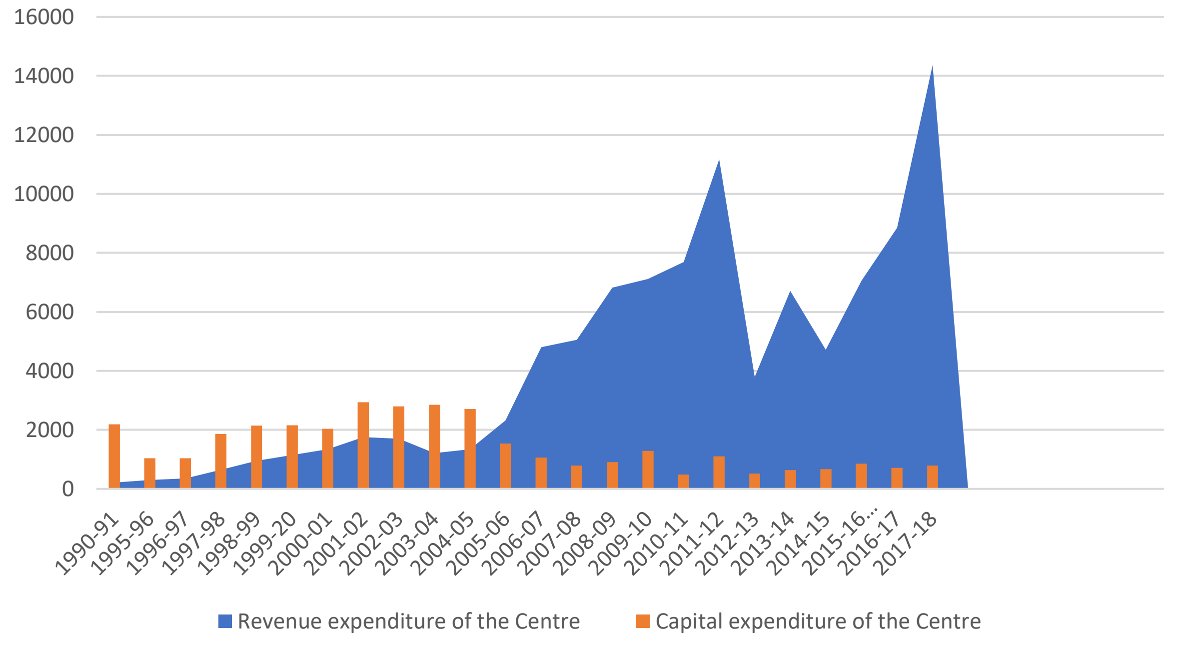
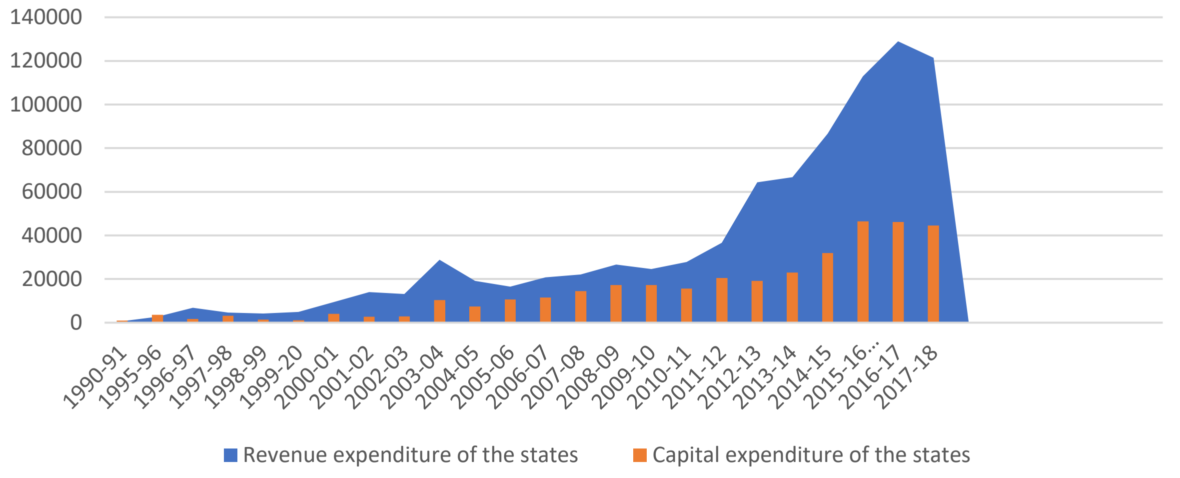


Figure 2.2(b): Expenditure of the states (in crores)



Source: Indian Public Finance Statistics (various volumes)

2.4. Sector-wise energy infrastructure development since 1991

The next level of analysis is at the sectoral level, where the infrastructure development of 3 major energy sources (Electricity, Petroleum and natural gas and coal) in India are studied. This section will give closer insights into the supply infrastructure of these sectors with major development in the study period.

2.4.1. Electricity

The recognition of electricity as a basic human need by the National Electricity Policy (NEP),2005, manifests the paramount role of the sector for the common people. With the objective of providing power with quality, affordability, accessibility, availability and reliability, the Indian electricity sector has pushed through radical reforms in the structure, operation and regulatory framework. The restructuring of the regulatory framework of the electricity sector was carried out parallel with the economic reforms of the early 1990s. The high investment needs and inadequate public resources urged the government to bring private investment to the sector. The Indian Electricity Act of 1911 and the Electricity (Supply) Act of 1948 were thus amended to attract domestic and foreign private investment. This was followed by the liberalisation of regulations of foreign direct investment in the power sector, including foreign equity investments up to Rs. 1500 crore, automatic permission for foreign equity involvement up to 100% is allowed for electricity generation, transmission, and distribution (apart from atomic reactor power plants). In order to attain the goals, the power transmission was made open for private investment.

On the generation front, revived Mega power projects mega projects in the private and public sectors that deliver electricity to more than one state (with a capacity of at least 1000 MW for such supply) were forwarded. The establishment of Power Trading Corporation (PTC) as a single power purchase entity was to facilitate the sale of power under the new policy. The PTC was created with the equity participation of Power Grid Corporation of India Ltd. (PGCIL), NTPC, Power Finance Corporation (PFC) and other financial institutions. The adoption of the Ultra Mega Power Projects (UMPP) Policy, which sought to develop very large-scale projects with an anticipated expenditure of around Rs. 16,000 crores and will operate on a build-own-operate basis, advanced this regime further. The Ministry of Power's Public Sector Utilities (PSU), the Power Finance Corporation, was chosen as the initiative's nodal agency. The initial projects adopting this scheme were established in the states of Madhya Pradesh's Sasan, Gujarat's Mundra, Chhattisgarh's Akaltara, Karnataka's Karvar, Maharashtra's Ratnagiri, Andhra Pradesh's Krishnapatnam, and Orissa's Sasan. The reforms of the regulatory framework of the sector were slow-paced. In addition to operational difficulties, SEBs' weak financial standing posed a significant barrier to the sector's expansion in India. The union government incentivised state governments to carry out reforms in the power sector for better performance. The Orissa Reforms Act of 1995 allowed Orissa to become the first state to implement significant changes in the power sector. This was followed by other major states also, including Haryana, Rajasthan, Andhra Pradesh and Gujarat. Union government took this reform drives to the next phase by the enactment of the Electricity Regulatory Commission Bill, permitting states to establish regulatory commissions at the state level and preparing the ground for the establishment of the Central Electricity Regulatory Commission (notified on 24.7.1998). These reform steps at both national and sub-national levels opened the way for a comprehensive reform package for the sector which came in August 2001 as Electricity Bill 2001. The bill replaced the three then-existing acts, viz., ‘the Indian Electricity Act of 1910’, ‘the Electricity (Supply) Act of 1948’, and ‘the Electricity Regulatory Commissions Act of 1998’ and a robust regulatory framework was installed.

An output-based performance assessment of the electricity sector in the study period can be presented by examining the trends in the vital infrastructure indicators viz the Installed capacity, Number of villages electrified, Length of Transmission and Distribution lines and Per capita electricity consumption. A combined data of both the plan-wise and year-wise are presented in Table :2.2 due to precise insights and availability of data. Gradual progress in all four indicators shows a positive outcome of the public spending energy sector in the study period.

Table 2.2 Growth of electricity sector since 1990

As on	Installed Capacity (MW)		of villages electrified	Length of T & D Lines (Ckt.Kms.)	Per capita Electricity Consumption (kWh)
	Utilities	Non-Utilities			
31.03.1990	63636	8116	470838	4407501	329
31.03.1992	69065	9301	487170	4574200	348
31.03.1997	85795	12079	498836	5140993	465
31.03.2002	105046	17145	512153	6030148	559
31.03.2007	132329	22335	482864	6939894	672
31.03.2008	143061	24986	487347	7287413	717
31.03.2009	147965	26674	497236	7487977	734
31.03.2010	159398	31517	500920	7801098	779
31.03.2011	173626	34444	547034	8365301	819
31.03.2012	199877	39375	556633	8726092	884
31.03.2013	223344	40726	560266	9080556	914
31.03.2014	248554	42258	571782	9312634	957
31.03.2015	274904	44657	578957	9972918	1010
31.03.2016	305162	48279	586065	10316547	1075
31.03.2017	326833	51529	592972	10686448	1122
31.03.2018	344002	54933	597121	11958511	1149
31.03.2019	356100	75207	597464	12682649	1181

Source: Central Electricity Authority

To start with, the development of supply infrastructure in terms of transmission and distribution lines follows an increasing trend throughout the period. The institutional efforts in the transmission sector development were the establishment of the Power Grid Corporation of India Limited (POWERGRID) in 1992 to construct, operate and maintain inter-state and interregional transmission systems. Other major schemes include APDP (200-01) and following APDRP and Restructured-APDRP. A notable growth momentum was started in the

11th five-year plan period, which was maintained in the following years. The efforts in the supply infrastructure augmentation in the 12th five-year plans were remarkable.

The completion of integrating regional grids into a single national grid (which was expected to finish by the end of the 11th five-year plan (2011-12), was the first mark in the 12th five-year plan. The National Electricity Fund (Interest Subsidy Scheme) was given approval by the Cabinet Committee on Economic Affairs (CCEA) to offer interest subsidies totalling 8,466 crores on loan disbursements totalling 25,000 crores to the state power utilities - both in the public and private sectors - to upgrade the distribution network in the 2011–12 period. To strengthen the sub-transmission and distribution network in urban areas, the 'Integrated Power Development Scheme (IPDS) was launched, which subsumed the Restructured Accelerated Power Development and Reforms Programme (R-APDRP), with an outlay of 32,612 crores. The new scheme for rural electrification, the 'Deendayal Upadhyaya Gram Jyoti Yojana' (DDUGJY), also contributed to the development of sub-transmission and distribution infrastructure in rural areas. The addition in the annual plan period of 2018 alone is around 1272063 Ckt. Km. which endorses the follow-up of individual schemes of previous years.

Considering the rural population of India, rural electrification has been a prime objective of infrastructure development planning since independence. On 8th April 2018, India achieved the landmark of electrification of all un-electrified census-inhabited villages in the country. The rural electrification effort had slow growth in the early years of the study period, which entered into an aggressive phase in the 11th and 12th five-year plans. The targeted deadlines of total electrification were changing over the years under different schemes like Accelerated Electrification of One Lakh villages and One Crore Households, Accelerated Rural Electrification Programme (AREP) and Kutir Jyoti Programme etc. The 2005 Rajiv Gandhi Grameen Vidyutikaran Yajna (RGGVY) was the beginning of a focused scheme for Rural electricity infrastructure and household electrification, with the Rural Electrification Corporation (REC) as the nodal agency. The Memorandum of Agreement (MoA) outlining the conditions for the program's implementation as envisioned by RGGVY was signed by 27 States and their utilities. Households below the poverty line (BPL) were given free connections, and projects funded by the scheme received a 90% capital subsidy from the Government of India. At the cost of Rs. 9732.90 crores, 235 projects totalling 68,763 villages and 83,10,000 BPL connections were approved under the Tenth Plan. The budgetary support for the scheme continued in the 11th and 12th five-year plan periods also. An upgraded version of this scheme was introduced in 2015 with the new name the 'Deendayal Upadhyaya Gram Jyoti Yojana' (DDUGJY). One of the main goals of this plan was to separate feeders for agriculture and non-agriculture to make distribution companies (discoms) more convenient. All discoms, including those in the private sector, are eligible to receive financial assistance under the new scheme. As a concurrent program to this scheme in 2017, Saubhagya (Pradhan et al.) was launched to achieve universal household electrification, with REC as the Nodal Agency for the operationalisation of the scheme. The scheme's total outlay was 16,320 crores, including 12,320 crores as gross budgetary support. The Nodal Agency for the scheme's implementation is REC. A slowdown has been seen in the number of villages electrified after the 2008 achievement. But rural electrification will benefit people only if it reaches every household in the country.

The Per capita electricity consumption (PCEC) is considered a vital development indicator. The end-user indicator of the outcome of public spending in the sector can be acknowledged by the trend in the PCEC. Table 8 shows that despite an increasing trend is visible there have been fluctuations in the growth rate in different five-year plan periods. As mentioned in the previous section, the 9th five-year plan period shows a slowdown in growth. The higher public spending on the infrastructure resulted in a great leap in both the 11th and 12th five-year plan periods.

The final indicator of electricity sector development is based on the installed capacity of generation. The 1990-91 period witnessed a deceleration in electricity generation in India. A capacity addition of 22,245 MW was targeted for the Seventh Plan, where actual achievement was lower at 21,401.6 MW. The government policies to bring private investment and additional investment to increase power generation started giving results slowly; thus, an increasing trend can be seen in installed capacity in both utilities and non-utilities. A better comprehension can be facilitated by Table 3(b) where capacity addition targets & achievements during various plans are presented. The slowdown in the power sector in the ninth five-year plan is visible here also as capacity addition achievement was less than 50 per cent of the target, where only 19,119 MW was added against the target of 40,245 MW. The game changer in this progression was in the 11th five-year plan, where new growth momentum was kick-started, and 69.8% of targeted capacity was achieved. During the Eleventh Five Year Plan, the shortfall in power supply decreased in terms of both overall energy availability and peak availability. While the peak deficit reduced from 13.8% in 2006–7 to 9.0% in 2012, the energy deficit decreased from 9.6% in the terminal year of the Tenth Plan (2006–7) to 8.7% during April–

December 2012. (Up to December 2012). On this foundation, the 12th five-year plan achieved more than the targeted capacity addition with an achievement percentage of 112%. The data of the annual plan after the 12th five-year plan leaves a positive impression on the future prospects of the sector.

2.4.2. Oil and Gas

The second category of energy sources that are close to the day-to-day life of common people in India are Oil and Gas. One-third of the energy requirement of the country is fully filled by hydrocarbon, thus taking on a key role in the energy mix of India. Considering the natural resource deposition, utilisation and potential growth, the sector is one of the underdeveloped energy sectors in the country. The high dependence on imports and transmission of global price volatilities makes the sector complex in its operation. The sector is governed under the Ministry of Petroleum and Natural Gas (MOP&NG) through different public sector taking (PSU) who are the major stakeholders in the sector. Among these, Oil and Natural Gas Corporation Limited (ONGC) and Oil India Limited (OIL) hold a major stake in the sector as a total share of about 71.5% in oil and 81% in gas production in the country lies with them (2017-18). Almost 61% of domestic crude oil output and 71.5 % of all domestic gas production are catered by ONGC. At the same time, 10% of domestic crude oil output and 9% of domestic petrol production are accounted for by OIL. In terms of oil and gas output, private/joint venture corporations account for 29% and 19.5%, respectively. The public spending in the sectors thus can be captured by the Sector-wise Internal and Extra Budgetary Resources (IEBR) to this major player under four different operations as Exploration & Production Sector, Refining & Marketing Sector, Petro-Chemicals Sector and Engineering Sector.

The supply infrastructure of the Oil and Gas sector comes under these four sectors. The major PSUs under these sectors are (Table 2.3):

Table 2.3 Major PSUs in Oil and Gas sector

Exploration & Production Sector	Refining & Marketing Sector	Petro-Chemicals Sector	Engineering Sector
-Oil and Natural Gas Corporation (ONGC) ***-Oil India Limited (OIL)*** ***-Gas Authority of India Ltd. (GAIL)*** ***-ONGC Videsh Limited (OVL)***	*-Indian Oil Corporation Limited (IOCL)* *-Hindustan Petroleum Corporation Limited (HPCL)* *-Bharat Petroleum Corporation Limited (BPCL)* *-Chennai Petroleum Corporation Limited (CPCL)* *-Bangalore Refinery Pvt Ltd (BRPL)* *-Indo-Burma Petroleum Co. Ltd.* *-Numaligarh Refinery Limited* *-Mangalore Refinery and Petrochemicals Limited (MRPL)* *-Kochi Refinery Limited (KRL)*	*-Bangalore Refinery Pvt Ltd (BRPL)* *-Bharat Petroleum Corporation Limited (BPCL)* *-Mangalore Refinery and Petrochemicals Limited (MRPL)* *-Hindustan Petroleum Corporation Limited (HPCL)* *-Indian Oil Corporation Limited (IOCL)* *-Chennai Petroleum Corporation Limited (CPCL)* *-Gas Authority of India Ltd. (GAIL)*	*-Indo-Burma Petroleum Co. Ltd.* *-Balmer Lawrie & Co. Ltd. (BL)* *-Biecco Lawrie Limited*

Source: Ministry of Petroleum & Natural Gas

The efforts of these PSUs have helped India to reduce its foreign dependence on oil and natural gas over the years and to attain progression in the refining sector to emerge as a global hub after China in Asia. The primary trigger for the government of India to prioritise energy supply infrastructure was the disruptions in the crude oil import from the gulf in the 1970s. The effort in that direction entered the reform period with policies of delicensing and partial disinvestment of major government agencies in the sector. This begins with the participation of private and foreign companies in 1991-93 auctions for 28 discovered fields (pre-NELP et al.). This was followed by multi-level reforms, which enhanced domestic productions, acquisitions abroad and joint ventures (JVs). The trends in total IEBR show a significantly increasing trend for the sector than a few years of downfalls. It should be noted that in the period of UPA 1 and UPA 2, the public spending sector entered a new growth phase. The major leaps in the level of public spending in the sector happened in 2004-5, 2008-09 and 2013-14, which endorses the output of the 11th five-year plan for the boost given to energy infrastructure in the country. In addition, even after the conclusion of 5-year plans (since 2017), this growth momentum is maintained.

Table 2.4. Sector-wise Internal and Extra Budgetary Resources (IEBR) under Petroleum & Gas Sector

Year	Exploration & Production Sector	Refining & Marketing Sector	Petro-Chemicals Sector	Engineering Sector	Total
1990-1991	3069	523	16	16	3624
1991-1992	2722	618	38	18	3396
1992-1993	4726	972	83	17	5798
1993-1994	8148	1442	161	10	9761
1994-1995	6511	2133	256	22	8922
1995-1996	5386	2737	606	26	8755
1996-1997	4911	3097	766	27	8801
1997-1998	5371	4312	415	43	10141
1998-1999	5259	5954	381	42	11636
1999-2000	5207	4746	107	30	10090
2000-2001	5230	4637	247	22	10136
2001-2002	9534	4224	229	13	14000
2002-2003	12149.4	3656.3	463.36	10.48	16279.5
2003-2004	12213.3	4412.66	957.33	7.64	17591
2004-2005	16293.1	5025.92	1645.52	4.61	22969.2
2005-2006	19774.8	5639.75	1674.17	6.79	27095.3
2006-2007	22286.1	6889.21	1925.16	4.65	31105.1
2007-2008	25151.1	5088.66	2502.51	17.26	32759.5

2008-2009	42958.7	9029.85	4818.51	19.1	56826.2
2009-2010	34320.6	16969.5	3481.55	41.34	54613
2010-2011	41816	16362.1	2708.42	45.03	60931.5
2011-2012	45987.4	17565.6	2209.42	32.61	65488.1
2012-2013	48573.7	15812.4	3489.31	67.28	68079.7
2013-2014	88245.3	16758	3137.69	107.37	107092
2014-2015	57502.3	20054.6	3008.99	69	69828.8
2015-2016	72954.7	22036.2	3581.98	90.574	66118.9
2016-2017	72,383	30,524	1,446	74	104426
2017-2018	95455	32794	3672	83	132004
2018-2019	49613	46990	3487	219	100309
2019-2020	44769	56668	3949	217	105603
2020-2021	52994	51446	5979	776	111195

Source: Indian Petroleum & Natural Gas Statistics (various editions)

A disaggregated analysis of the sector will refine our judgements on public spending in the sector. The major subsector under the petroleum and gas sector is the exploration and production sector. The reform activities in the sector were also primarily aimed at rejuvenating the activities of exploration and production in the country. The IEBR shows that before 2002, the sector was under a low growth period. The government's attempts to involve more private and foreign players in the sector post-1991 have affected public spending in the sector. The major reform step in the sector was the launching of the New Exploration Licensing Policy (NELP) in 1998, in which 48 exploration blocks were offered under its round-I. The primary goal of NELP was to generate extensive risk capital into the oil and gas sector from Indian and foreign corporations. The NELP ensured a competitive bidding system to get licenses for exploration where National Oil Companies (NOCs) also competed on an equal footing with Indian and foreign companies. In the period between 1997 to 2010, the first phase of liberalisation of the exploration and production sector was completed, in which 9 NELP and 4 Coal Bed Methane (CBM) rounds were completed, where the auction of 254 exploratory and 33 CBM blocks was managed. Post end of 12th five-year, the government pushed for further liberalisation of the sector where initiatives like the approval of discovered small field policy (2015) and hydrocarbon exploration and license policy (HELP) (2016), operationalisation of the National Data Repository (NDR)and Open Acreage Licensing Policy (OALP) were forwarded. In terms of IEBR, a steady growth path is absent for the study period, where the 2008-09 and 2013-14 periods witnessed higher spending. This can be attributed to the beginning of Commercial production of Coal Bed Methane (CBM) in July 2007 in the Raniganj (South) block in West Bengal and the completion of different projects.

The refinery and marketing sector became the flagship sector in the study period. From an insignificant sector, it emerged as the top priority as India marked itself on the global map as a refinery hub. Soon after the reforms started, many joint ventures were initiated in the refining sector. For example, Bharat Shell Limited – a joint venture between BPCL and Shell overseas investment, BPCL - Oman oil company Limited for implementation of central India refinery project which shows the surge in IEBR in the 1993-95 period. Even though a growth momentum was visible for the sector from the 10th five-year plan, a high growth phase began in the 2008-09 period. The JVs for enhancing distribution infrastructure, including pipeline project and gas distribution projects, was carried out in these years, like the 2005 BPCL-GAIL joint venture for gas distribution projects in the state of Kerala and Karnataka.

In the petrochemical factor, government spending started showing growth at the beginning of the 10th five-year plan, whereas the engineering sector got that boost in the 11th five-year plan. The engineering sector remains a low-focused sector among other sectors where higher public spending is expected in coming years.

2.4.3. Coal and Lignite

The relevance of the coal sector in the Indian economy is multifaceted. The independent stature as an energy source and as the principal driver of the electricity sector brings a peculiar case of interdependence. Coal caters to nearly 50% of the total energy requirement of India, and as the cheapest source of electricity production, it plays a crucial role in electricity sector development in the country. The existence of the lignite sector attached to the coal sector allows us to study it along with coal. The electricity sector consumed 64.07% of total coal and 84.46% of Lignite in India in 2020-21. The coal production in 2020-21 was 716.08 million metric tons which makes India the world's second-largest producer of cold. Apart from the electricity sector, the steel and washery industry (6.65%), the sponge iron industry (1.06%), the cement industry (0.75%), and fertilisers and chemicals industries (0.19%) are the major consumers of Coal in India which hold India's energy dependence on the coal sector (Energy Statistics 2022). The industrial sector growth, which is fueled by coal, pushed the import of coal in India in the past years behind China. The limited natural reserve of petroleum and natural gas, geo-political regulations on nuclear sector development, and under-developed and environmental constraints on other sources, including hydel projects, ensure the decisive position of coal in the energy mix of India. This particular position of the sector can be considered as the reason for holding the sector under public control throughout history; thus, the dominant share of coal production in India is under the public sector. The Coal Mines (Nationalisation) Act came into force in 1973, under which all the coal mines were nationalised. Among other energy sectors, the coal industry was the slowest sector to undergo reform after 1991.

The exploration, production, distribution and other major activities regarding coal and lignite in India are under the Ministry of Coal, Government of India. The public sector corporations - Coal India Limited (CIL) and its seven subsidiaries: South Eastern Coalfields Limited, Bharat Coking Coal Limited, Central Coalfields Limited, Western Coalfields Limited, Northern Coalfield Limited, Eastern Coalfields Limited, Mahanadi Coalfields Limited, Neyveli Lignite Corporation and Singareni Collieries Company Limited (SCCL), a joint sector undertaking of the governments of Andhra Pradesh and India are the prime stakeholders in the sector. The major joint ventures in the sector are International Coal Ventures Private Limited (ICVPL) was formed in 2009 for the acquisition of coking coal properties outside India. And CIL-NTPC Urja Private Limited (JV between CIL and NTPC, formed in April 2010 for the acquisition of coal blocks in India and abroad). The predominance of the public sector in production is thus a salient feature of the Indian Coal sector.

Table 2.5 Number of Working Coal Mines

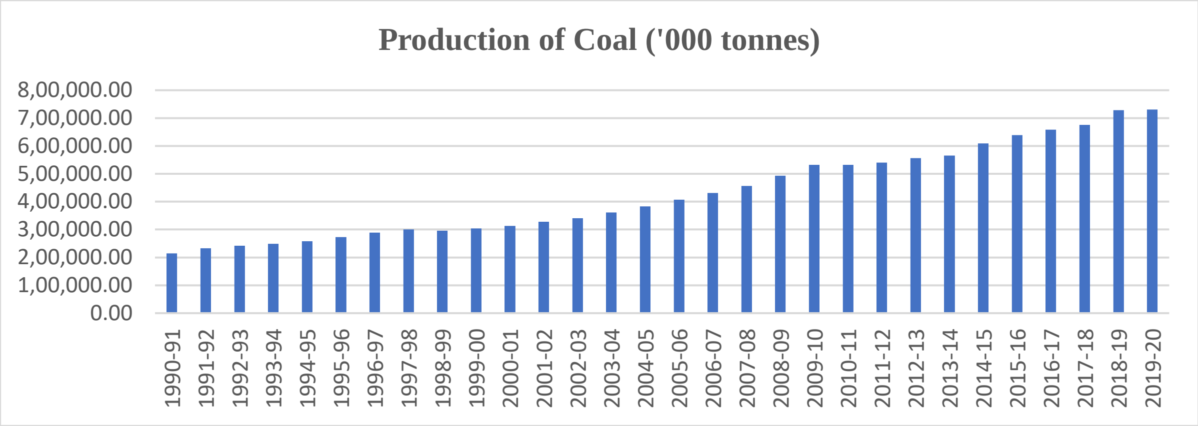
Five-year plans	Total Number of Working Coal Mines	By ownership		Total Number of Working Lignite Mines	By ownership	
		Public	Private		Public	Private
End of Ninth FYP (2001-02)	564	555	9	6	5	1
End of Tenth FYP (2006-07)	561	543	18	11	10	1
End of Eleventh FYP (2011-12)	559	533	26	14	13	1
End of Twelfth FYP (2016-17)	476	455	21	19	17	2
Annual Plans (2017-18)	455	433	22	18	16	2
Annual Plans (2018-19)	454	432	22	19	17	2
Annual Plans (2019-20)	442	420	22	19	17	2

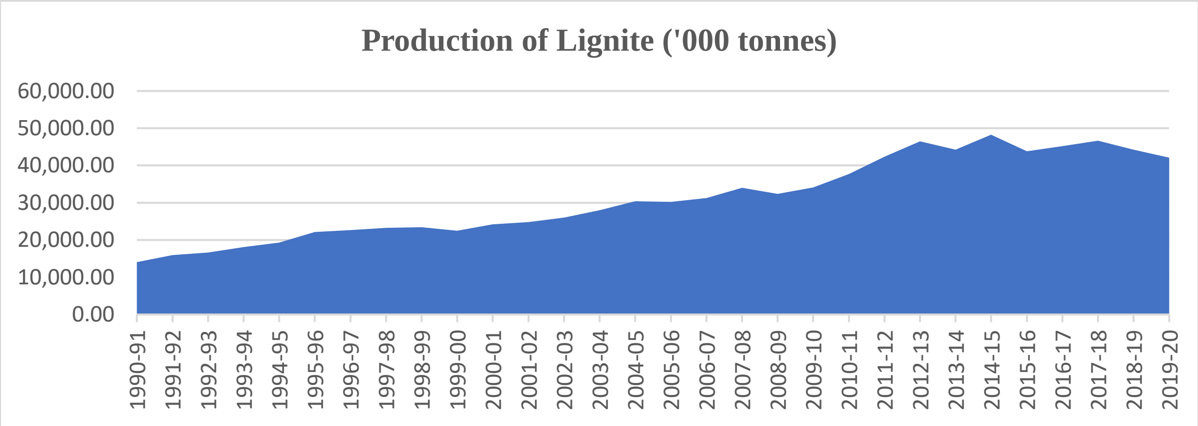
Source: Coal Controller's Organisation, Ministry of Coal

The coal sector was the last sector among other energy infrastructure sectors to embrace private participation in India. Coal was one of the excluded sectors from the provisions of the New Industrial Policy of 1991, which abolished industrial licensing and promoted private players in the industrial growth of the country. But in 1993, the Coal Mines (Nationalisation) Act 1973 was amended to allow the operation of captive coal mines by private sector companies in iron and steel, power sector and coal washing. The next major step in this direction happened in March 2015 when private corporations granted permission to mine coal for use in their own cement, steel, power and aluminium plants. This prepared the final stage of structural reform for the sector in 2018, when both the Coking Coal Mines (Nationalization) Act of 1972 and the Coal Mines (Nationalization) Act, 1973, were repealed by the government of India, thus completing the denationalisation process.

The review of the coal and lignite sector from 1990-91 shows an increasing trend in production, which follows throughout the study period. By the end of 1990-91, there were 24 projects (20 in the coal sector and 4 in the lignite sector), each costing over Rs. 100 crores under implementation. Among them, nine projects were delayed due to problems. Relating to the acquisition of land, rehabilitation, supply of equipment by local manufacturers etc. In the 8th five-year, the coal sector was mainly concerned about the demand from electricity, steel and cement industries. The coal consumption increased both during the sixth and seventh five-year plan at 5.5% and 7.4% per annum, respectively. The planning target of the 8th five-year plan was to reach a level of 308 million tons by the end of the plan period to achieve the plan target for power generation under coal based thermal sector and for the Iron and Steel industries. The number of projects implemented in the coal sector rose to 71 by the end of 1994, but 22 projects were undergoing time overruns (about 38 months) and cost overruns (about 77 crores per project).

Figure 2.3 Production of Coal and Lignite





Source: Coal Controller's. Organisation, Ministry of Coal

The financial position of CIL in the 8th five-year plan period was not so promising. The CIL implemented the cash and carried scheme in October 1992 to regulate the growth of arrears and large outstanding sales dues. The borrowings of Coal India Limited (CIL) from the Central Government as of 3rd March I, 1994, were Rs 3814 crore. Even though CIL tried to utilise the new liberalised policy regime to form joint ventures in longwall mining projects, the attempts were not realised in the plan period, mainly due to the unattractive profit generation of the PSU. In the 9th five-year plan, both coal and lignite production experienced a decline. After four years of slowdown, the production of coal registered a growth of 5.9% in 2000.

The prodigious program in the coal sector launched in the 10th five-year plan was the Ultra-Mega Power Projects (UMPPs) program. The Ministry of Power started the development of ultra-mega coal-based plants, each with a capacity of at least 4,000 megawatts. Developers received these projects through competitive tariff-based bidding. In the final year of the tenth five-year plan, the CEA identified nine sites in nine States for the proposed UMPPs. These were four pithead sites, one each in Chhattisgarh, Jharkhand, Madhya Pradesh, and Orissa, and five coastal locations, one each in Gujarat, Maharashtra, Karnataka, Andhra Pradesh, and Tamil

Nadu. The total outlay realised in the 10th five-year plan was 16582 crores, where 15563 was IEBR, and the rest was budgetary support.

In the 11th Five-year plan, a total increase of 280.84% in total outlay was proposed for the sector where IEBR was 61826 crores. The boost given to energy infrastructure in the 11th five-year plan was evident in the coal and lignite sector also, with impressive growth in the total production. The target for coal production at the end of the Eleventh Plan was initially set at 680 million tons, and the actual achievement was 540 million tons. There was a substantial demand-supply imbalance of 100 million tonnes in the final year (2011–12) of the Eleventh Plan due to the demand being close to 640 million tonnes, which was only partially filled by imports. This has resulted in a negative impact on the supply of coal to final consumers in the power sector. There was a focused approach to increasing domestic coal production from captive mines in the Eleventh Plan. Out of the 195 blocks assigned, only 29 captive blocks could begin production; as a result, the plan's goal of 104 million tonnes was not met in its last year. Delays in obtaining forest and environmental clearances, difficulties in acquiring land, the allotment of a block to more than one user, and other factors contributed to this neglect. Working Group in Coal & Lignite for XI Plan proposed a total capital outlay of '34259 Crore for CIL, SCCL, and NLC and 7702 Crore for the departmental schemes of the Ministry of Coal to achieve the projected coal production in XI Plan. However, the Planning Commission approved a total capital spending for the XI Plan of 37,100.00 Crores. An IEBR of 35,774.37 crores and a GBS of 1,326.00 crores were intended to support the authorised Eleventh Plan outlay of '37,100 crores for MoC. Only 63% of the approved budget, or 26,337.62 crores, was actually spent during the Eleventh Plan. This included the IEBR of three PSUs, CIL, SCCL, and NLC totalling 26,374.20 crore and the remaining GBS of 1,500 crores for projects funded by the Ministry of Coal. The main shortages are in the CIL, and NLC reported expenditures, while SCCL is projected to spend 3,707.59 against the allowed IEBR of 3,340. The most important step taken in the 11th five-year plan was the establishment of a new joint venture, the International Coal Ventures Limited (ICVL), primarily for operations abroad. The ICVL was incorporated on 20th May 2009 as a Joint Venture Company of Steel Authority of India Limited (SAIL), CIL, Rashtriya Ispat Nigam Limited (RINL), National Mineral Development Corporation (NMDC) and National Thermal Power Corporation (NTPC) with equity holding in the ratio of 2:2:1:1:1 respectively. ICVL was formed as a special purpose vehicle (SPV) for the participation of PSUs in the acquisition of coal resources abroad. In 2011, Coal India Limited was conferred with the Maharatna status and Neyveli Lignite Corporation was conferred with the Navratna status, thus enabling greater autonomy in its functioning along with higher financial powers.

The increasing trend in the production of both coal and lignite was carried forward in the 12th Five-year plan and annual plans after that. The proposed total outlay for the 12th Five-year plan for CIL was 25000 crores, along with 35000 crores for the proposed acquisition of assets abroad, including Mozambique. The outlay for SCCL and NLC was 10350 and 29239.10 crores, respectively. Under Departmental Schemes, regional exploration (456.52 cr.), detailed drilling in non-CIL blocks (974.69 cr.), Environmental Measures and Subsidence Control scheme (EMSC) (4950.05 cr.), Conservation and Safety measures in coal mines (820 cr.) and development of transport infrastructure (600 cr.) in the coal fields were allocated. In 2013-14 the efforts for Public Private Partnership (PPP) with CIL as one of the partners in coal production was initiated in the budget. The objective of this initiative was to improve the production and productivity of the coal mines of CIL. After the denationalisation of 2018, based on demand projection in "Vision 2030" for the Coal sector, the medium- and long-term production plans are prepared, wherein the growth of 8.2% is expected for Coal India Limited till 2024-24 to serve coal demand in India.

The final appraisal of the development of the sector can be based on the capital expenditure of three PSUs in the sector for 11th and 12th Five-year plans and annual plans after 2017, as these periods witnessed remarkable growth in the sector. The figure shows that in the 12th Five-year plan, capital expenditure in CIL has increased aggressively, which shows a slowdown in the annual plan periods. The capital expenditure in NLC was stagnant in both the 11th and 12th Five-year plan periods, which entered a growth phase in the terminal year of the 12th Five-year plan and elevated in the annual plans, whereas such a trend is absent in the case of SCCL.

Table 2.6. Capital Expenditure of CIL, SCCL & NLC

Year	Capital Expenditure of CIL	Capital Expenditure of SCCL	Capital Expenditure of NLC
2006-07	2059.69	448.63	1123.65
2007-08	2033.51	573.97	1766.71
2008-09	2507.17	650.44	1559.41
2009-10	2809.99	888.67	1363.1
2010-11	2539.72	643.81	1444.65
2011-12	3370.21	1070.56	1684.38
2012-13	2915.23	2047.26	1827.9
2013-14	4329.86	2455.55	1817.32
2014-15	5173.49	2809	1969.76
2015-16	6123.03	2820.22	1666.04
2016-17	7700.06	2013.55	4575.68
2017-18	9334.55	1477.39	5105.43
2018-19	7311.46	1229.69	7208.16
2019-20	6269.65	2131.8	6469.62

2.5. Conclusion

The fundamental question of the magnitude of state participation in the infrastructure development of a country has been asked in India since independence. In the evolution of the Indian economy, different experiments were carried out in this regard. The policymakers were pushed through different situations and constraints that enabled them to decide upon different paths to glory. Indian economy, since 1991 economic restructuring, experienced drastic changes in its functioning and structure. The spheres of public spending have mutated severely with enhanced objectives. Infrastructure development has been identified as a priority sector for government interventions since independence, but different sectors were given differentiated focus. Energy infrastructure was one of the under-discussed sectors despite its central role in the holistic progress of the economy. This study was an attempt to track the development of Indian energy infrastructure from the perspective of public spending. The study period between 1990 to 2020 marks three decades of reforms of the Indian economy in which all major sectors undergo changes. This study reviews these changes and perceives how the government's role transformed in the study period.

The appraisal exercise in the study is broadly based on five-year plans and different governments in power. In the study period, six governments and six five-year plans were completed. This study is structured as follows, beginning with the analysis of macro-level public spending in energy infrastructure development, and then the infrastructure of three major energy sources (Electricity, Coal and Petrol) are evaluated. In the macro level analysis, the combined budget transaction of the union government and state governments was studied. In the sectoral level examination, both output-based performance assessment and other indicators on major PSUs in the particular sectors are included.

The study reveals an expansionary growth path of public spending in energy infrastructure development in India since 1991. In the first decade after the economic restructuring, the efforts were mostly to encourage private participation in infrastructure development. The 2000-10 decade was the spell of revamp in the public spending on the energy infrastructure, as the government realised the slow growth in the sector and mounting demand pressure.

Public spending entered an accelerated path from 2014-15, which is followed till today. In terms of five-year plans, the 11th five-year plan proved to be the game changer for the Indian energy infrastructure across different energy sources. Gaining the top priority in the plan with about 27% of the total allocation, a never-before boost was received by the sector. The dissection of public spending shows that the first half of the study period was the phase in which capital expenditure was higher than revenue expenditure, especially from 2001 to 2005. This was later moved to revenue expenditure-led growth after that. It was also revealed that post-2014, the acceleration in public spending in the sector is driven by revenue expenditure growth than capital expenditure.

The sectoral level assessment of energy infrastructure also shows the progressive nature of the sectors in the study period. The regulatory framework of all three energy sources in the country was navigated through structural reforms in the last 30 years at different levels. From a bottom-up approach, the achievement in rural electrification was the most important milestone in the study period, apart from the increase in the supply capacity, especially in the 12th five-year plan. As mentioned earlier, the electricity sector highly benefited from the 11th and 12th five-year plans. The Petroleum, natural gas, coal and lignite sectors assessment was done based on the operations of major PSUs in their respective sectors. In the petroleum sector, the emergence of India as a continental hub of refineries is propitious. It was found that the efforts of the government in different subsectors of the Oil and Natural Gas sectors to bring private participation in the first decade of the economic reforms affected the sector in total. The low-paced growth period from 1990-91 to 2001-02 validates this. The last energy sector to embrace liberalised policy regime was the Coal sector. The five-year plan outlays, and capital expenditure of major PSUs in the sector shows the growth movement the sector initiated in the last two five-year plans and thereafter.

On the policy front, the findings of this study give many key insights. First, the preponderance of revenue expenditure in the total public spending on energy infrastructure needs a serious check. In the absence of a long-term policy framework like five-year plans, an Intensive approach will be needed in annual budgets to revert this feature. Second, the ingrained debate on five-year plans versus annual plans will not be settled only based on expenditure data. Thus, a comprehensive verdict cannot be passed on the findings of this study on this debate. But the fact that energy infrastructure was magnified in the 11th five-year plan period deserves endorsement by the policymakers. An underlying long-term plan, especially considering the longer gestation period for most of the energy infrastructure, a system like the five-year plan will be suitable to give a better orientation for planning and development. Third, the 11th five-year plan was distinctive among other plans as that was proposed and implemented under a single ruling alliance. This should be compared with the low performance of energy sectors and sluggish growth in the early 1990s, where instability of the union government was common. Thus, it shows the necessity of a stable government at the union level in India for a flourishing energy sector. Fourth, the indispensable question of the real outcome of the liberalisation and privatisation policies of 1991 stands tall after three decades. Again, a wholesome judgement will be irrelevant as different sectors followed different paths in these 30 years. The reforms of the basic regulatory framework itself are incomplete for sectors like electricity to make use of macro-level reforms and grow (Shameem & KRC,2022). Fifth, despite the celebration of achievement in rural electrification, the ground-level service delivery mechanism is still fundamentally insufficient. The slow growth in rural electrification after the 2018 declaration should make the government cautious. The increase in per capita electricity consumption is considered an indication of the well-being of people. In India, the regional imbalance in per capita electricity consumption is a matter of concern which needs attention. Sixth, the growing refinery sector of the Indian petroleum industry poses the potential to provide a new geo-political influence for the country. The efforts to tap this potential include both internal and external activities. Seventh, throughout the study period, it was found that apart from technical issues, the production activities of different energy sectors were affected by socio-political factors. Considering the energy requirement of a growing economy, the occurrence of these types of hurdles is intolerable. Finally, the environmental concerns and sustainability questions are not addressed in this study, but each of the energy sources is exposed to these questions at different levels. From the natural ageing of oil fields and resultant low outcome to the environmental impact of coalfields with complete denationalisation raises concerns. The development of energy infrastructure in a country like India, with a huge population, will be a never-ending process. Here responsible governance and competent regulatory frameworks will decide the future course of the energy sector.

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Chapter 3

ECONOMIC GROWTH AND SECTORAL LEVEL ELECTRICITY CONSUMPTION NEXUS IN INDIA: NEW EVIDENCE FROM COMBINED COINTEGRATION AND FREQUENCY DOMAIN CAUSALITY APPROACHES

3.1. Introduction[1]

The evolution of sectoral contribution to the Gross Domestic Product (GDP) and the growth process of the economy is associated with the progression of the production pattern of the country. To this end, the predominance of the agricultural sector to the growth of the industrial and service sector is a widely observed path. The invincible role played by the energy sector in this development is traced by the pattern of energy consumption in the mode of production. Energy- Economy interaction thus brought a new arena of investigation, which was crucial in the planning and development of the countries. In the last four decades, the relationship between energy consumption and economic activities became a widely studied topic in economic literature. The prime objective of these studies is to establish the cause-and-effect relationship between various variables and the direction of that link to augment the energy sector and economic activities. One of the early attempts was by Kraft & Kraft (1978) in which output and energy consumption for the United States from 1947–to 1974 were studied and concluded that there is unidirectional causality from the former to the latter. The series of empirical studies followed employed different econometric analytical approaches and proxy variables for different countries and periods but failed to present identical results.

Theoretically, energy is not considered independently as a factor of production, like labour and capital. But in the modern age, it is inevitable in the whole production process. The discussion about considering Energy as a factor of production is still unsettled, whereas it is counted as an intermediate input in production; thus, the critical role energy plays in Value-adding production and economic growth as a whole is pivotal. The study of the interaction between energy use and economic growth is always oriented on the following four competing hypotheses, as follows: conservation hypothesis, growth hypothesis, feedback hypothesis, and neutrality hypothesis. The conclusions of these studies are relevant as they supplement

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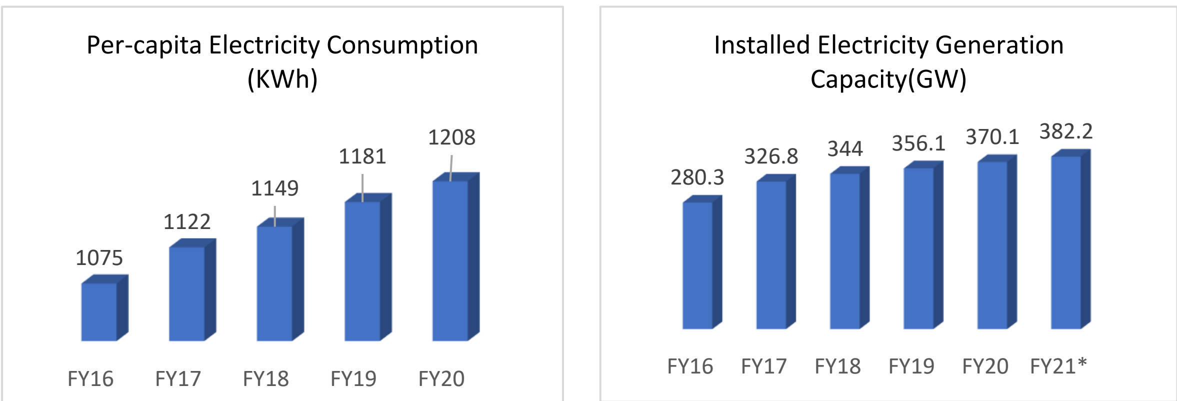
decisions regarding energy policies and the economic planning of the country. Many studies have been reported in the past couple of decades that support these mutually contradictory hypotheses in the context of India. Notable studies include Asafu-Adjaye (2000), Masih & Masih (1996), Gupta & Sahu (2009), Wolde-Rufael (2010), Tiwari (2011), Nain et al. (2012), Nain et al. (2017) for Growth Hypothesis, Ghosh (2002a), Soytas & Sari (2003), Keppler (2007), Chen et al. (2007), Abbas & Choudhury (2013), Kumari & Sharma (2018), and Tang et al. (2016) for Conservation Hypothesis, Paul & Bhattacharya (2004), Chitedze et al. (2021), Tiwari (2012), Ahmad et al., (2016); W. Ahmad et al. (2014) for Feedback hypothesis and Neutrality hypothesis validated by Murry & Nan (1994), and Zhang (2011) and Nain et al. (2017). This complexity in tracing this relationship and contradictory results from previous studies encourage us to explore the short- and long-term associations between energy use and economic factors in India.

The emergence of electricity as the most convenient energy form revolutionized the daily life of people. From lightning uses to modern transistors, electricity changed the entire course of human life. It has direct implications on the well-being of people, thus progressive demand for electricity became a fundamental feature of all economies. As a highly populated developing country, the importance of the electricity sector developed over the years in India. With a national electric grid of installed capacity of 382.73 GW, India currently holds the position of the world’s 3rd largest producer and consumer of electricity. With the growing population, especially in urban centres, with increasing electrification, the electricity demand and particularly the per capita electricity consumption is expected to reach higher levels over the coming years (See Figure 3.1).

Figure 3.1 Per-capita Electricity Consumption and Installed Electricity generation capacity



Source: Central Electricity Authority (*until March 2021)

Considering the expanding market size and inexorable presence of the state in the production, transmission, and even consumption of electricity in India, understanding every dynamic in the prevailing structure is pivotal. Here the assessment of the association between electricity consumption and the economic growth of the country becomes significant. The literature on this relationship is predominantly occupied with bivariate analyses, Aggregate level analyses, and studies including factors like emission. A disaggregated sectoral analysis of the Indian electricity sector, which we introduce, will thus provide new insights on electricity consumption by different core sectors of the economy and their contribution to the economic progress of the country. The findings are expected to precipitate a new framework for Energy policy in India where the focal point will be diversified based on individual needs and the performance of the sectors. The study intends to investigate India's long-term transition in power consumption and growth trajectories, as well as to assess the causal link between output growth and energy consumption in various sectors, utilizing annual data on Sectoral electricity consumption, overall economic activities, Agriculture Value Added, Industrial Value Added, Service Value Added for the period 1971 - 2019.

The rest of the article is structured as follows: A survey of the literature on the relationship between energy use and economic growth is presented in Section 2. The third section provides an overview of India's energy sector and energy use. The study's data and methodology are described in Section 4. Section 5 presents empirical findings, while Section 6 brings the study to a conclusion.

3.2. Literature Survey

Plenty of studies assess the link between energy consumption and environmental quality nexus in-country and cross country level (Rafindadi, 2016a, 2016b; Rafindadi et al., 2018; Rafindadi & Mika'Ilu, 2019; Rafindadi & Usman, 2019,2021)). However, the pioneering work of (Kraft & Kraft (1978) on the causal relationship between energy consumption and economic growth in the United States for the period 1974 to 1974, indicated a unidirectional causality from income to energy, marking the beginning of the literature on the energy-economic nexus. Since then, many studies have brought evidence for and against the unidirectional causality, i.e., the conservation hypothesis and the other three hypotheses. The first set of studies in this line was led by Yu & Hwang (1984), who countered the conclusion of Kraft & Kraft (1978), showing the absence of any causality between energy consumption and income for the USA. Further, Abosedra & Baghestani (1989) confirmed unidirectional causation from GNP to energy. Yu and Choi (1985) evaluated this association for several nations and reported the absence of any significant relationships between the UK, USA, and

Poland. Studies on this relationship took a methodological shift by employing Cointegration techniques at the beginning of the 1990s. Yu & Jin (1992) tested Cointegration between energy and output for monthly US data and negated any long-term relationship between them. Stern (1993) and Cheng (1995) also followed this conclusion on US data using multivariate VAR models.

The non-uniformity of empirical results and conclusions on this relationship is very evident in the literature. Masih & Masih (1996) investigated the Cointegration and causality for India, Pakistan, Indonesia, Malaysia, Singapore, and the Philippines. The co-integration between energy and GDP was found for India, Pakistan, and Indonesia and the causal relationship was mixed for them. Asafu-Adjaye (2000) investigated the linkage between income and energy use in 4 Asian economies and supported the Growth hypothesis for India and Indonesia and the Feedback hypothesis for the Philippines and Thailand. Wolde-Rufael (2005) investigated long term and causal relationship between per capita GDP and per capita energy consumption for 19 African countries from 1971 to 2001. The results were mixed as long-term relationships were evident for eight countries.

The study of Ouedraogo (2013) on West African economies found long-run causality from energy consumption to output, whereas in the short-run direction is the opposite. Yasar (2017) studied this relation for 119 countries belonging to different income groups and concluded no long-run relationship is visible for low-income countries, whereas the conservative hypothesis and feedback hypothesis were true for upper-middle-income group higher-income group countries, respectively

Alternatively, the Conservative hypothesis was supported by many studies on different country-level analyses. Aqeel & Butt (2001) and Nadeem & Munir (2016) in the case of Pakistan, Bartleet & Gounder (2010) in New Zealand, Khobai et al. (2017) for BRICS countries, and Fang & Chang (2016) for 16 countries in the Asia Pacific region. Rafindadi (2015) estimated that an increase of one per cent in economic growth affects the energy consumption of Germany by 2.1 053 per cent. However, other macro-economic variables like financial development and trade openness were found to be decreasing the energy consumption. In addition to that, it was found that one percentage addition in renewable energy consumption pushes the economic growth in Germany by 0.219% (Rafindadi & Ozturk, 2017b). On the contrary, financial development, affluence, and trade openness boosted energy consumption in South Africa for the period 1970 to 2011 (Rafindadi & Ozturk, 2017a)

The feedback hypothesis, which states that energy consumption and output are causally linked in both directions, was found to be significant for 15 Asian economies by Nasreen &

Anwar (2014) and Canada by Ghali & El-Sakka (2004). Conversely, the conclusion of the study by Menegaki & Tuğcu (2016) on 42 sub-Saharan countries supported the neutrality hypothesis for 28 years from 1985. Similarly, the neutrality hypothesis was revealed by (Jafari et al. (2012) for Indonesia from 1971 to 2007.

The empirical outcomes of studies on the energy-economy nexus differ in many terms. Towards assimilating the changes in real life, new proxy variables were incorporated into the empirical studies over time. Electricity consumption transpired as a major proxy variable for energy use in researchers as electricity became vital to sectors across the economy. This gave the emergence of a new wave of studies in energy economy relationships. A study on a sample of 100 countries on the causal relationship between electricity consumption and economic growth concluded that in developed economies, this relationship is stronger than in deprived nations Ferguson et al. (2000). The empirical results based on the panel cointegration analysis of Mehrara (2007) came up in support of the Conservative hypothesis for the oil-exporting countries. For 15 European transition economies, Acaravcı & Ozturk (2010) concluded the absence of any long-term equilibrium link between electricity consumption per capita and real gross domestic product (GDP) per capita. Panel Cointegration tests were employed for this study with data from 1990 to 2006. Using ANFIS (adaptive neuro-fuzzy inference system) methodology, Maksimović et al. (2017) analyzed the impact of electricity consumption from different sources of economic growth in European Union countries and stated that electricity consumption from renewable sources holds a greater impact. Aydin (2019) applied both Time and frequency domain panel Granger causality tests and found results in favor of the feedback hypothesis where electricity from non-renewable sources was used as a variable.

Subsequently, Yoo & Kwak (2010) evaluated the association between electricity use and output growth in seven South American countries: Argentina, Brazil, Chile, Columbia, Ecuador, Peru, and Venezuela. Five countries among them followed the Growth hypothesis and one country (Venezuela) showed a bidirectional relationship, whereas there was no causal relationship in the case of one country (Peru). The causal relationship between electricity consumption and economic growth for eleven MENA countries was tested by Ozturk & Acaravci (2011) using the ARDL bounds co-integration tests. For the period 1990–2006, the study gave mixed results regarding the long-run association between the variables. The one-way causal relationship between electricity consumption and economic growth was significant in both the short-run and long-run for Oman, Saudi Arabia, and Egypt, whereas in the case of Israel, short-run Granger causality was vice versa. The estimated results System Generalized Methods-of-Moments (System GMM) model by Lawal et al. (2020) for sub-Sahara African count rises found a positive relationship between electricity consumption and growth between the period 1971 and 2017.

Abbas & Choudhury (2013) analyzed the causal relationship between electricity consumption and the GDP of India and Pakistan for the period 1972-to 2008. Using Engle & Granger's (1987) causality test, the results concluded economic growth caused electricity consumption in India, and bi-directional causality was evident in Pakistan. Tang & Shahbaz (2013) used the Johansen & Juselius (1990) test and the Toda & Yamamoto (1995) Granger causality tests to study the causality between electricity consumption and real output in Pakistan. The study was conducted at both aggregate and sectoral levels for the period and proved the existence of a cointegration relationship with causality from electricity consumption to real output (total), manufacturing, and service sector outputs in Pakistan. Khan et al. (2020) uncovered evidence for a positive effect of electricity consumption on Pakistani economic growth, which was supported by Ali et al. (2020) for the period from 1960 to 2015.

In the meantime, the findings of single-country research on the direction of causality between electricity consumption and economic growth variables also varied. According to Shiu & Lam (2004) and Yuan et al. (2007), the Growth hypothesis was found to be valid in the Chinese economic growth. In the case of Turkey, both in the long run and short run Acaravci et al. (2015) found causality from electricity consumption to economic growth, though not the reverse for the period 1974 to 2013. The sectoral level analysis of the Turkish economy by Dogan et al. (2016) concluded that the use of electricity positively affected agrarian production in the non-coastal regions, and evidence of bidirectional causality was present for the entire panel and coastal regions in Turkey.

Subsequently, the analysis of the Japanese economy by (Rafindadi & Ozturk, 2016), applying an extended Cobb-Douglas production function with an ARDL bounds test approach, established the long-run impact of economic growth and financial development, export, and import on electricity consumption in the country. For Poland, by employing Vector error correction and the Toda-Yamamoto approach (1995) Gurgul & Lach (2012) observed feedback causal relationships between Economic output, electricity consumption, and employment. Kasperowicz (2014) also supported this bidirectional relationship between electricity consumption and economic growth in Poland. For the period 1981 to 2015, Chitedze et al. (2021a) showed one-way causation between agriculture and service sector performance and electricity consumption and two-way causality between manufacturing and electricity consumption in Nigeria. Odhiambo (2021) explained neutrality hypothesis was found significant in the case of Botswana.

Evidence of the conservative hypothesis was concluded for Australia by (Narayan & Smyth (2005) between 1966 and 1999 and for Ghana by Adom (2011). Using the Vector Error Correction model, Ho & Siu (2007) explained a unidirectional causality from electricity consumption to real output in Hong Kong for the period 1966-2002. The possible asymmetry in the co-movement of electricity consumption and economic growth was revealed by Rafindadi & Usman (2020) with a study on the Brazilian economy, which revealed that a positive shock to economic growth stimulates electricity consumption more than a negative shock of a similar magnitude decreases consumption. An asymmetric behaviour was observed in the relationship between electricity consumption and economic growth in Vietnam by Ha & Ngoc (2021) where negative changes have a greater effect than positive changes both in the short run and long run. In the case of Bangladesh, Mozumder & Marathe (2007), Masuduzzaman (2012) and Islam (2021) found one-way causality from per capita GDP to per capita electricity consumption (1971-1999), from electricity consumption to real GDP (1981-2011) and from GDP to electricity consumption (1972-2014) respectively.

In the context of India, one of the earlier notable studies was by Ghosh (2002b), which found no evidence for a long-run equilibrium relationship between electricity consumption per capita and Gross Domestic Product (GDP) per capita. By using annual data for the period 1950–51 to 1996–97, this study showed one-way causality running from economic growth to electricity consumption without any feedback effect. Adhegaonkar (2015) also supported the findings of Ghosh (2002b) which stated the absence of any causal effect of electric power consumption on economic growth in India from 1970 to 2011. Kumari & Sharma (2016) found similar results in the long run for the period 1974-2014 for India but established a unidirectional causality from GDP to electricity consumption. Rajkumari (2020) found evidence for the neutrality hypothesis in the case of Karnataka state, considering electricity consumption and economic growth. The Vector Autoregression (VAR) model estimated by Singh & Vashishtha (2020) also re-established the neutrality hypothesis for India for the period 1971-2017. the study also found the one-way causality from per capita GDP to per capita electricity consumption. The state-level assessment of the impact of electricity consumption along with sectoral growth was estimated by Tiwari et al. (2021) for the period 1960-61 to 2014-15. The sector-by-sector study revealed a one-way association between electricity consumption and agriculture growth, as well as economic growth and electricity consumption in the industrial sector. The study results partially contradicted the conclusion of Ghosh (2002) as a long-run relationship between economic growth and the agriculture sector electricity consumption. Gupta & Sahu (2009) observed that electricity promoted greater economic growth from 1960 to 2006, validating the Growth hypothesis for India. The growth hypothesis was endorsed by Wu et al. (2019). in India for the period 1971–2014 relying on the results Bootstrap ARDL test. Considering the studies on the particular relationship in India is discernible that an extensive analysis of aggregated data on electricity consumption in India is quite justifiable. The present study attempts to fit in the gap of regress examination of sector-specific electricity consumption and its influence on economic growth in the country with recent data. Beyond the domain of electricity consumption and sectoral growth of the economy, a more discrete effort to dissect electricity consumption by major sectors and their impact on the economy is forwarded by this study. However, notable studies on the relationship between electricity consumption and economic growth in India are portrayed in Table 3.1.

Table 3.1 Relationship between Electricity Consumption and Economic growth in India.

Study	Period	Methodology	Variables	Conclusion
Ghosh (2002b)	1950 - 1997	Granger causality test	Per capita GDP, per capita electricity consumption	EG -> ELC
Gupta & Sahu (2009)	1960−2006	Granger causality test	Real GDP, electricity consumption	EC -> EG
Ghosh (2009)	1970–2006	ARDL bounds test, EC	Electricity supply; real GDP Employment India,	EG-> ELS
Abbas & Choudhury (2013)	1972−2008	Johansen test, VECM Granger causality	Electricity consumption, real GDP (total and agriculture	EG -> EC (total) EC ↔ EG (AGR)
Akhmat & Zaman (2013)	1975-2010	Granger causality (VAR)	Electricity and per capita GDP	EC->EG
Cowan et al. (2014)	1990-2010	Bootstrap panel causality approach	Electricity, GDP growth	LR: ELC ≠EG
Mohanty & Chaturvedi (2015)	1970−2011	ECM, Granger causality test	India Electricity consumption, real GDP	EC -> EG
Nain et al. (2017)	1971-2011	ARDL bounds test Toda and Yamamoto	Sectoral and aggregate electricity consumption: RGDP	ELC ≠ EG; SR: ELC->EG; - ELC ≠ EG(AGR); IND LR: ELC ≠ EG; SR: ELC->EG domestic and commercial - LR and SR: EG->ELC
Raza et al. (2016)	1980−2010	Pedroni's panel cointegration, Panel Granger causality test	Electricity consumption, real GDP, labor, capital	EC -> EG
Kumari & Sharma (2016)	1974−2014	Johansen cointegration test,	GDP per capita, per capita electric	EG -> EC

		Granger causality test	power consumption	
Nain et al. (2017)	1971–2011	ARDL bound test, VECM, and Toda-Yamamoto tests.	CO_2, Electricity Consumption and EG	ELC -> EG
Eren et al. (2019)	1971–2015.	VECM, Granger causality test	Renewable energy consumption, financial development, and economic growth	EC ↔ EG
Wu et al. (2019)	1971–2014	Bootstrap ARDL test	Real GDP and per capita electricity Consumption	ELC -> EG
(Tiwari et al., 2021)	1960 – 2014	Panel cointegration tests, Heterogeneous panel causality test	PCPC, PCPCA, PCPCI, NSDP	EC-> AGR Growth EG -> EC IND

Note: EG = Economic Growth GDP = Gross Domestic Product

EC = Energy Consumption

ELC = Electricity Consumption ELS = Electricity supply

AGR = Agricultural sector

IND = Industrial Sector PCPC = per capita power consumption at the state level

PCPCA = per capita power consumption in the agricultural sector

PCPCI = per capita power consumption in the industrial sector

NSDP = per capita net state domestic product (NSDP)

3.3. Materials and methods

3.3.1 Data and model construction

The study employs annual data on per capita real GDP at 2010 constant prices as a measure of economic growth obtained from WDI (World Development Indicators), while the consumption of electricity at the sectoral level such as agriculture, industry, and service sector (we consider in this study service sector electricity consumption as total electricity consumption minus agricultural electricity consumption minus industrial electricity consumption) in GWh obtained from Central Statistical Office and Reserve Bank of India for the period 1971-2019. (Tiwari et al., 2021).

The function specification aiming to analyze the impact of sectoral level electricity consumption on economic growth is specified in equation 1 by following Ghosh (2002b); Nain et al. (2017); Paul & Bhattacharya (2004).

$$GDP_t = f(ECAGR_t, ECIND_t, ECSERV_t) \quad (1)$$

The specified model in equation one is based on the premise from the existing literature showing India's inability to attain quadruple economic growth and decrease unemployment and poverty reduction is attributed to the shortage of energy consumption (Paul & Bhattacharya, 2004). Therefore, it is possible to argue that the specified model is free from omitted variable bias since many other studies also showed the important nexus between energy consumption and economic growth (Altinay & Karagol, 2005) ; (Ghosh, 2002b) ; (Shahbaz & Feridun, 2012).

3.3.2 Econometric methods

3.3.2.1 Unit Root Tests

For testing the problem of unit root related to study variables in this study, Augmented Dickey-Fuller (Dickey & Fuller, 1979), Phillips & Perron (1988) unit root tests are applied. These two tests are designed to compare the alternative hypothesis of stationary series against the null hypothesis of a unit root. However, the ADF and PP tests fail to detect data set-related structural breaks. As a result, we employed the Zivot & Andrews (2002) unit root test to determine the structural break in a series. A structural break in the series might cause biases in the determination of the integration order of the series (Kirikkaleli & Adebayo, 2021). The ZA unit root test identifies structural breakdowns at any time and estimates unit root attributes of the series.

3.3.3.2 Bayer–Hanck combined cointegration

The individual cointegration tests such as Engle and Granger (EG), Johansen (JOH), Peter Boswijk (BO), and Banerje, Dolado, and Mestre (BDM) tests may offer different conclusions while estimating the cointegration of two or more series. Hence, the derived conclusion may not be valid since these tests have lower power. To overcome this, the study uses the Bayer-Hanck test of combined cointegrations test, which combines the aforementioned individual cointegrations tests and provides a joint test statistic with the null hypothesis of the absence of cointegration. The Bayer & Hanck (2013) combined cointegration approach relies on the formula developed by Fisher (1992) to get the level of statistical significance by employing the following equations 2 and 3.

$$EG-JOH = -2[\ln(P_{EG}) + \ln(P_{JOH}) \qquad (2)$$

$$EG-JOH-BO-BDM = -2[\ln(P_{EG}) + \ln(P_{JOH}) + \ln(P_{BO}) + \ln(P_{BDM})] \qquad (3)$$

Where the individual cointegration tests-based probability values are represented by using P_{EG}, P_{JOH}, $P_{BO,}$ and P_{BDM}. Only when the estimated Fisher statistics exceed the Bayer and Hanck (2013) critical values, is the alternative hypothesis of cointegration accepted.

3.3.2.3 FMOLS, DOLS, and CCR technique

The long-term coefficient from the ARDL model were tested for robustness by the FMOLS of Phillips & Hansen (1990), DOLS developed by Stock & Watson, (1993), and CCR model by (Park, 1992). Multiple authors used these models in their studies to validate the long-run elasticities evolved from the ARDL technique (Dogan and Kirikkaleli, 2021; Bildirici, 2017). The FMOLS approach is unique in that it can offer optimum cointegrating regression estimates among series, which has the order of integration one. The method also handles the issue of serial correlation and endogeneity without endangering the estimates' robustness. The DOLS procedure is an alternative estimator for the long-run equation. It is recognized to have advantages over FMOLS, with the distinctive characteristic of DOLS being an asymptotically efficient estimator and the capacity to remove feedback in the cointegrating system. DOLS may be used in place of FMOLS, as proposed by Saikkonen, (1991) and Stock and Watson (1993). The process of estimation in DOLS has lead and lag to the cointegration regression. When converting variables in their second order, the OLS estimator falls short. As a result, the Canonical cointegration regression (CCR) approach excels in eliminating the bias of the second order.

3.3.2.4. Breitung–Candelon Frequency-Domain Causality Test

For capturing the short-, medium-, and long-term causality of the study variables employed using frequency domain causality test introduced by Breitung & Candelon (2006). The main advantage of the frequency-domain approach is that it permits seasonal variations even if the size of the sample is small. Moreover, it decomposes the causality in various periods consisting of the long-, medium- and short-term. Further, non-linearity and causality can be distinguished in each term.

Finally, the study used the Toda-Yamamoto causality introduced by Toda and Yamamoto (1995) as a measure to confirm the robustness of our findings emanated from the frequency domain causality test.

3.4. Results and discussion

The summary statistics of the study variables - economic growth and the electricity consumption of agricultural, industrial, and service sectors are presented in Table 2. The outcomes of descriptive statistics show that economic growth has a higher mean value, followed by the industrial, service, and agricultural sectors' electricity consumption, respectively. This outcome is expected since the electricity consumption in the industrial sector is often relatively higher than in the service and industrial sectors in India. In terms of variance, the service and agricultural sectors' electricity consumption has a variation high compared to industrial sector power use and output. Similarly, services and agricultural sector electricity consumption is negatively skewed, while industrial sector electricity consumption and economic growth are positively skewed since the estimated values are away from the standard value of zero.

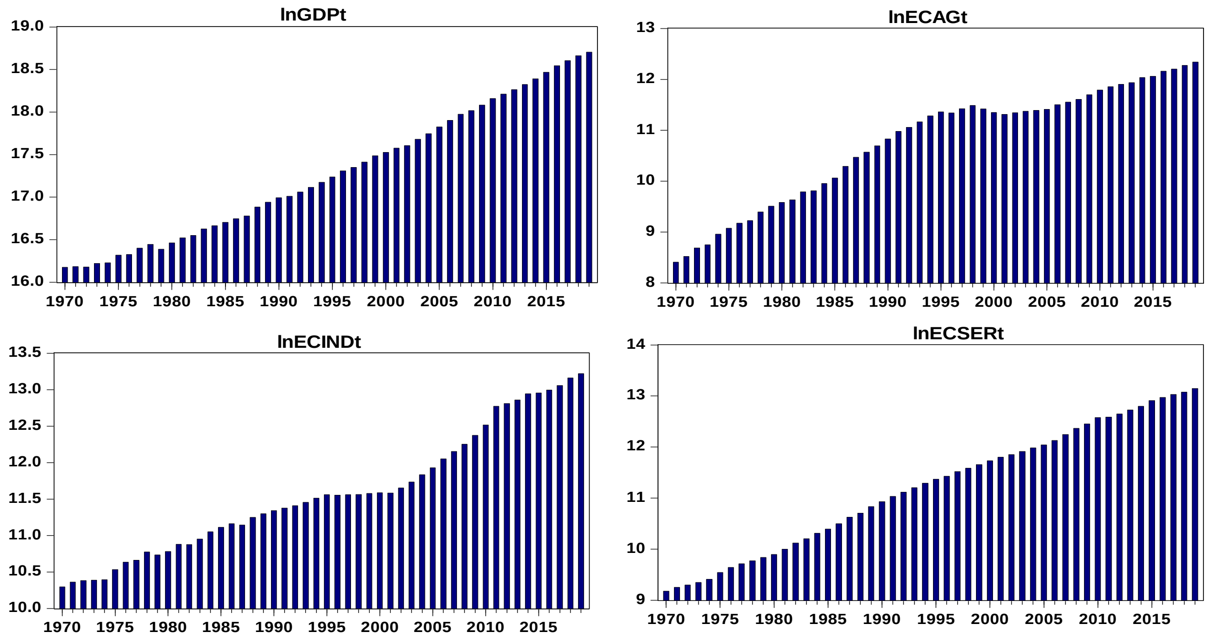
Table 3.2 Descriptive statistics

	lnGDPt	lnECAGt	lnECINDt	lnECSERt
Mean	17.283	10.759	11.580	11.214
Median	17.206	11.296	11.534	11.331
Maximum	18.704	12.338	13.220	13.146
Minimum	16.174	8.405	10.295	9.177
Std. Dev.	0.791	1.143	0.848	1.223
Skewness	0.230	-0.574	0.416	-0.096

Further, the series under consideration is represented graphically in Figure 2 to offer adequate information about the series. The graphical representation generally shows an upward trend in the study variables such as economic growth and the electricity consumption of agricultural, industrial, and service sectors during the study period. However, the electricity consumption of agricultural and industrial sectors slows down in the early twenty-first century before coming back to an increasing trend again. The decline in industrial electricity consumption may be attributed to weak investment demand in India from 2000 to 2001[2]. The service sector electricity consumption and economic growth show a stable increase throughout the period.

[2]Please see for more details https://www.rbi.org.in/scripts/PublicationReportDetails.aspx?ID=325

Figure 3.2 Graphical representation of study variables



After analyzing the trend of the variables, we have explored the possible unit root problem in each series under investigation since the presence of unit root may produce spurious regression outcomes. To this end, this study employs the Augmented Dicky Fuller (ADF) test of Dickey and Fuller (1979) and the Phillips-Perron (PP) test of Phillips and Perron (1988) test to uncover the unit root problem in the study variables. Employment of these tests on the series helps understand the level of association and also the long-short run dynamics. The emanated outcomes are reported in Table 3, which shows that all the study variables are stationary at their first difference, but they are stationary at their level.

Table 3.3 Unit root tests results (ADF and PP)

	ADF		**PP**	
	Level	Δ	Level	Δ
$lnGDP_t$	-2.826	-8.533*	-3.063	-9.821*
lnECAGt	-1.603	-5.028*	-1.505	-5.073*
lnECINDt	-1.038	-5.395*	-1.045	-5.522*
$lnECSER_t$	-0.718	-5.455*	-1.076	-5.435*

Note: * shows a 1% significance level.

However, using conventional unit root tests to examine the integration order of a series in the presence of structural breaks will be misleading. Therefore, the Zivot & Andrews (1992) structural break unit root test is employed to accommodate the structural break while evaluating the integration order. The output of the Zivot & Andrews (1992) structural break unit root test is reported in Table 4, which also shows that variables are first difference stationary even though there is a structural break in the series.

Table 3.4 Unit root test results (Zivot & Andrews, 2002)

	Level		Δ	
	t-Statistic	Break	t-Statistic	Break
$lnGDP_t$	-4.052	1988	-11.169*	1979
lnECAGt	-3.970	1985	-7.021*	1995
lnECINDt	-4.052	1995	-6.681*	2003
$lnECSER_t$	-3.620	1988	-6.240*	1991

Note: * shows a 1% significance level.

After confirming the integration order of the study variables, the cointegration of the study series has conducted by using the Bayer-Hanck (2013) combined cointegration since it offers reliable and consistent outcomes by using Boswijk, Johansen, Engle and Granger, and Banerjee et al. tests. Table 5 portrays the outcome of Bayer and Hanck's cointegration results. The estimated value of the EG-J statistic is greater than the critical value. Similarly, the estimated statistic of EG-J- BA-BO surpasses the table value. Therefore, the evidence accepts the alternative hypothesis, i.e., cointegration, by refuting the null hypothesis of no cointegration. The possible inferences from this finding are that the estimated moves to long-term equilibrium in the presence of these variables. The impact of each explanatory variable on the dependent variables is required in the next stage of analysis.

Table 3.5 Bayer and Hanck's (2013) cointegration test results

Estimated model	EG-J	EG-J- Ba-Bo	Decision
$lnGDP_t=f(lnECAG_t, lnECIND_t, lnECSER_t)$	18.034*	76.590*	Cointegration
Significance of critical value	5%	5%	
	10.637	20.486	

Note: * stands for 1% significance level.

Table 3.6 shows the results of the test on the nexus between the dependent variable and the independent variables. The emanated outcomes show that agricultural electricity consumption significantly reduces economic growth across various estimates. The adverse effect of electricity consumption in the agriculture sector on economic growth may be due to the lack of mechanization in the Indian agriculture sector. The use of obsolete technology in the agriculture sector requires a large quantity of electricity, but the productivity of such machines is weak compared to modern technology-driven agriculture equipment. For example, high power water pumps used for irrigation are a major source of electricity consumption in the rural agrarian sector. Despite the level of yields, these motors use electricity in a progressive trend over the year. Farm mechanization with modern technology is necessary to enhance economic growth, which can ensure efficient use of electricity.

However, the electricity consumption in the industrial and service sector significantly enhances the economic growth in India. It implies that the industrial sector and service sector has the potential to contribute to economic growth through electricity consumption. In the case of the Industrial sector, the various sub-sectors such as manufacturing, iron, coal, and other industries consume a substantial amount of electricity for producing the output. In the case of the service sector, we have reached the same inference since electricity is required for running all major subsectors such as IT & IT enabled sectors, communication, and transport sector activities. Post 1991 New economic policy; the Indian economy witnessed unprecedented growth in the service sector. Even though this service sector boom is tagged as jobless growth in the economy, it is undeniable that the tertiary sector emerged as a major income-generating sector of the economy. Therefore, the conservation policy of electricity consumption in the industrial and services sectors will inversely affect the growth trajectory of India. Hence, a judicious energy policy is required for the economy where electricity consumption of these sectors is catered to along with the concerns of climate change.

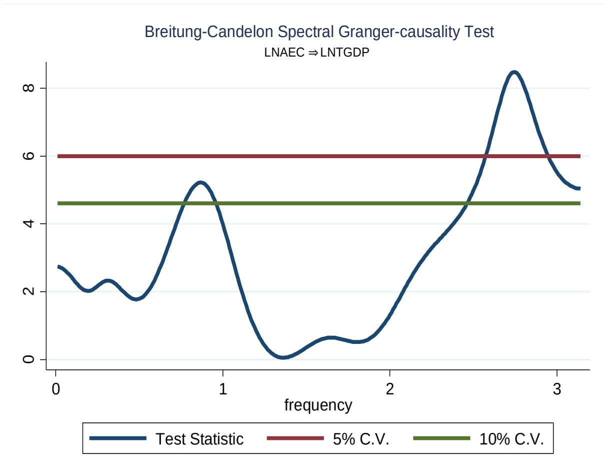
Table 3.6: Long run Estimation cointegration regression analysis (FMOLS, DOLS, CCR)

Dependent variable: $\ln GDP_t$						
	FMOLS		DOLS		CCR	
Predictors	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**
lnECAGt	-0.333*	-9.018	-0.317*	-7.159	-0.329*	-9.379
lnECINDt	0.178*	3.881	0.181*	3.202	0.183*	3.902
$\ln ECSER_t$	0.826*	14.684	0.808*	10.735	0.821*	14.726
Constant	9.548*	45.491	9.605*	45.120	9.512*	44.993
R^2	0.99		0.99		0.99	
Ad R^2	0.99		0.99		0.99	

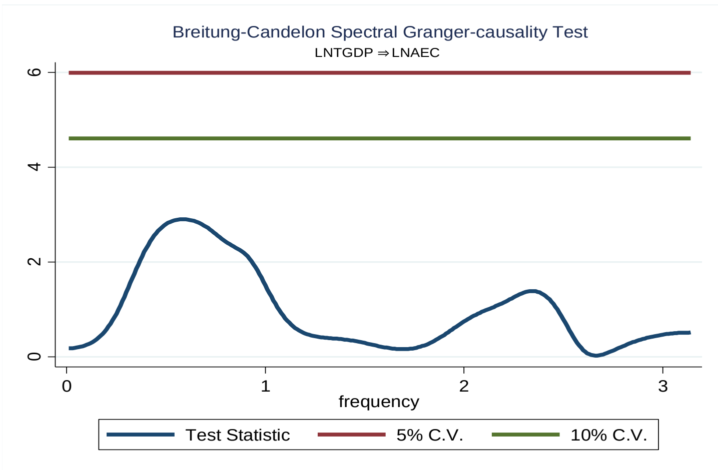
Note: * stands for 1% significance level.

In the final step of empirical analysis, the study performed a frequency domain causality approach proposed by Breitung and Candelon (2006). This approach is different from the traditional causality test related to the time domain in two ways. Firstly, this approach is based on the frequency domain; hence the estimation of causality would be in different frequencies. Secondly, it assumes permanent low-frequency shock and temporary high-frequency shock of a variable are not the same in terms of sensitivity to other variables. Figure 3-5 portrays the outcome of the BC causality test, where the frequencies for the investigated relationship between the variables are 0–1,1-2 and 2-3. The temporary causality is indicted by 2–3 frequency, while permanent causality is expressed by 0–1 frequency. Moreover, the green (lower) line indicates a 10% level of significance, while the red (upper) line shows a 5% level of significance. The estimated line is represented by using a bluish curve.

Figure 2 illustrates the one-way causation between agricultural electricity consumption and economic growth in a frequency short to long run. The null hypothesis that agricultural electricity consumption does not Granger causes economic growth is rejected at frequencies 0.8-1 at a 10% level of significance and 2-3 at a 5% level of significance. Similarly, figure 3 depicts a unidirectional causality from industrial electricity consumption to economic growth at various frequencies at 5% and 10% levels of significance from short run to medium run. Likewise, figure 4 shows a one-way causality runs from service sector electricity consumption to economic growth by rejecting the null hypothesis that service sector electricity consumption does not Granger causes economic growth at 5% and 10% level of significance during the short to medium run. These findings imply the validity of the growth hypothesis of electricity consumption in various sectors of the Indian economy. Finally, the Toda–Yamamoto causality test reported in Table 6 also confirmed the findings are robust.

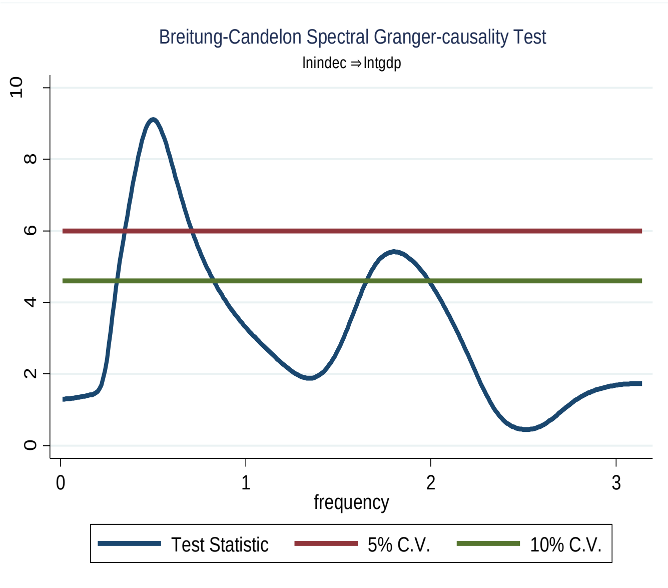


(a)

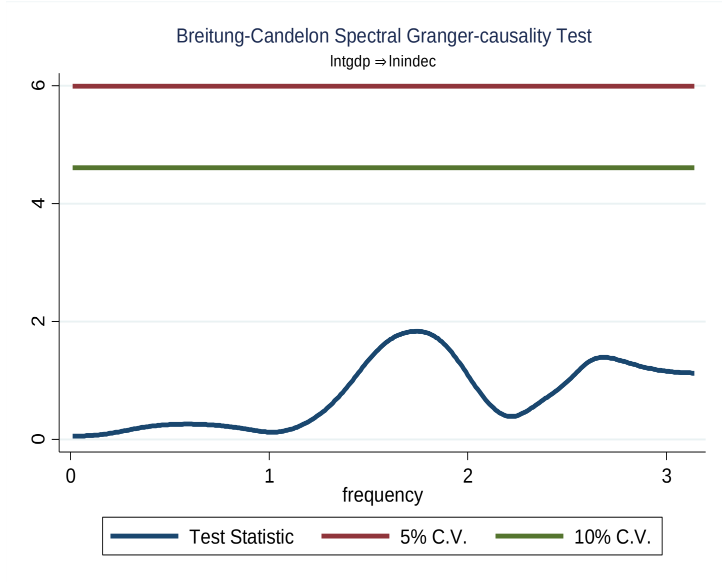


(b)

Figure.3.3 Spectral BC causality between agricultural electricity consumption and economic growth

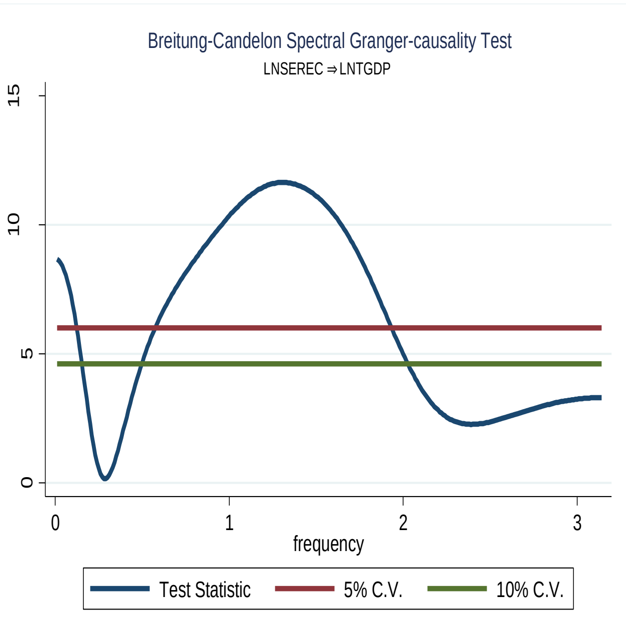


(a)

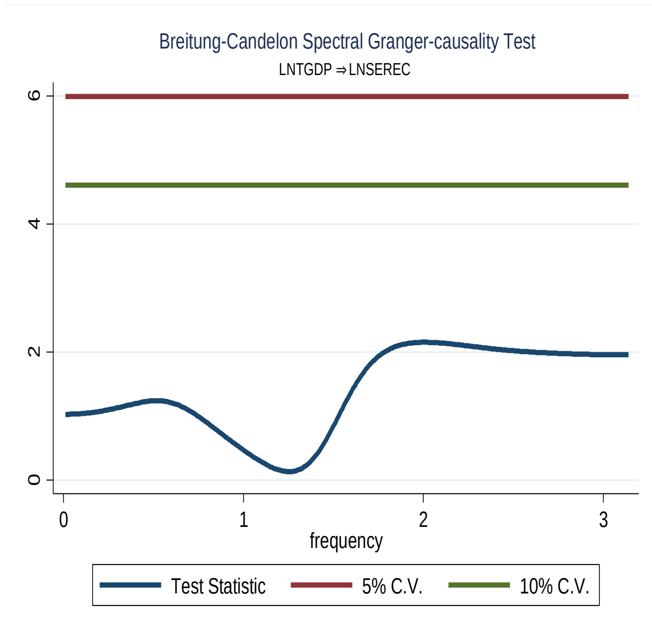


(b)

Figure.3.4 Spectral BC causality between industrial electricity consumption and economic growth



(a)



(b)

Figure.3.5 Spectral BC causality between service sector electricity consumption and economic growth.

Table 3.7: Toda–Yamamoto causality

Null Hypothesis:	F-Statistic	Prob.	Decision
lnECAGt does not Granger Cause lnGDP$_t$	5.079*	0.007	Reject Null Hypothesis
lnGDP$_t$ does not Granger Cause lnECAGt	0.858	0.609	Accept Null Hypothesis
lnECINDt does not Granger Cause lnGDP$_t$	2.349***	0.091	Reject Null Hypothesis
lnGDP$_t$ does not Granger Cause lnECINDt	0.852	0.613	Accept Null Hypothesis
lnECSER$_t$ does not Granger Cause lnGDP$_t$	2.493***	0.077	Reject Null Hypothesis
lnGDP$_t$ does not Granger Cause lnECSER$_t$	1.228	0.377	Accept Null Hypothesis

Note: * and *** stands for 1% and 10% significance level.

3.5. Conclusion and Policy discussion

The emancipation process of any society is directly fueled by the level of accessible energy for each individual and sector. India, as one of the world's most populated countries, is still in this process with many anomalies. The economic inequality existing in the country determines the shape and magnitude of the common needs of the economy. The Indian energy sector, which is predominantly led by state-owned institutions, formulates the policies based on the objective of a welfare state. Historically, electricity as a source of energy has enabled the development process and social welfare of nations across the world. With the towering population, electricity is yet to establish its impact on the lives of people to its full capacity in India. The basic premises of comprehensive electricity policies in India is consist of the rural agrarian sector which employs a large section of the population, the industrial sector, which is the major consumer of energy in the country, and the fastest-growing urban-based service sector, to address these three sectors and their energy concerns empirical and theoretical researches are needed, and there the analysis of this study proves to be relevant.

The primary objective of this study was to evaluate the performance of different core sectors of the economy with their reliance on the electricity sector of the country. The empirical analysis of annual data of per capita real GDP and disaggregated electricity consumption for the period 1971 to 2019 brings few virtuous findings. Firstly, for the test of unit root, the study relied on the Zivot-Andrew (2002) structural break unit root test over the conventional unit root tests, which show the variables are first different stationary. Secondly, the Bayer and Hanck (2013) combined cointegration test found evidence for the presence of cointegration between the variables. The estimated result of FMOLS, DOLS, and CCR technique on long-run co-integration gave mixture results that are relatable to Indian realities. The agricultural electricity consumption is found to be associated with inverse economic growth, whereas shreds of evidence supported growth enhancement by Industrial and Service sector electricity consumption in the study period. Finally, the results of the Frequency domain causality approach of Breitung & Candelon (2006) and Toda and Yamamoto (1995) test explain the presence of evidence for the Growth hypothesis in India at the sectoral level as unidirectional causality from three sectors to economic growth were found at least in a frequency of short run to medium run.

At the policy level, based on current analysis and findings, a more sectoral level exclusive but compatible Electricity policy is suggested. Firstly, the conventional logic of the Growth hypothesis, which considers electricity consumption as a stimulus for growth, pushes for the exaltation of the energy system of the country at a different level. This includes large-scale investment in energy supply infrastructure and adequate enhancement of individual sectors to avail that. Beyond budget allocations, considering the capacity and demand of different sectors, public expenditure to increase electricity supply should be forwarded. In the absence of past Five-year planning and spending as before, the Government of India can structure a five year like planning and execution pursued exclusively for the energy sector, particularly for the electricity sector, which will enable to elevate the sector in that given period and the government will be able to have a proper evaluation of the impact such large-scale investment in the sector. Secondly, even though the sectoral share of agriculture in the total GDP of the economy is comparatively less (14.83 in 2019-20), the sector still employs nearly 54.6 % of the total workforce (Annual report 2020-21 - Department of agriculture, Government of India) who lives mostly in rural India. The future of electricity in this large sector of the population is thus directly related to their domestic household needs, employment, the output produced, and productivity. The findings of the study also pointed out a vital point in this regard effects of electricity consumption in agriculture. The inadequate modernization of farming activities in India thus needs attention for both productivity concerns and Energy efficiency targets.

Thirdly, the debate on which sector will lead the Indian economy in the future have implications on macro-level policy-making where output produced, employment generated, energy demand, environmental viability, etc. are measured for consideration. The study found that both Industrial and Service sectors significantly enhance growth in India, which means energy demands and utilizations favour the co-existence and nurturing of both sectors. But the stable increases exhibited by the service sector electricity consumption and economic growth in the study period can be attributed to the increased importance that the government gave to the sector in the last 30 years. If the performance of the service sector on other measures is kept constant, it is clear that sector can play a major role in the future growth trajectory of the economy, and the electricity demands will be ever-increasing with that growth, considering the pace of urbanization (especially the growth of Tier 2 and Tier 3 cities) and the mushrooming service providing firms beyond typical I.T and I.T enabled services. And the demand needs of the Industrial sector, which is still a major consumer of Total energy supply in India, should be catered to along with the encouragement for energy-efficient production, which has higher environmental effects. Future research on energy-intensive industries and CO2 emissions based on the environmental impact of service sector growth will also be needed in the comprehensive policymaking. In addition, the periodic up-gradation of energy sector management in India will be also decisive in the determination of prospects of the sector. In the growth of the electricity sector as an infrastructure of facility and as an independent industry institutional framework need holistic amendments (Shameem & Chittedi, 2022)

The study can be extended by incorporating the generation part of the electricity sector, which will give additional dynamics where factors like coal consumption of the country are decisive. Moreover, sector-specific analysis can reveal insights on major consumers within the sector and thus formulates policies to complement contribution to the total performance of the economy and welfare of the people.

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Chapter 4

STRIDES FOR ABERRATIONS: THE ELECTRICITY (AMENDMENT) BILL, 2021 OF INDIA

4.1. Introduction [3]

The electricity sector in India shares many features with the Indian agricultural sector in terms of the magnitude of operational complexities and ceaseless problems. The progressive transitions in the sector on both demand and supply sides in recent years are associated with the socio-economic development of the country. (Abdoli et al., 2015; P. Dasgupta & Chaudhuri, 2020). The government reform interventions in this sector are always aimed at making it a robust structure with sufficient flexibility. Any such reforms are evaluated based on positive future implications on the stakeholders including the public as public service, workers as the employer, and traders as an industry. The current discussion was actuated by the government with the release of a set of amendments to the Electricity Act, 2003 as the draft of the Electricity (Amendment) Bill, 2020 (EAB) by the Ministry of Power, Government of India on April 17, 2020, and later tabled on the parliament of India as the Electricity (Amendment) Bill, 2021 without any modifications. As the recurring problems in the sector have compelled many periodic reforms, a holistic reform package is coming after a long time. It should be noted that those periodic reforms have minimal impact on many institutional and operational disabilities of the sector as a whole. The failure of the much-celebrated Ujwal DISCOM Assurance Yojana (*UDAY*)[4] is a notable example in this regard (Kaur & Chakraborty, 2018). In that sense, the government has enough justification to bring a new level of reforms for a structurally stabilized electricity sector that is growth-oriented and welfare-oriented simultaneously. But strong disagreement and opposition were raised by the stakeholders regarding some of the new approaches and solutions in the proposed bill. Critics say that the central government misused the Covid-19 lockdown period to introduce the bill which earlier failed to get the parliament's node twice in 2014 and 2018 (Kanitkar et al., 2020).

India as a nation is the third-largest producer and consumer of electricity in the world, with a national electric grid of an installed capacity of 3,88,134 MW (as 31.08.2021, Central Electricity Authority). The regulatory paradigm of the sector dates back to pre-Independence

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[4] UDAY is a scheme to provide financial turnaround and revival of indebted power distribution companies in the country launched by the Government of India in 2015.

with the Indian Electricity Act of 1910. It was followed by periodic legislation and programs which shaped the sector. The Electricity (Supply) Act (1948) and the Electricity Regulatory Commission Act (1998) are the major predecessor of the Electricity Act of 2003. The Electricity Act of 2003 was the first attempt to transform the power sector in India which covered provisions regarding generation, distribution, transmission, and trading in power. The newly introduced Electricity (Amendment) Bill by the Ministry of power, plans to address the recurring issues in the sector governed by the outdated Electricity Act, 2003, along with some policy modifications. Therefore, the major proposals of the latest amendment bill merit a close examination especially as the stakeholders including state governments, workers at different levels of the sector, etc have raised concerns about the efficacy of the bill. The paper adopts an interpretive policy analysis approach, where most imperative recommendations of the proposed bill will be evaluated with apprehensions of oppositions to the bill (Browne et al., 2019). In this approach, the paper analyzes five major policy recommendations while narrating the problem in the application of them within the existing framework. In doing so, it also represents the impact of the policies on the “being governed” parties and political rationalities that are expected to counteract. Further, a Policy Field Analysis map is provided to depict the post-reform structure of the electricity sector in India drafted by the bill (Sandfort & Stone, 2008). The Policy field analysis helps in identifying players and the relationship between them in the arena of governance of the sector after the full implementation of the amendments and thus provides insights into other undisclosed narratives.

The remainder of this paper includes a brief description Indian electricity sector followed by a review of literature on past policy reforms, a critical examination of provisions in the new Electricity (Amendment) Bill, and the concluding remarks.

4.2. Context and review of literature

The appraisal of Indian Electricity sector development and its impact on the economic progress of the country is not compact, as the discussion goes beyond the structural capacity and attained utilization. The underdevelopment of the sector in terms of the production, transmission structures built and electrification points out the potential of the sector. The mighty population which is thriving for a better standard of living with sophisticated modern services and the economy that caters to this transformation is expected to improve the current position of the country in the world’s production and consumption of electricity. The universal electrification schemes on the demand side and the heavy push for green energy on the supply side are flag bearers of this transformation process in recent years. The rapid growth of electricity demand in India which is more than overall energy demand also exhibits the growth potential of the sector (International Energy Agency, 2021). The government initiatives like 100% percentage rural electrification under the Deen Dayal Upadhyaya Gram Joyti Yojana, and 'Pradhan Mantri Sahaj Bijli Har Ghar Yojana' (Saubhaagya) also gives an immense push for the sector on the demand side. The estimated electricity consumption registered an increase from 6,94,392 GWh during 2010-11 to 12,91,494 GWh during 2019-20(P), with a CAGR of 6.74%. The larger share of the industrial sector (42.69 %) followed by the domestic sector (24.01%) and the agricultural sector (17.67%) explains the vitality of the electricity sector to the overall economic growth of the country. This is extended to the export trends in the sector were for the period of 2010-11 to 2019-20, export of the electricity has increased with a CAGR of 61.29% (National Statistical Office, 2021).

Even though these figures are highly promising, they will not be able to cover the deep-rooted afflictions in the operation of the sector. The complexities in the regulations and reformations of the sector can be attributed primarily to the constitutional existence of the sector as a subject in a concurrent list where both the union government and regional state governments can make policies. At the same time, the delay in the inevitable reforms needed for any sectors to grow over the years coupled with mismanagement has resulted in corruption, underutilization, and mounting losses of the distribution companies (DISCOMs).

The governance of the sector is headed by the Ministry of power in the union government (established in 1992) and the Department of power in respective state governments. At the policy level, the formulation of the Electricity Act - 2003 marked the beginning of the structurally administrated electricity sector in India. As a holistic legal framework for the sector, the act underlaid the policies regarding the generation, transmission, and distribution of electricity in the country. The act delicensed the generation of electricity and kept transmission and distribution under government watch along with the creation of independent State electricity regulatory commissions for the regulation of tariff rates, subsidies, etc.

The periodic assessment and amendment were needed and intended for the act, but multiple attempts for comprehensive reforms were failed. More than such comprehensive reforms, the policy focus was pulled towards heavy losses incurred by the state-owned DISCOMs and their financial revival. In 2012, a financial restructuring plan (FRP) was announced for that objective. Under this financial bailout package, outstanding short-term liabilities of DISCOMs were taken over by the State government and converted to bonds or restructured by banks with a 3-year moratorium. The UDAY scheme announced in 2015 was also in the same line, which primarily aimed at the financial turnaround of distribution companies. Under the scheme states will take over 75 percent of the debt of DISCOMs (as of September 30, 2015) and balance 25 % of the debt to remain with the DISCOMs, which will be issued as state-backed bonds or reprised by banks. The novelty of the scheme lays on prescribed operational targets given for the participating states with the timeline to achieve them like a reduction of AT&C (Aggregate Technical and commercial) losses to 15% by 2018-19 as per loss reduction targeting and reducing the gap between ACS (Average cost of supply) and ARR (Average revenue realized) to zero by the same period. There was care for the power sector in the Covid-19 economic revival package announced by the union government of India, in terms of providing concessional loans from Power finance corporation and Rural electrification corporation and many relaxations in ongoing payments to the union government.

The Electricity Amendment Bill 2021 is the new addition to this series of reforms aiming at both the financial discipline for distribution companies and framing updated regulatory structure for the sector. The electricity sector in India has been studied on the techno-economic frontier over the years. The extensive studies in the literature on the energy-economy relationships also utilized electricity consumption as the variable for energy consumption. The technological assessment of the sector at the operational level and infrastructure development-based evaluation also finds a reasonable place in the literature, where real policy appraisals are quite limited.

The unprecedented magnitude of opposition against the Electricity Amendment Bill from different state governments and workers' unions seeks academic attention. The common condor of opposition from different sections is the allegations of promoting chronic capitalism to attempt of lacerating the federal structure of the country. The state government ruled by national opposition parties forwarded strong opposition accusing trespass to their powers. Chief ministers of West Bengal and Tamil Nadu wrote a letter to the Prime minister showing the disagreements on different provisions in the bill. The Kerala state legislative assembly passed a resolution on August 5th, 2021 demanding withdrawal of the bill. The state governments, as a stakeholder in regulations of the sector at the regional level and owners of distribution companies, are concerned over a situation of "cherry-picking" by private distribution companies as they would prioritize high-end clients in the urban-industrial segment and leave state distribution companies to operate for the rural agrarian sector and other social sector obligations which will deepen their financial crisis. In addition, the newly entered private distribution companies will be allowed to use existing power supply infrastructure without any new investment and obligations of maintenance which also increases the worries of the state governments. Their objections extend to high penalties for failure to Renewable purchase obligation even in case of genuine reasons like disruptions due to natural calamities and load dispatch provisions, which are in total weakens the power of state governments in the sector (Ramakrishnan, 2021). In the union budget of 2022, the finance minister of India announced the state governments could raise up to 5000 crore rupees as special assistance but should implement power sector reforms. These power sector reforms were precise provisions in the Electricity Amendment Bill 2021. The chief minister of Telangana state opened a new sphere of discussion as he pointed out that the Union government resorted to an alternative way to implement its decisions on a sector where state governments also have equal say.

The resistance from workers unions in the sector and farmers across the country were are more united, that even organizations affiliated with the ruling party have come up with open protest. The employees and engineers in the power sector under the banner National Coordination Committee of Electricity Employees & Engineers (NCCOEEE) and All-India Power Engineers Federation (AIPEF) staged different protests including a one-day national wide strike, protest demonstrations at all state capitals, and four days "Satyagraha"[5] at the national capital. The union government's move to push the bill in the winter session of parliament instigated further resistance from these organizations. The primary blame on union government from these organizations is that, as the major stakeholders in the power sector employees and engineers were never consulted on the drafting of a massive reform like EAB. They claim that their opinions should have been considered prior, as the private distribution companies will be allowed to use the infrastructure which they built after years of labor and toil. The Unions also cites the failure of the distribution sub-licensee model in the state of Madhya Pradesh where the crisis created by private companies is still sub judice before the court. The demand for nullifying Electricity Amendment Bill was raised in the farmers' protests against the three controversial farm laws passed in the parliament of India in September 2020. The farmers fear the bill facilities privatization of the sector which will end free and subsidized electricity supply for the sector.

The basic characteristics of problems in the electricity sector in India are almost similar to the issues that were common in other state-owned and led sectors before the large-scale liberalization policies in 1991. Veluchamy et al. (2018) explain that the unchecked financial losses incurred by the DISCOMs are the result of untargeted subsidies, irrational tariffs,

[5] Satyagraha is a particular form of nonviolent or civil resistance popularized by Mahatma Gandhi in the Indian independence movement.

corruptions and theft, highly manipulative political interventions. The sustainability of the sector along with challenges on energy security of the country will depend on the policy measures to correct these issues in the sector. The failure of the subsidy policies of different states coupled with heavy leakage in both subsidies and theft related to the rural agrarian sector puts pressure on the sector despite 'promising moves' in the supply front in terms of renewable production of electricity. The 24*7 Free electricity supply to agrarian households in states like Telangana also raises concerns on fiscal and power supply sustainability (Mohammed & Chittedi, 2021). On the distribution front, the question of accessibility and availability of electricity has been addressed on a large scale as rural electrification touched 100 percent, and power surplus was marked in the country with one of the world's largest country-wide grids (National Statistical Office, 2021). But still, the financial crisis of DISCOMs shows distorted. The existence of many subcategories and slabs and relying on the Average cost of supply in tariff calculation is one among the crisis pullers as a cost-reflective tariff system is far from the reality (Shankar & Avni, 2021). This distortion is carried forward by cross-subsidies thus the benefits expected by high voltage consumers are not realized (P. Aggarwal et al., 2020).

As the DISCOMs play the role of intermediary between end consumers and generators. The failure in tariff collection which is common affects the needed cash flow to the operation of transmission and generation sectors (Nirula, 2019). Measures to address these delays in payment are expected to be part of reform actions in the whole sector. The efficiency analysis of Sarangi et al.(2021) stated that financial restructuring and reforms in the management style alone will help in total cost saving worth 2387 billion Indian rupees of state-owned DISCOMs. Das & Srikanth, (2020) discussed three structural reasons which leads to the crisis in the Southern states of the country. Firstly, over-ambitious demand projection, which intently results in long-term power purchase agreements (PPA) mostly thermal power stations. Thirdly, the higher share of agriculture and low-income rural consumers are entitled to subsidies which are often delayed (Das & Srikanth, 2020). The paper questions the merit of pushing mandatory power procurement from Renewable energy sources as those result in high cost of procurement and amplifying financial distress (Kanitkar et al., 2020).

Stranger et al. (2021)critically examined the schemes like UDAY claiming that the challenges of DISCOMs in various states are different and single modeled attempts like UDAY are unlikely to give wanted results. Only seven states including Tamil Nadu, Telangana, Kerala, Gujarat, Andhra Pradesh, Goa, and Himachal Pradesh achieved the targets of bringing registered losses below 15 %. The estimated result of Kaur & Chakraborty (2018) exposed the failure of the UDAY scheme as average AT&C losses in all participating states are on an average 25.41 percent and the gap between ACS (Average cost of supply) and ARR (Average revenue realized) has widened in many states (as on October 2018). The fiscal incentive to participating states was common in schemes like UDAY, Deen Dayal Upadhyaya Gram Joyti Yojana (DDUGJY), Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhaagya) which in turn expects DISCOMs to carry out needed structural reforms and investments. However, the mixed outcomes of the UDAY scheme cautious the pattern and design of existing reforms (Kaur & Chakraborty, 2018). There is even evidence showing a negative impact on the public debt level of state governments in the post-UDAY period (Misra et al., 2021). Thus, micro-level approaches are to be promoted where local experience and pastor reforms results will allow much more adaptability in policy implementation. The premises for a new set of reforms was again altered by the challenges posed by the Covid-19 lockdown. The country-wide lockdown resulted in a significant drop in energy consumption levels (Gulati et al., 2021). This was followed by lowered electricity demand as projected earlier, which also affected the anticipated sale in the power market and thus pushed the debt level further high (Kanitkar, 2020).

The call for private sector efficiency as the policy solution for many issues in the sector has been part of different legislations including the Electricity Act of 2003. Mostly the privatization of DISCOMs like in urban centers like Mumbai, Delhi, Kolkata, etc. and the Distribution franchise model are two major attempts implemented in India. Concerns on competitive bidding, lag in transitions, unchanged level of losses incurred, absence of clear operational framework, etc. brought a grey shade to the final verdict on these models. Thus, the majority of states showed reluctance to accept and execute them (Stranger et al., 2021; Thakur et al., 2017) even in the presence of few success stories.

The Electricity Amendment Bill 2021, as a reform package, brings new provisions regarding the basic structure and operation of the sector. Even after multiple failures in carrying out such an amendment, the intention is backed with concerns on the incapability of existing provisions to manage the rapid development in the sector in recent years (Sonkusare & Charan, 2020). The development of the national electricity grid and increase in inter-state transmissions necessitated an entity to monitor and control the same. Here the amendment on the role of the National Load Despatch Centre (NLDC) in the bill becomes more relevant (Sonkusare & Charan, 2020). Another such key provision is the new set of reforms are regarding enforceability PPAs and arbitrations in case of disputes through the Electricity Contract Enforcement Authority (ECEA). However, more critically, Singh & Tongia (2020) argue that the Act fails to address the root causes of the crisis in the sector rather than focuses on the selected challenges which lack a significant push for sustainability, technological up-gradation, etc. For example, the Creation of ECEA and ensuring payment security are only needed for "upstream players" in the sector, not the end of the supply chain. The provisions appeared to favor more centralization of the sector which negates the diversity in the problems in different states. Singh & Tongia (2020) also criticized that creating new institutions for every new problem is not a sustainable solution as conflicts among such Institutions themselves drags the efficiency of the whole system down, rather attempt towards empowering existing institutions will be more creative as experiences of not fulfilling objectives of past reforms and schemes are evident even including Electricity Bill of 2003 itself.

The intention of introducing the Distribution sub licensees' model and private players in Electricity Amendment Bill 2021 blindly is questioned by Kanitkar et al. (2020) as the previous experiences are not propitious. This is accused on the basis that private distributions were only installed in urban centers with bulk consumers. The cost-reflective pricing method also needs to recheck because the longer distribution lines and supporting infrastructure for supply to rural areas will push prices high without subsidies, which will result in an affordability crisis, and thus large sector of rural households will be left out (Kanitkar et al., 2020). In a country like India, it will be suicidal to deny access to electricity for that large section. (Debnath et al., 2021).

The only provision in the bill towards the aim of environmental sustainability is the target-based subscription from renewable energy sources through Renewable Purchase Obligation (RPO). Singh & Tongia (2020) explain that the goal of clean and affordable electricity, should not be fully entrusted to the addition of larger renewable energy-based generation. Debnath et al. (2021) point out over-ambitious transition towards renewable energy sources will not be solely a technological shift in India but a disruption in the existing ecology around the coal-driven Indian economy, where several Institutions, politics, and livelihood will be at stake. In the context of the European Union, (Leal-Arcas & Filis (2014) explain that the development of infrastructure capabilities and sufficient political will are needed for meeting 'renewable share' obligations. The disparities among European Union members in these factors, especially between highly industrialized countries like Belgium, Netherlands, and U.K with lower counterparts shows that such obligations will be a serious challenge for some countries and not for others. Thus, with existing structural bottlenecks even with conventional resources, affording new RPO will be a question in the Indian case.

4.3. Evaluation of The Electricity (Amendment) Bill,2021

A first-hand review of the new bill can be summarized as provisions to enhance payment security mechanism, creation of Electricity Contract Enforcement Authority (ECEA) for promoting investment in the power sector, a further enticement for private players in distribution, cost-reflective electricity pricing, and replacing subsidies with direct benefit transfer (DBT) to the consumer. Even if these provisions appear to be mutually exclusive, on the operational level the interplay between them can cause serious challenges to the existing nature of the electricity sector as a whole and electricity as a public service in specific. Apart from these, the Amendment Bill proposed that a Minimum fixed percentage (as prescribed by the Central Government) of electricity from renewable sources of energy should be purchased by state commissions as Renewable Purchase Obligation (RPO), which appears to be promising. Even if the level of Renewable sources purchase is subjected to further discussion between states and central government, the Bill will assure Renewable Sources in the electricity production of the country from now onwards. This is a great step, considering the fact that India still relies heavily on non-renewable sources like coal for electricity production. Penalty for failure to comply with this Renewable Purchase Obligation (RPO) is an additional assurance that it is not a vague direction that the government expects by the new National renewable energy policy.

Considering the low commercial and investment activities in the electricity sector in India, the bill brings three major attempts to revamp the sector. First, the inception of the Electricity Contract Enforcement Authority (ECEA), second, enhanced payment security mechanism; third, remodeled Distribution sub-licensees system. The bill calls for the establishment of a new Electricity Contract Enforcement Authority. It is intended to fill the gap in the Electricity Act, 2003 regarding issues related to the enforceability of Power Purchase Agreements (PPAs) and contracts related to transmission. The proposed ECEA will be the sole adjudicating authority with original jurisdiction upon matters on the performance of obligations under a contract regarding sale, purchase, and transmission of electricity, with the exclusion of jurisdiction on the determination of tariff or any other dispute regarding tariff. Under the Amendment Bill, the orders of ECEA will be executed in the same manner as in the case of a decree of a civil court. Further, an appeal against the orders of ECEA will be heard by the Appellate Tribunal for Electricity (APTEL). Considering the need for a strong authority for watching contractual obligations especially when the cases of parties not honoring contracts are not rare, ECEA is a reassuring step towards the confidence of stakeholders like licensees and power generators. The questions regarding the establishment of another semi-judicial authority exclusively for one commodity or service can be dumbed on the existing overloaded judicial system in the country, but the demarcation between regulating and enforcing contracts is unclear. And it is not an unknown fact that one of the major reasons for the financial woes of state distribution companies (DISCOMS) are crores of rupees they pay to the power generating company, even if their power was not consumed, as a fixed cost under power purchase agreements (PPAs). The amendment bill lacks in providing provisions to amend such contracts rather than enforcement by ECEA.

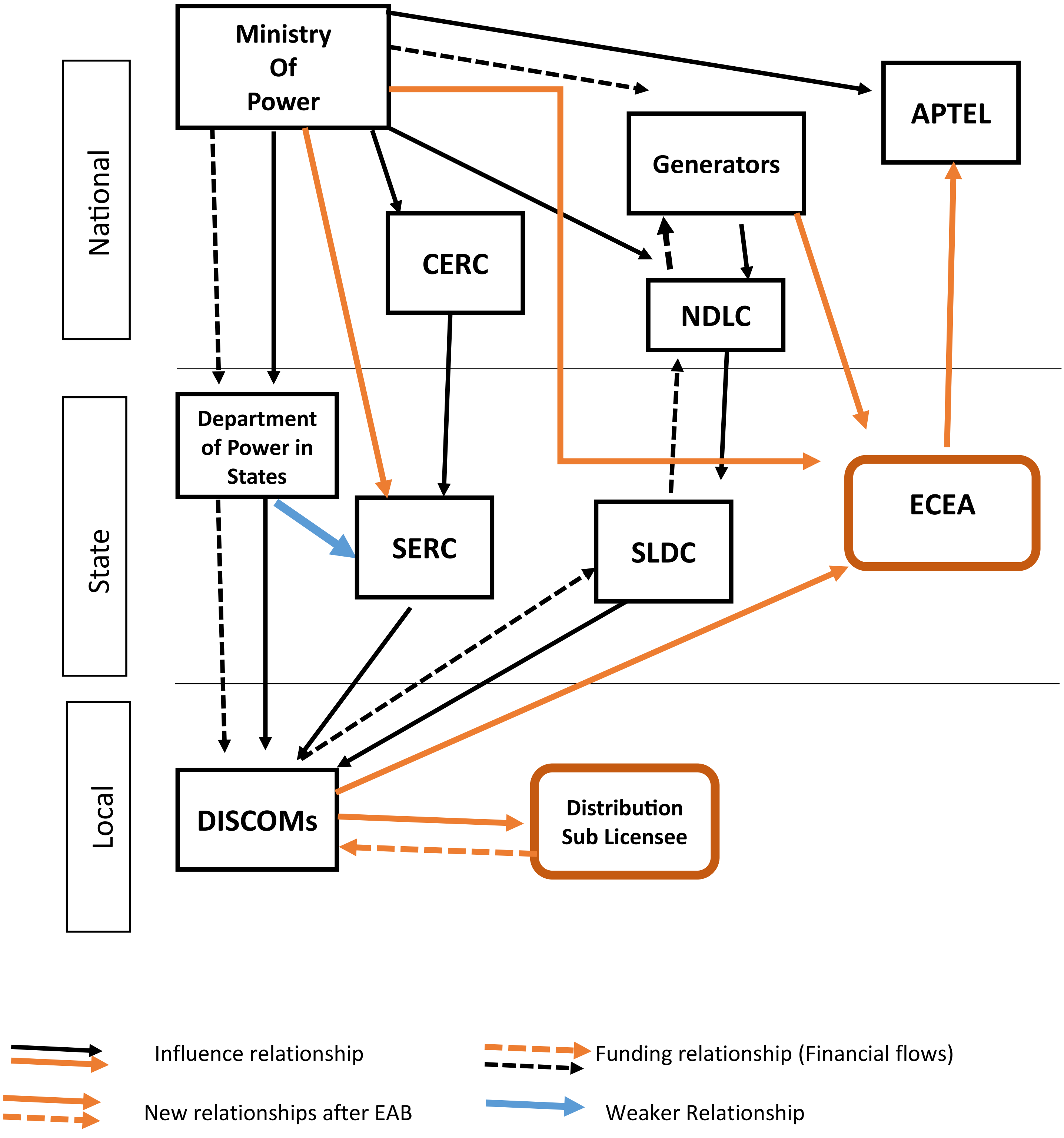
The large pool of unpaid dues to power generators was the result of the absence of any sturdy payment security mechanism for the scheduling of electricity. The Amendment bill proposes a mechanism wherein "no electricity shall be scheduled or despatched under such contract unless adequate security of payment as agreed upon by the parties to the contract, has been provided". The National Load Despatch Centre will be assigned to oversee the payment mechanism before scheduling the despatch of electricity to the states.

The financial stresses of state-owned electricity distribution companies are always a policy challenge for the government. The schemes like Ujjwal DISCOM Assurance Yojana (UDAY) were an attempt to taper this and revive the financial health of distribution companies. The amendment bill proposes, a new approach as a solution, that any distribution licensees, can appoint another entity as a "distribution sub-licensee" for distribution of electricity on its behalf, within its area of supply. The sub-licensing will allow states to select private companies for the distribution of electricity supply in a particular area. Even if there are claims about the distinction between the sub-licensee and the existing "franchisee" model, there is complete ambiguity about the mechanism. The franchise model is the existing partial privatization model in the electricity distribution, which was operating in cities like Gaya, Kanpur, Gwalior, Ujjain, Aurangabad, Ranchi, and Jamshedpur. This system lacked its precision and failed, as the regulatory commissions were compelled to cancel the franchise (Stranger et al., 2021; Thakur et al., 2017). So, in the absence of a clear framework to operate, privatizing the distribution of electricity will end up changing the prime focus from providing public service to private profit and thus the emergence of private monopolies.

The most controversial element in the amendment bill is regarding the provisions on retail tariffs and subsidies. The first impact of the new bill that will affect common people is the new method of retail tariff determination. The bill directs the appropriate commission to determine the tariff for the retail sale of electricity, which should reflect the actual cost and should not account for any subsidies. The benefit of subsidies will be there after being granted directly to the consumer through the Direct benefit transfer (DBT) method. Further, based on tariff policies, surcharges, and cross-subsidies shall be progressively reduced. At the operational level, the licensee charges the consumer as per the tariff determined by the commissions without accounting for subsidies and the consumer including farmers will have to pay the bill amount full and expect the subsidies amount to reach them. This is a double-edged sword on farmers in the country, firstly, the future of free electricity schemes in many states will be put on hold and secondly, the farmers will be compelled to pay the full electricity bill in advance, where 'the ability to pay principle will be a matter of discussion. Considering the introduction of private distribution companies by the amendment bill, now by a delay in payment of subsidies (which is a common practice for many other DBT subsidies) by the government, will finally end up in franchisee cutting off the connection of farmers. It is to be noted that the Amendment bill is specifically silent on free electricity schemes to farmers in many states like Telangana, whereas the proposed bill has many provisions that have heavy implications on such schemes. The opposition from states including Telangana, Tamil Nadu, Andhra Pradesh is crucial in this regard.

One of the core reasons for the state governments to oppose the new amendment bill is because the very nature of the bill is against the existing constitutionally structured federal system in India. Electricity is a subject in the concurrent list of the constitution of India, where both union and state governments can make policies and laws governing the sector. The amendment bill proposes increased centralizations where many discretions and rights of state governments are meticulously removed. In the Electricity Bill, 2003 itself there were attempts to curdle the role of state governments like the power to set tariff and other parameters were transferred to the independent regulatory regulator from state electricity board. The new bill moves further by creating a new independent contract enforcement authority and assigning National load despatch centers to oversee the payment-security mechanism before scheduling the despatch of electricity. The establishment of ECEA over the state regulatory commissions will reduce their role and future of renegotiations, and amendments that state government will intend to initiate on contracts will be at stake. Further in the amendment bill, the role of the state commission in the determination of cross-subsidies is dethroned and the mandate of the union government will be replaced. The introduction of the single selection committee for appointment of members of the Appellate tribunal for electricity and members of ECEA, Central commission, State commission, and Joint commissions, appear to be very innocent, but it will take away the right of states to appoint officials to its state electricity regulatory commission. These can be concluded as the impertinence towards Indian federalism. A policy field analysis map is presented here to present this increased centralization (Figure 1). The new relationships envisaged by the bill give undisputable control to union governments on the electricity sector of the country, over the state governments. The appointments in State electricity regulatory commissions and creation of ECEA will give direct access for the union government to regulations and enforcement departments of the sector at the state level for manipulations.

Figure 4.1: Policy field map of Indian electricity sector post-Electricity (Amendment) Bill, 2021



CERC/SERC: Central/State Electricity Regulatory Commission

NDLC/SLDC: National/State Load Despatch Centre

ECEA: Electricity Contract Enforcement Authority

APTEL: Appellate Tribunal for Electricity

4.4. Conclusion

It is an undebatable fact that many provisions of the Electricity Act 2003 needed updates considering various developmental hurdles, but any reforms are defined as reforms when they will fulfil the pre-determined objectives and serve as a future-oriented statutory paradigm. In that sense, the final verdict on the draft of the Electricity (Amendment) Bill, 2021 is on a grey shade.

The paper discussed the few vital reforms recommended by the Electricity (Amendment) Bill,2021 that are capable to reconstruct the entire electricity sector of India. Our analysis suggests that the existing crisis regarding the financial health of DISCOMs and its complexities are addressed by the bill through different approaches including enhanced payment security mechanism, redesigning tariff calculations, the enforceability of contracts, and better monitoring. Even if the intentions behind each of these provisions are meritorious, what is lacking is an adequate understanding of the impact of these changes on various stakeholders. The share of rural agrarian households in the population of India is one such section where policymakers should be well aware of, in the process of framing reforms, as their aspirations are assimilated. The concerns of the state governments and workers in different departments of the sectors also deserve attention. Therefore, concerted efforts should be made to gain their confidence. Respecting the opposition from state governments and workers' unions, the union government's decision to slow down the process of passing the bill, along with considering dilution of certain clauses are appreciable, but imposing them through alternative ways such as making them as eligibility for special financial assistance will be detrimental. If a consensus on entry of private distribution companies and subsidy system is derived, the EAB will be instrumental in transfiguring the sector. The provisions on minimum coverage areas and a mix of Urban-rural areas to this are expected to help bring the accord, which will ensure pragmatism in the implementation of the bill. In that way, beyond a blind acceptance of private participants as the sole solution, EAB will ensure to cater increased demand of electricity from rural sector post electrification drives and exponential growth of urban centers in the country. (S. Dasgupta, 2021). The current government has achievements like the success of rural electrification through the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) program in its credit. From such a government, a more prudent and inclusive approach is expected while making prodigious reforms.

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Chapter 5

TRANSPORT INFRASTRUCTURE AND MANUFACTURING SECTOR: AN ENERGY PERSPECTIVE FROM INDIA

5.1. Introduction [6]

The development of transport infrastructure is a critical step in the process of overall development of any region. Thus, it is argued that transport infrastructure enhances the mobility of people, goods, and information which ensures the operation and progression of the economy(Mohmand et al., 2021). In this vein, the important role of transport infrastructure is established on many parameters in the literature, such as resource mobilization and productivity augmentation (Pradhan & Bagchi, 2013), employment generation (Nenavath, 2021), labour productivity (Deng, 2013), and poverty reduction (Haimin, 2010). Moreover, the transport infrastructure generally includes roads, railways, airports, and seaports; their performance and development are expected to positively affect the growth of the economy (Deng, 2013). As a result, the transport infrastructure gained relevance in the policy discussions of both developed and developing countries (Liu, 2018; Menon & Mahanty, 2012). Hence, policymakers in India always gave importance to the development of transport infrastructure to facilitate its human capital development and productive capacity enhancement(Ahmed et al., 2013).

Moreover, this is evident from the increased capital spending on infrastructure development in India since the 1991 economic reforms. For instance, in India, the total investment in the roads and highway sector has gone up more than three times in the six years from FY15 to FY20 Press Information Bureau (PIB, 2021). Similarly, in terms of performance, domestic air traffic has shown a growth rate of over 14 % per annum. Moreover, the immense pressure on the energy sector of India asserted by the 1.21 billion population and sectors catering to this population always seek attention for energy viability of development activities. Hence, transport infrastructure development also comes under this review as this sector is considered to be an intense consumer of energy globally, especially fossil fuels (Neves et al.,

[6] The main content of this chapter has been published in the International Journal of Energy Sector Management (Scopus Indexed – Q2, Publisher: Emerald Group Publishing Ltd.), titled “Transport Infrastructure and Manufacturing Sector: An Energy Perspective from India” (DOI: 10.1108/IJESM-04-2022-0010).

2017). For example, oil has become a significant source of energy in transportation, which accounts for nearly 50% of India's total oil consumption in 2020 (IEA 2020). It also established that 29 per cent of the total passenger transport energy consumption is jointly shared by three-wheelers and buses, while 31 per cent, 27 per cent, 5 per cent and 8 per cent of the total passenger energy consumption attributed to two-wheelers, four-wheelers, rail, and domestic aviation, respectively[7]. Besides, this sector holds a significant 10.22 per cent of total final energy consumption in India, which is projected to increase over the years (NSO, 2021). Even though the COVID-19 pandemic and lockdown reduced energy demand in the country by a fall of 5 per cent, it is expected to reach the pre-pandemic levels with a faster growth rate (WEC, 2021).

On that account, the trivia of transport sector energy consumption in India need to be studied. Unfortunately, the prominent section of studies is based on transport infrastructure - economic growth relationships and the transport sector - energy consumption relationships which are visibly extensions of the economic growth-energy consumption nexus discussion. Further, the majority of existing literature on transport sector energy consumption is confined to causality studies between transport sector energy consumption and economic growth with different data periods, methodologies, and proxy variables with inconclusive empirical findings (Liu, 2018; Menon & Mahanty, 2012). Thus, unlike the existing studies, this study specifies three questions about transport sector energy consumption that are valid in the Indian context: i) how transportation infrastructure performance contributes to the transport sector energy consumption? ii) what is the role of public expenditure in transport-on-transport sector energy consumption? ii) whether manufacturing growth contributes to the transport sector energy consumption or not?

Furthermore, the theoretical underpinning of higher public investment in transport infrastructure is majorly related to economies of agglomerations, which is empirically observed in many countries. Hence, the importance of the manufacturing sector has been emphasized in the growth progression of India since its independence (Shameem P et al., 2022; Villanthenkodath et al., 2021), and the special nurturing enjoyed by post-economic reforms makes this sector responsible for producing a positive impact through the agglomeration effect of transport infrastructure development. As a sectoral-level analysis, this study will become an

[7] For more details of transportation of India (see https://www.ceew.in/publications/india-transport-energy-use-carbon-emissions-and-decarbonisation#315)

appraisal of transport infrastructure performance, public spending in transport infrastructure development and the manufacturing sector in determining the transport sector energy consumption for the study period.

The remainder of the paper is structured as follows: the literature review is discussed in Section 2, followed by the data and methodology in Section 4. The empirical estimation and results are presented in Section 5, followed by conclusions.

5.2. Review of Literature

The existing literature pertaining to the current study can be divided into three distinct sections. The first section related to public infrastructure investment impact on the economy, followed by studies focusing on transport infrastructure. And the third section is related to the energy consumption of the sector incorporated into the first two strands. The transport sector energy consumption entered as a variable in the sectoral level analysis of economy-energy nexus studies. The emergence of studies on the dynamic relationship between transport infrastructure, public investment, and energy consumption of the sector is limited in the context of India. Thus, the study with a focus on transport infrastructure performance, public spending in transport infrastructure development and the manufacturing sector in determining the transport sector energy consumption will be a path-breaking empirical exploration in this domain. As a democratic country with governments at different levels, the public provisions of infrastructure are audited with periodic elections in India. Historically also, governments are assigned to be major stakeholders in investment in public infrastructure, including transport in India.

5.2.1 Public infrastructure

Theoretically, two prominent prepositions on public investment in infrastructure are Wagner's law and endogenous growth theory. According to Wagner's law, economic development leads to higher investment in public infrastructure. The Keynesian discussion on crowding out and the effect of public infrastructure investment was countered later, and the endogenous growth theory received attention, which supported the notion that investment in infrastructure will promote economic development. This production function-based approach gave an immense push for later studies on public infrastructure investment. Han et al. (2020) braced the view that developing countries should make more investment in infrastructure development as increased infrastructure per worker has a greater impact on those economies having a larger young population. To conclude, Ramey (2020) stated public investment spending in infrastructure enables to reach higher output potential of the economy, as they can be Keynesian demand stimulus in the short run and Neoclassical supply stimulus in the long run. However, interestingly, the structural macroeconomic model revealed a significant crowd in effect between private and public sector investment in the real economy of India, which include agriculture, manufacturing, infrastructure, and service sector. Huang & Peng (2014).

5.2.2 Transport infrastructure

More specific attention to transport infrastructure and its impact on economic growth was gained after the unfolding of the new economic geography approach. Using data from 1995 to 2010, the dynamic panel analysis of Chi (2015) explained that government spending on transport infrastructure was an inevitable force in the economic growth of European countries through its positive impact on impact employment, GDP, exports, and industrial production. In addition, Vlahinić Lenz et al. (2018) found that during the transition period in Central and Eastern European Member States, investments were concentrated on roads and railways structures which later had a positive impact on the economic growth of the regions. In the case of China, the structural up-gradation of transport infrastructure positively impacted the regional economic growth during the period 2007–2015 (Ke et al., 2020). A similar conclusion has been reached by (Sun et al., 2021; Wang et al., 2020). However, the absence of studies on the Indian context with special attention to the manufacturing sector should be noted here

Empirical studies supporting a positive relationship between transport infrastructure development and economic growth in India are also present in the literature. Pradhan & Bagchi (2013) found bidirectional causality between road transportation and economic growth for the period 1970 - 2010. The estimated results of the Vector Error Correction Model (VECM) also showed bidirectional causality between road transportation and capital formation in India. The autoregressive distributed lag (ARDL) and vector error correction model (VECM) models of Pradhan et al. (2013) analyzed the cointegration between transport infrastructure with foreign direct investment and economic growth. The study concluded that the development of transport infrastructure should be considered a prerequisite to promoting foreign direct investment and economic growth in the country. The estimated results of the ARDL model of Nenavath (2021) also followed the conclusion that transport infrastructure has a positive impact on economic growth in the long run, with a one-way causality running from transport infrastructure to economic development over the period 1990 – to 2020. The results of Mitra et al. (2012) followed a conclusion by citing infrastructure provisions will help industries face strong international competition and help their exporting capacity. Kailthya & Kambhampati (2022) analyzed the effect of roads on manufacturing productivity in India using plant-level data from 1998 to 2012. Beyond the expected reduction in the transport cost by enhanced road infrastructure, the study found that improved infrastructure will stimulate economic activity in total, which results in higher manufacturing total factor productivity. The World bank Enterprises survey mentioned that one of the major obstacles for Indian manufacturing units (10%) are the absence of needed transportation infrastructure (World Bank, 2014).

5.2.3 Energy consumption

A multivariate analysis combining transport infrastructure and economic growth with energy consumption of the transport sector is the final set of studies related to the current study in the literature. This inclusion of transport energy consumption was based on the higher energy use and emission contribution by the sector. However, a negative relationship was forwarded by Neves et al. (2017) for OECD countries using bound test results. As mentioned, in the earlier section, for individual countries' cases, this relationship was found to be diverse where few related variables also were studied. Lin & Du (2015) studied data from 30 provinces in China from 1997 to 2011 and revealed that disparities in income level and urbanization level affect the energy demand from the transport sector in different provinces. The positive relationship between transport energy consumption and economic growth was established for Malaysia (Azlina et al., 2014), Tunisia (Achour & Belloumi, 2016), Egypt (Ibrahiem, 2018), Pakistan (Danish & Baloch, 2018; Mohmand et al., 2021).

The expansion in the volume of transport, structural change, and energy intensity were counted by Tiwari & Gulati (2013) as determining factors in transport sector energy consumption in India. The study also stated that despite the energy intensity of different transport means slumped over the years, the surge in transport volume is the major determinant of energy demand for both passenger and freight transport. A notable early study integrating transport infrastructure, energy consumption, and economic growth was by Pradhan (2010). Using Johansen cointegration and the VECM Granger causality approach, the study estimated an intuitive relationship between variables for the period 1970-2007. The findings include one-way causality from transport infrastructure and economic growth to energy consumption in India. However, in the Indian context, studies on transport energy consumption following transport infrastructure performance, public spending on transport and manufacturing output as the determinants received less attention in the literature.

5.3. Data description and methodology

In this study, we investigated the impact of transport infrastructure performance, public spending on transport infrastructure, and value-added in the manufacturing sector on transport sector energy consumption in India over the period 1987 to 2019. A brief introduction to the variables used and their measurements are given in Table 1. In order to begin with the variable used, transport infrastructure development in India is predominantly funded by the union government and state government. Hence, the combined spending of both of these governments is used in the study, including capital and revenue expenditure. Further, the current study developed two indexes for analysis, the transport infrastructure performance index and the transport energy consumption index. For doing so, the principal component analysis (PCA) was applied because PCA is a statistical approach commonly used to examine and diagnose that have an internal correlation.

Table 5.1. Description of variables

Variable	Definition	Unit of measurement	Source
INFRAPI	Infrastructure Performance Index		
	Ports: Traffic at All Ports	000 tons	Centre for Monitoring Indian Economy
	Road: Length	total Kms	Centre for Monitoring Indian Economy
	Road: Density	Total Km per '000 sq km of area	Centre for Monitoring Indian Economy
	Railway: Freight Traffic	'000 tons	Centre for Monitoring Indian Economy
	Railway: Passenger traffic	Million units	Centre for Monitoring Indian Economy
	Railway: Route Length	Total Kms	Centre for Monitoring Indian Economy
	Air: Freight carried	Million ton-km	World Development Indicators
	Air: Passengers carried	Total number	World Development Indicators
TENERGY	Transport Sector energy consumption Index		
	Oil Consumption	Million tons	B.P. Statistical Review of World Energy
	Electricity: Traction & Railways	Gigawatt hours	Energy statistics
PUBSP	Public Spending in Transport infrastructure	Rupees in Crore	Indian Public Finance Statistics
MANV	Value Added in the Manufacturing sector	At 2011-12 Price (in Crores of ₹)	India KLEMS

Sources: Authors' compilation.

In order to have a holistic perspective of the transport infrastructure, eight variables from four different transport means, namely port, road, railway, and air, are used in the construction of this index. Data on all components are extracted from the database of CMIE for the period. For better precision and data availability, for the transport sector, energy consumption data was taken from two data sources. However, the oil and petroleum consumption data from the B.P statistical review of world energy and electricity consumption by the railway and transportation sector is sourced from different volumes of energy statistics by the National Statistical Office (NSO) of India. Further, this two are combined using PCA to develop the index for transport energy consumption.

Table 5.2A explains the PCA to develop a transport infrastructure performance index. The first part of Table 5.2A shows the maximum eigenvalue of 7.646 for component 1 and 0.214 for component 2 as follows. The first component indicates a 95.58 % proportion of variation, followed by 2.68 % by the second component and 1.37 by the third component. Section of Table 2 specifies eigenvalue loading in all 8 components. In terms of strength, component 1 is again evident here, which is thus integrated into the construction of the Transport infrastructure performance index, confirmed by the scree plot test. A similar approach is followed for developing the transport energy consumption index. The first segment of Table 2B shows eigenvalues are assigned to two components, in which component 1 has a higher eigenvalue here. Moreover, the proportion of variance to component one is 99.67 %. The eigenvalue loading into components are Lntanoil and Lntranel explains why component one is considered for the construction of the index. However, the scree plot of the index is given in Figures 1A&1B. Finally, value added in the manufacturing sector is used as the variable for the growth of the manufacturing sector in the country.

Table 5.2A. Transport Infrastructure Performance Index

Eigenvalue calculation				
Number	Value	Difference	Proportion	Cumulative Proportion
Component 1	7.6466	7.4323	0.9558	0.9558
Component 2	0.2143	0.1049	0.0268	0.9826
Component 3	0.1093	0.0934	0.0137	0.9963
Component 4	0.0158	0.0084	0.002	0.9983
Component 5	0.0074	0.0026	0.0009	0.9992
Component 6	0.0047	0.0033	0.0006	0.9998
Component 7	0.0014	0.0014	0.0002	1
Component 8	0.0001	-	0	1

Coefficient estimation for PCA of Transport Infrastructure Performance Index								
Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Lntraf	0.3526	-0.4485	-0.1645	-0.2085	-0.315	0.6104	0.3612	0.0404
Lnroad	0.3605	0.0341	-0.1878	-0.0499	-0.3293	-0.4622	0.1481	-0.6979
Lnrodden	0.3607	0.0105	-0.1717	0.0069	-0.3343	-0.475	0.0188	0.7089
Lnfr	0.3574	-0.3185	-0.0387	0.031	0.0326	0.0949	-0.8666	-0.0849
Lnpase	0.3539	-0.3754	0.0204	0.5794	0.4957	-0.148	0.2984	-0.0042
Lnroutle	0.3406	0.6036	-0.5469	0.2472	0.2467	0.3137	-0.0054	0.0096
Lnairfr	0.3434	0.4241	0.7304	0.148	-0.3154	0.2156	-0.029	-0.009
lnairpas	0.3586	0.1046	0.1808	-0.731	0.5229	-0.1107	0.0792	0.0373

Table 5.2B. Transport sector energy consumption Index

Eigenvalue calculation				
Number	**Value**	**Difference**	**Proportion**	**Cumulative Proportion**
Component 1	1.99343	1.98686	0.9967	0.9967
Component 2	0.00657	.	0.0033	1

Coefficient estimation for PCA of Transport Infrastructure Performance Index		
Variable	PC1	PC2
Lnoil	0.7071	0.7071
Lnelec	0.7071	-0.7071

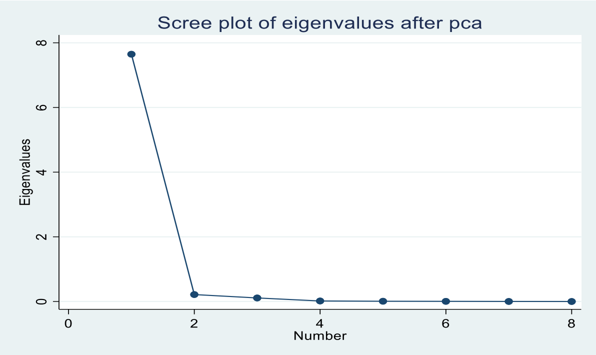


Figure 5.1A: Scree plot of Eigen values for Transport Infrastructure Performance Index

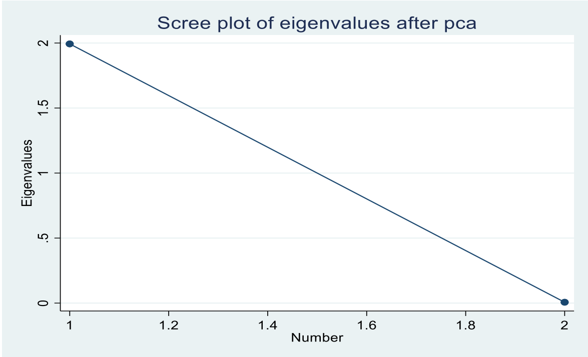


Figure 5.1B: Scree plot of Eigen values for Transport sector energy consumption Index

The model for assessing the determinants of transport sector energy consumption is specified by equation number 1.

$$Tranenrgy_t = f(Infrpi_t, Pubsp_t, ManV_t) \quad (1)$$

The specified model in equation 1 is based on the existing literature on the association of mentioned independent variables with the energy consumption in the sector. The inclusion of all major transport structures in the construction of the index also assures that the specified model is free from omitted variables bias. Where $Tranenrgy$ = transport sector energy consumption, the dependent variable, *Infrapi* = transport infrastructure performance index, *Pubsp* is public spending in transport infrastructure, and *ManV* is the proxy for value Added in the manufacturing sector. However, the study uses the log-linear model by following (Muazu et al., 2022; Taşkın et al., 2020; Villanthenkodath & Velan, 2022) for estimation.

The primary step in the time series analysis especially involving the cointegration test is to check the stationary properties of the variables. A time series is said to be stationary if the mean and variance of the series do not change over time. The standard Augmented Dickey-Fuller (Dickey & Fuller, 1979) and Phillip-Perron (Phillips & Perron, 1988) are used in this study to test the problem of the unit root of variables.

The empirical estimation of the long-run and short-run relationship in the study is based on the Autoregressive distributed lag (ARDL) bound test approach of cointegration developed by Pesaran & Shin (1995) and Pesaran et al. (2001). The ARDL bounds testing method is expected to give superior results in this study than any other conventional cointegration technique because of various reasons. Firstly, this technique is proved to be more effective than other methods in small sample sizes, from 30 to 80 observations. This method can be employed irrespective of their order of integration or mixed cointegration, yet it provides reliable results. Finally, the ARDL bound testing approach addresses the problem of endogeneity of regressors and unbiased estimates of the long-run model (Harris & Sollis, 2003).

The FMOLS developed by P. Phillips & Hansen (1990), DOLS by Stock & Watson (1993), and CCR model by Park (1992) are employed to validate long-run elasticities Dogan & Kirikkaleli (2021), Bildirici & Gökmenoğlu (2017). Optimum cointegrating regression estimates among series with an order of integration one are indicated by the FMOLS approach. FMOLS approach is superior in addressing serial correlation and endogeneity problems without affecting the robustness of estimates. The DOLS procedure is an alternative estimator for the long-run equation. It is recognized to have advantages over FMOLS, with the distinctive characteristic of DOLS being an asymptotically efficient estimator and the capacity to remove feedback in the cointegrating system. DOLS may be used in place of FMOLS, as proposed by

Saikkonen (1991) and Stock & Watson (1993). The process of estimation in DOLS has led and lagged to the cointegration regression. When converting variables in their second order, the OLS estimator falls short. As a result, the Canonical cointegration regression (CCR) approach excels in eliminating the bias of the second order. In addition, a modified Wald test-based causality check and several post-estimation diagnostic tests, including J.B., L.M., and ARCH tests for model stability, are also performed in this study.

5.4. Empirical results and discussions

While beginning the discussion of estimated results, the summary description of the variables in the study are presented in Table 3. It shows that the value added in the manufacturing sector shows the highest average among the variables. The transport energy index developed in the study is negatively skewed, and the rest three variables are positively skewed. However, the trend and shape of the variables in the analysis are illustrated in Figure 2; the positive trend has been evident for all the variables.

Table 5.3 Descriptive statistics

	TENERGY	INFRAPI	LNPUBSP	LNMANV
Mean	-0.048314	-0.043848	10.35004	13.57162
Median	-0.001025	-0.205203	10.29313	13.47355
Maximum	1.469315	1.378739	12.40407	14.65969
Minimum	-1.816831	-1.440495	8.313838	12.53176
Std. Dev.	0.976086	0.983242	1.346804	0.639338
Skewness	-0.206756	0.103355	0.005474	0.110778
Kurtosis	1.904778	1.497908	1.570251	1.808398
Jarque-Bera	1.827338	3.065345	2.725734	1.958670
Probability	0.401050	0.215958	0.255926	0.375561
Sum	-1.546034	-1.403128	331.2014	434.2919
Sum Sq. Dev.	29.53509	29.96972	56.23034	12.67134
Observations	32	32	32	32

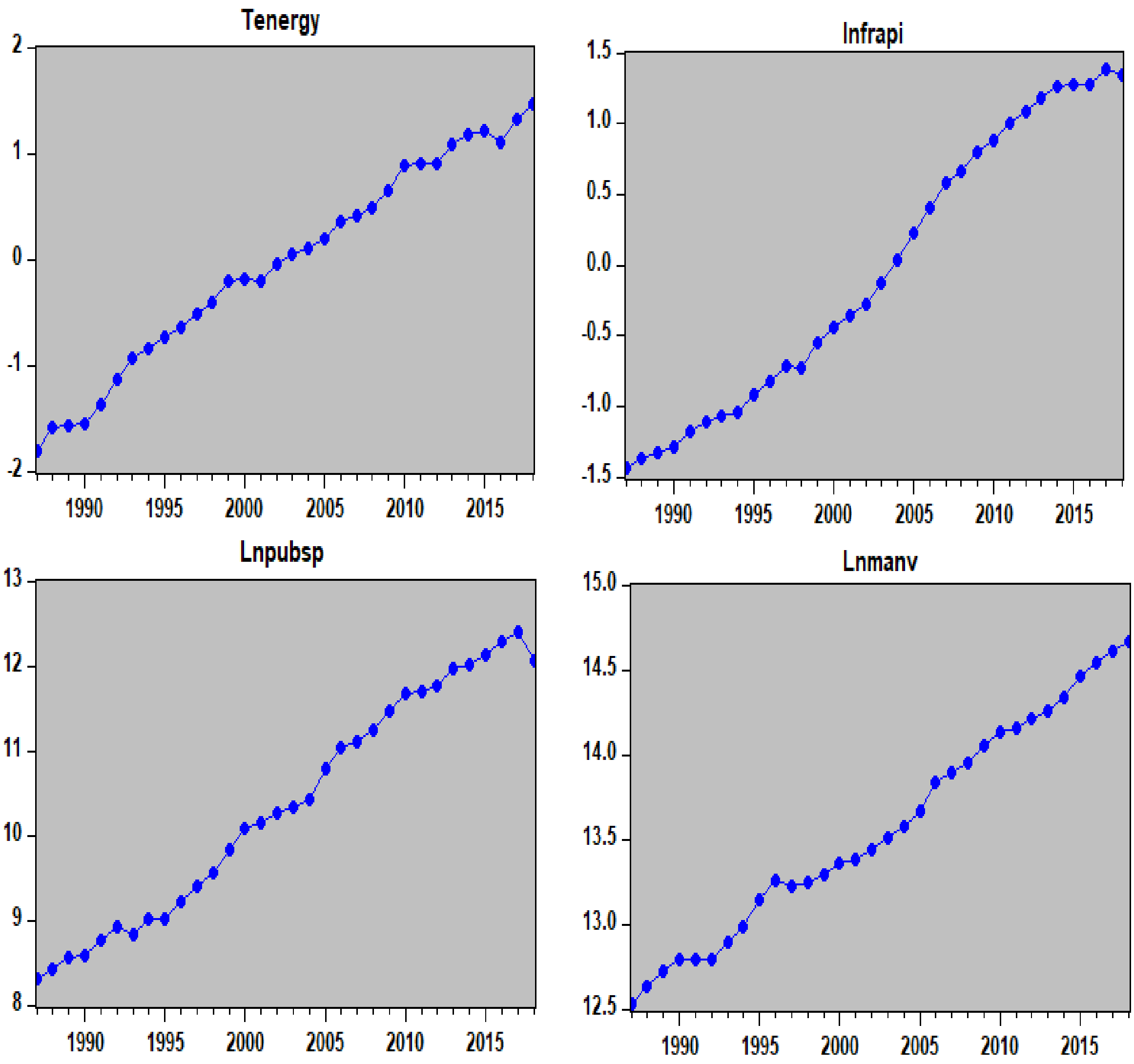


Figure 5.2. The visual plot of variables

The preliminary exercise for the assessment of any significant association between time series data is to identify the order of integration. As mentioned in the earlier sections, the advantage of the ARDL approach is that it allows for analysis even with the variable of mixed order of integration, but it is a prerequisite to ensure none of the series follows the I (2) order of integration. The Augmented Dickey-Fuller and Phillip-Perron tests are applied to test the order of integration. The results of unit roots are presented in Table 4. The estimated results show that the null hypothesis of both tests is rejected at the first difference for all variables, which explains that all variables are found to be stationary at the first difference. As they are integrated into the order, I (1) and the existence of any cointegrating relationships among the variables should be identified.

Table 5.4. Results of unit root tests.				
	ADF		PP	
Variables	Level	First difference	Level	First difference
Tenergy	-2.197	-5.750*	-2.880	-8.237*
Infrapi	-0.196	-3.515*	-0.246	-3.531*
Lnpubsp	-0.941	-3.864*	-0.941	-3.864*
Lnmanv	0.177	-4.039*	0.590	-4.173*
1% critical value	-3.679	-3.679	-3.661	-3.670
5% critical value	-2.967	-2.967	-2.960	-2.963
10% critical value	-2.622	-2.622	-2.619	-2.621

Note:* indicates 1% significance.

The application of the ARDL bound test developed by Pesaran and Shin (1995) and Pesaran et al. (2001) successfully established the long relationship between the variable. The AIC was used to identify the optimal lag for the study. The result of the ARDL bounds test is reported in Table 5. After that, the long-run and short-run results obtained from the estimated model are reported in Table 6. As mentioned earlier, the model examines the impact of the transport infrastructure performance index, public spending in the transport sector, and value-added in the manufacturing sector on energy consumption in the transport sector. The estimated results confirm the existence of cointegration between the variables. Few long-run and short-run relationships are found to be significant.

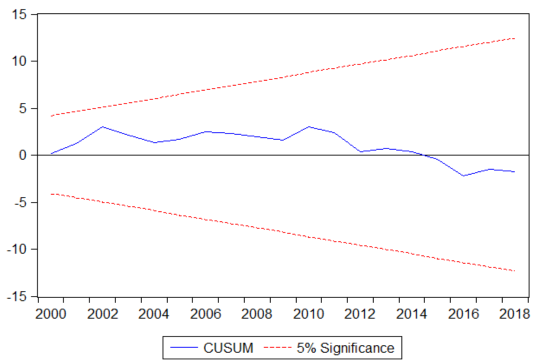
Table 5.5. ARDL Bound test				
Model:				
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.564082*	10%	2.37	3.2
K=3		5%	2.79	3.67
		1%	3.65	4.66
The critical value of Narayan (2005) has been used by authors				
Note:* indicates 1% significance.				

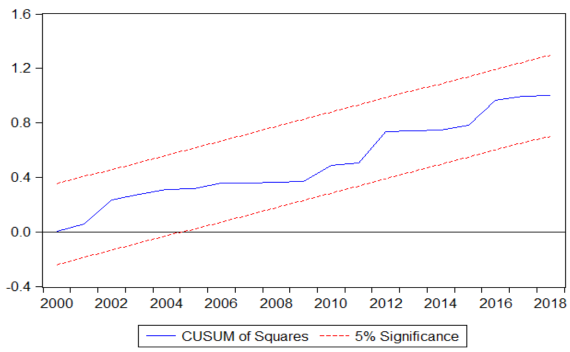
Table 5.6. ARDL Test results

Variable	Coefficient	t-Statistic	Prob.
Long run			
INFRAPI	-0.157000	-0.426856	0.6743
LNPUBSP	-0.191978	-0.669168	0.5114
LNMANV	2.143736	4.385382	0.0003*
Constant	-26.89505	-4.551168	0.0002
Short-run			
TNERGY(-1)*	-0.474190	-3.738645	0.0014*
LNPUBSP	-0.091034	-0.710261	0.4862
LNMANV(-1)	1.016539	3.303088	0.0037*
D(INFRAPI(-1))	0.697849	2.219426	0.0388**
D(LNMANV(-1))	-1.123578	-2.939335	0.0084*
D(LNMANV(-2))	-0.987977	-2.386473	0.0276**
ECT	-0.474190	-5803218	0.0000*
Diagnostic tests			
χ2 NORMAL	0.175(0.9161)	R-squared	0.55
χ2 SERIAL	0.645(0.5366)	Adjusted R-squared	0.488
χ2 ARCH	1.2130.2808)	Durbin-Watson stat	1.945

Note:* and ** indicates 1% and 5% level of significance.

Figure 5.3 Stability of the estimated model





Particularly, the significant observation identified by the ARDL bound test is the short-run and long-run impact of manufacturing sector growth on transport energy consumption. Thus, the positive relationship explains that the energy demand of the transport sector will be associated with the growth of the manufacturing sector in India. The short-run results point outs that the performance of transport infrastructure in the country affects the energy consumption in the sector, which supports the mobility demand of the emerging economy. The progression of the economy and improved quality of people's life will result in higher demand for mobility which is reflected in the transport infrastructure performance in the study. The Error correction term incorporated in the model shows a moderate speed in convergence to long-run equilibrium. The diagnostic tests for heteroscedasticity, serial correlation, graphs, and ARCH problems confirm that the model is free from such errors and ensures the needed stability. Besides, Figure 3 shows the stability of the estimated model.

However, the long-run association between dependent and independent variables is presented as a result of FMLOS, DOLS, and CCR methods in Table 7. The relationship between manufacturing sector performance and transport energy consumption is reaffirmed by these tests also. Over the years manufacturing sector in the country has held a major share in total energy consumption. The results of sectoral level analysis, like the current study, reveal that the energy demand of the manufacturing sector is multifaceted, with evidence of transport energy consumption.

Table 5.7: Long-run cointegration regression analysis (FMOLS, DOLS, CCR)

Dependent variable: Tenergy

	FMOLS		**DOLS**		**CCR**	
Predictors	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**
INFRAPI	-0.897	-2.360*	-0.850	-1.767***	-0.829	-2.221*
LNPUBSP	0.698	2.780*	0.447	1.143	0.672	2.302*
LNMANV	1.421	3.927*	1.871	3.378*	1.370	3.623*
Constant	-26.61	-5.133*	-30.17	-4.522*	-25.64	-5.365*
R^2	0.978		0.989		0.978	
Ad R^2	0.975		0.981		0.976	

Note:* and *** indicates 1% and 10% level of significance, respectively.

Further, the outcome from FMLOS, DOLS, and CCR significantly disclose a negative impact transport infrastructure performance index on energy consumption in the sector; in a way, it gives a positive shade to the current facilities. Thus, the finding is in line with the argument stating the improved infrastructure will stimulate the efficiency proposed by Kailthya & Kambhampati (2022), Pradhan et al. (2013), Ke et al. (2020), and Chi (2015). However, the FMLOS, DOLS, and CCR-based outcome of a positive association between public spending in the sector and energy consumption make this introspective in terms of the sustainability aspect. Hence, our finding is not supporting the observations related to the beneficial role of public spending made by Huang & Peng (2014) for poverty alleviation. Therefore, the higher investment by the government in the transport infrastructure should be directed by more energy-saving technologies and investment options. The socio-economic development of people will be supplemented by higher demand for mobility, which will be mirrored in the higher use of transport infrastructure in the country. Moreover, the manufacturing sector development increases transport energy consumption, which indicates that industries are not sustainable in India. Thus, our finding corroborates with studies that are conducted in Malaysia by (Azlina et al., 2014), Tunisia (Achour & Belloumi, 2016), Egypt (Ibrahiem, 2018), Pakistan (Danish & Baloch, 2018; Mohmand et al., 2021).

The causality test results using the modified Wald test are reported in Table 8. The results suggest that one-way causality runs among variables, where special attention should be given to causality between Transport energy consumption - transport infrastructure performance and public spending on the transport infrastructure - transport infrastructure performance. The uni-directional causality between the manufacturing sector and transport infrastructure performance index gives evidence for the dependence of the productive sector of the economy on the infrastructure provisions available.

Table 5.8 Granger causality analysis			
Excluded	**Chi-sq**	**df**	**Prob.**
Dependent variable: TENERGY			
INFRAPI	0.115244	2	0.9440
LNPUBSP	0.239867	2	0.8870
LNMANV	3.773837	2	0.1515
All	5.277332	6	0.5088
Dependent variable: INFRAPI			
TENERGY	5.615321	2	0.0603***
LNPUBSP	2.974202	2	0.2260
LNMANV	4.676918	2	0.0965***
All	11.11415	6	0.0849***
Dependent variable: LNPUBSP			
TENERGY	13.31912	2	0.0013*
INFRAPI	8.379823	2	0.0151**
LNMANV	2.800132	2	0.2466
All	16.73328	6	0.0103**
Dependent variable: LNMANV			
TENERGY	3.719884	2	0.1557
INFRAPI	3.000017	2	0.2231
LNPUBSP	0.251170	2	0.8820
All	8.624384	6	0.1958
Note: *, ** and *** indicates 1%, 5% and 10% level of significance, respectively.			

5.5. Conclusion and policy inferences

The energy demand and consumption of the manufacturing sector in India have been studied over the years. The increased share of the sector in the total energy use of the country is mainly discussed in terms of energy intensity, energy dependence, obsolete technology, etc. This study attempted to dissect transport infrastructure performance, public spending in transport infrastructure development and the manufacturing sector in determining the transport sector energy consumption. The study forwarded an innovative perspective where transport sector energy consumption is assessed with manufacturing sector performance and performance of existing transport infrastructure along with public spending on transport infrastructure development. The study period (1987 to 2019) majorly consists of the years of structural transformation of the Indian economy, which was formerly actuated in 1991 as the new economic policy. Growth accelerating economic policies based on liberalization and a higher focus of government spending on social overhead capital are celebrated traits of the post-new economic policy era.

The transport infrastructure has been one of the focal points of the redefined realm of public expenditure since then. The public spending on transport included both the union government and provincial state government are included in the study. And for the transport infrastructure performance, 8 different variables for four modes of transportation are incorporated. The short-run and long-run dynamics between the variables were explored using ARDL bound test approach followed by FMLOS, DOLS, and CCR methods. The modified Wald test method was used to understand the direction of the variables in the model.

Using ADF and P.P. tests, stationary checks were performed and confirmed the data series are integrated into order one. The ARDL bound test results assert that the performance of transport infrastructure and manufacturing sector output of the economy is interrelated with the energy consumption of the transport sector. To an extent, these findings follow the results of Abbas & Choudhury (2013), Kumari & Sharma (2018), and Tang et al. (2016) on the energy-economy nexus in India. The long-run cointegration regression analysis based on FMLOS, DOLS, and CCR tests extended the understanding as a positive relationship between public spending on transport infrastructure and value-added in the manufacturing sector was observed.

The results of the empirical examination in the study serve certain important insights for public policies in the development of the manufacturing sector and transport sectors of India. Apart from that, a lot of transport infrastructure development projects at the state level with massive investments are also undergoing. Thus, public spending on transportation should be prioritized in a way that should account for the environmental cost. By doing this, the transportation-related consumption and production activities of India become eco-friendlier, and the health issues of human beings due to transportation can be reduced. It implies that making a sustainable public investment in transportation brings both economic gains via increased production and consumption activities and social gains via improved health due to less energy consumption, thereby reducing pollution. Moreover, the transition of the Indian economy to a service sector-led economy will not abate the role of the manufacturing sector of the country, considering the demand of the growing economy and the aspirations of the people. In that context, an energy perspective should be incorporated throughout the development process of the sector, intentionally by the policymakers. This will ensure manufacturing sector development with energy-saving advanced technology and lower energy intensity of manufacturing units. Further, the researchers need to obtain the patents for new modes of transportation in the manufacturing sector in India to make environmentally viable concurrently offering employment opportunities to a large extent. Along with the reinforcement of existing laws on environmental sustainability, this study seeks attention from policymakers to start examining different domains of energy use by sectors like the manufacturing or service sector so that sector-specific policies will be made that can be critical in the carbon emission obligations and better energy sector management in the future.

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Chapter 6

AGRICULTURAL ELECTRICITY CONSUMPTION IN TELANGANA: TRENDS AND NEEDS

6.1. Introduction

In the development of any sector, the characteristics of inputs required for the progression will transform over the years. Understanding changes and providing these requisites is assigned the responsibility of welfare governments in developing countries. The Indian agriculture sector has experienced this transformation from a feudal state to modern farming. Even though the debate on transformation in socio-economic conditions around Indian farming is valid, the changes in the organisation are undeniable. Embracing mechanised farming was such a change that was highly motivated by agricultural development planning in the 1960s to tackle food deficit and rural poverty. The energy needs of rural farming communities and agricultural activities also started growing from then. This was quickly assimilated into general agricultural policies, and the announcement of subsidised electricity programs started in many states of India.

The policy-making and management of the agriculture sector are listed as a state matter in the constitution of India. And electricity is in the concurrent list of the constitution, where both state and union governments share the responsibility. On this background, assessments of agriculture energy policy in India are realistic when they are performed at a state level. This study is intended to evaluate the progression of agrarian usage of electricity in the south Indian state of Telangana. Being a young state formed in 2014, Telangana attracts attention because many factors evolved historically and in the years after independent statehood. To begin with the percentage of agriculture households in the state, according to NSSO 77th round, 54.2% of rural households are agricultural households in the state (265500 households out of 483890 rural households). This depicts the economic importance of the agriculture sector to households in the state. Secondly, as per Periodic Labor Force Survey 2019-20, the agricultural sector employs 48.4% of the state's total population. The livelihood of a significantly high percentage of people in the state is thus related to the agricultural sector. Thirdly, any studies on the electricity sector of the Telangana state are relevant as the state faced a severe power deficit at the time of formation in 2014. The energy infrastructure development and management helped the state increase the installed power capacity from 9,470 MW in 2014-15 to 17,218 MW in

2020-21. In addition, the per capita power consumption of the state was above all India level from the time of formation at 985 units against all India average of 917 in the 2013 FY itself. On this base, the electricity sector development of the state also deserves attention.

Finally, the above-mentioned first two factors had huge implications for the political economy of the state of Telangana. Formally part of Andhra Pradesh state, it was the first state in India where electricity subsidies for farmers were started. Different governments carried this over the years, and after the formation of the new state in 2018, the celebrated 24-hour free electricity program was launched. The first-of-its-kind program in India ensured free electricity to farmers around the clock. The fiscal and energy sustainability of the program is open for debate. However, the heavy pressure it exerts on the state exchequer is visible as 10500 Crore rupees were allocated in subsidy for the power sector in the 2021-22 state budget. Against this backdrop, an appraisal of the agriculture sector - electricity consumption relationship in the state of Telangana gains importance. The energy-economy nexus is studied extensively in the literature with different methodologies for different countries. Even in the case of India, studies are available with mutually competing conclusions. This study brings an extension to this series with a focus on the agrarian sector and electricity consumption at a state level. The current study will be the first comprehensive attempt to analyse trends, and future development of Agrarian electricity needs in the state of Telangana. The study discusses the contribution of agriculture to the state economy with the development of energy infrastructure in the state post-state formation, the trends in agriculture electricity demand and supply situations with evidence from all India input survey, NSSO 70th round- Situation assessment survey of agricultural households and finally with an econometric analysis of the long-term relationship between agriculture output and electricity use in the state.

The rest of the article is structured as Section 2 reviews the current literature on the study area, Section 3 with a major analysis of different heads, and Section 4 concludes the study where future policy suggestions are discussed.

6.2. Review of literature

The transition of the Agricultural sector from a feudal system to a modern structure came with changes in the organisation and production process. This transition in Indian agriculture, from principally human and animal inputs driven to modem mechanised farming, made the sector energy-intensive (Jha, 2012). The technological changes, along with the enhanced inputs in the production process, raised the sector's total productivity (Schultz, 1964). Agriculture electricity demand comes from direct and indirect energy uses, where the former includes machinery, irrigation and other field operations. In contrast, the latter includes energy needs for the production of inputs like fertilisers, seeds, pesticides etc. (Ali et al., 2019).

The existing literature on energy demand in the Agricultural sector is predominantly based on causality studies as the extension of energy - economy nexus discourse. The relationship between agriculture sector output and electricity consumption with different causalities is found for different countries. Considering Asian economies, unidirectional causality for Malaysia (Pei et al. (2016), bi-directional causality for Turkey Dogan et al. (2016) and Türkekul & UnakItan (2011) and in the case of Pakistan neutrality Zaman et al. (2012) and bi-directional Ahmed & Zeshan (2014) was found.

The causal link between economic activity and electricity consumption in India has been established in literature at both aggregate and disaggregate levels (Shameem et al., 2022; Nain et al., 2012). The studies focusing on agricultural electricity consumption also indicated the existence of long-run and short relationships in India. Abbas and Chaudhary (2013) found a bi-directional causality between agriculture sector electricity use and output in India from 1972 to 2008. Jha (2013) forwarded a state-level analysis of these variables, which concluded that the energy consumption of high-productive states like Punjab in Haryana is seven times more than low productivity states like Odisha, which established the significance of electricity use in agricultural productivity at the state level.

The significance of energy inputs, including electricity, oil and gas, in agricultural production was examined by Inumula et al. (2020), who concluded a positive long-run relationship between variables from 1985 to 2017. Kumar 2020 comprehensively studied the Gross state domestic product and electricity consumption at the state level (17 States from 1993 to 2018 with electricity and GSDP variables) and country-level data (1980 to 2018 with electricity and technology factors variables). The study also followed most of the existing literature in the domain where a one-way causal relationship between electricity used to agricultural output was found both in the short and long run.

This association's empirical and empathetic establishment resulted in the inclusion of electricity subsidies in agriculture policy in India. Even though it was only one among other input subsidies like fertilisers and seed subsidies, the electricity subsidies gained a special status due to economic and political reasons. (R. Badiani et al., 2012). In the green revolution of the 1960s where groundwater irrigation emerged as a vital input that necessitated government intervention in infrastructure development for irrigation needs and distribution of motor sets to farmers, which was followed by the supply of subsidised electricity (Badiani et al. (2012); Rosegrant & Evenson (1992). (Briscoe & Malik, 2006; Repetto, 1994). Electricity subsidies gained popular appeal as they positively impacted the production process and output. This positive impact varies across the states, but government and political parties embraced subsidised electricity as an election promise. These promises and resultant subsidised electricity schemes evolved over the years to free electricity programs; thus, one-third of total states in India provide either free electricity or heavily subsidised electricity to farmers (Dubash & Rajan, 2001) (Badiani et al. (2012); Rasul, (2016); Badiani-Magnusson & Jessoe (2018).

As a newly formed state, Telangana attracts attention in many aspects. Due to many factors, the large and significant agriculture sector and its energy need top the list. The formation of the Telangana bifurcating Andhra Pradesh state of South India resulted from decades of protest based on socio-economic and political reasons. (Melkote et al., 2010). The disparities in infrastructure development, especially in power generation and surface irrigation, were paramount in demand for an independent state (Seshan, 2018). But since its formation, no studies have exclusively addressed agricultural electricity use and the electricity supply infrastructure of Telangana. The second half of the 20th century witnessed the growth of well irrigation, replacing the traditional tank irrigation in the region, which later extended as the growth of tube wells. The demand and supply of electricity became significant for the farmers after this transformation which was catered by subsidised electricity in the state Vakulabharanam, V. (2004). Pingle, G. (2011). Andhra Pradesh was the first state in the country to introduce a subsidised electricity scheme, and Telangana is the first state to provide 24-hour free electricity to farmers in the country (Shameem & Reddy, 2020). But there are only a few noteworthy studies in the literature where these schemes are the main focus. World Bank (2001) reported that electric pump-owning farmers make a gross income thrice of non-owning farmers in the rainfed and water purchaser's category. Here the irrigation cost, including electricity tariff, enters into the cost burden of pump-owning farmers, which was 15% of farm income on average (Dossani & Ranganathan (2004).

The effectiveness of subsidised electricity schemes was explained by Fosli et al. (2021) based on a field survey which surmised that these schemes are lifelines for farmers in the drought-prone areas of Andhra Pradesh. As there is an absence of a holistic study on the electricity consumption of the agriculture sector in Telangana, this study can be a foundation for appraisal of the newly introduced free electricity program in Telangana and its updation in future.

6.3. Data analysis

6.3.1 Agricultural Sector and Telangana Economy

The significance of the agriculture sector for the state of Telangana is beyond its socio-political roots. Even in terms of sectoral contribution to the state's Gross domestic product, it might appear like a service sector-driven economy. The agricultural sector possesses high economic significance as the sector employs 48.4% of the total workforce (Periodic Labor Force Survey, 2019-20). It engages 56 per cent of rural households in the state (NSSO 77th Round (2019). According to the population census 2011, out of the total working population of the state, 36.19 % are agricultural labourers, and 19.28 % are cultivators' categories. Among the 33 districts in the state, in Mahabubabad, Bhadradri Kothagudem, Jogulamba, Gadwal, Suryapet, Khammam Jayashankar Mulugu agriculture labourers share in total workers is more than 50%. From this fact, assessing the agricultural sector and its needs become relevant for the state.

From a macroeconomic perspective, the magnitude of the contribution of the agriculture sector and its progression path leaves a neutral impression. The Gross state domestic product (GSDP) and Gross state value added (GSVA) in the agricultural and allied sectors in the last decade, with a special focus on years after the formation of the new state, substantiate this (Figure 06.1). Telangana state is located in a semi-arid region; therefore, the level of rainfall is critical in agriculture production. The first two years of the new state witnessed a deficiency in rainfall and severe drought in the region. The area under food grains production dropped from 26.13 lakh hectares in 2014-15 to 20.46 lakh hectares in 2015-16. The effect was the decline in the agriculture sector GSDP in these two years, which later entered into a growth path from 2016. Here also, the above-normal rainfall played a critical role which was sustained till last year (except the 2017-19 period with slightly below normal level). The contribution of agriculture and allied sector to GSDP maintain a consistency which can be read as a positive aspect. Even though the sector employs the major share of the workforce, this stagnation in contribution to GSDP is associated with the value of goods produced compared to the service sector and industrial sector, the higher public spending for the sector, including infrastructure development in irrigation and extortionate programs like Rythu Bandhu is expected to give a better outcome than the current level. But the progress in domestic agriculture products endorses these government schemes in the sector.

Figure 6.1(a): Agriculture and allied sector GSDP at Constant Prices (2011-12) (Rs. in crore)

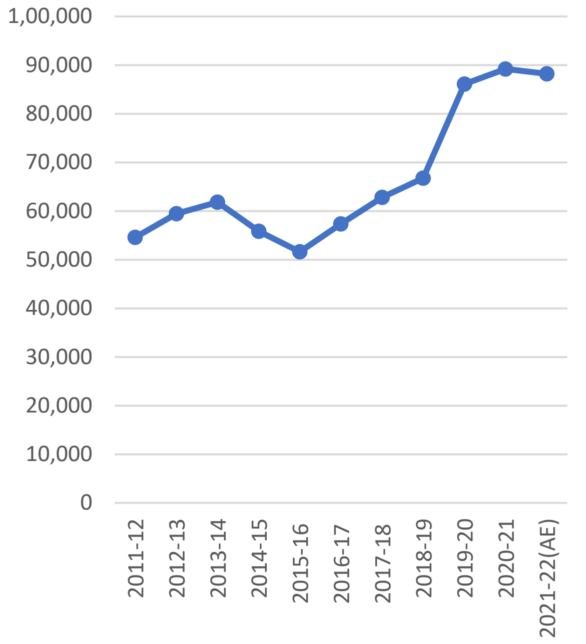
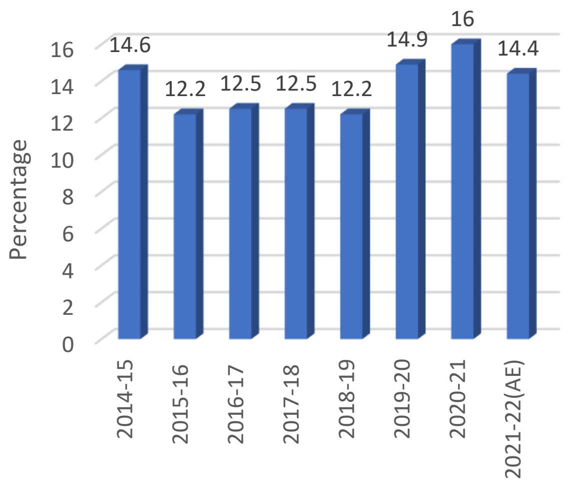


Figure 6.1(b): Agriculture and allied sector contribution to GSDP at Constant Prices (2011-12)



Source: Telangana Socio-Economic Outlook (various editions)

The state's gross value added (GVA) figures explain this from a supply-side prospect where value added in the sector is considered (Figure 0 6.2). Here also than the years of drought and consequent fall in production GSVA by agricultural sector shows a positive consistency. The growth rate of GVA in the agriculture sector touched the 20 % mark in 2020-21, which was higher than all of India's GVA in agriculture growth. This is reflected in the contribution of agriculture in GSVA in the same period. The state annual average GVA growth rate of the agriculture sector in the last five years (between 2016-17 and 2020-21) is 14.5%. The sector-wise breakdown of GSVA facilitates policymakers in understanding sector-specific problems and trends. The crop production in total agriculture output constitutes the major share of GSVA. The electricity demand of the agricultural sector in production activities of this sub-sector thus calls for the inclusion of an energy policy specialised for agrarian needs.

Figure 6.2(a): GSVA by Agriculture at Constant Prices (2011-12)

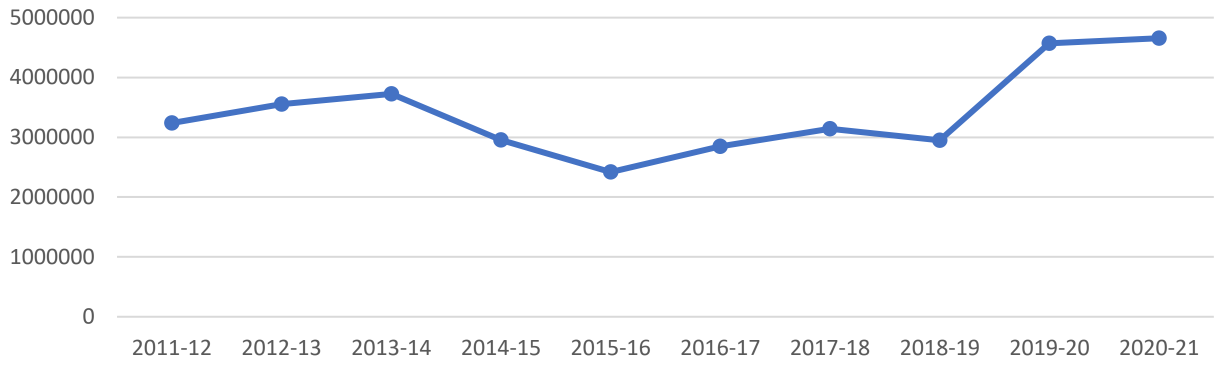
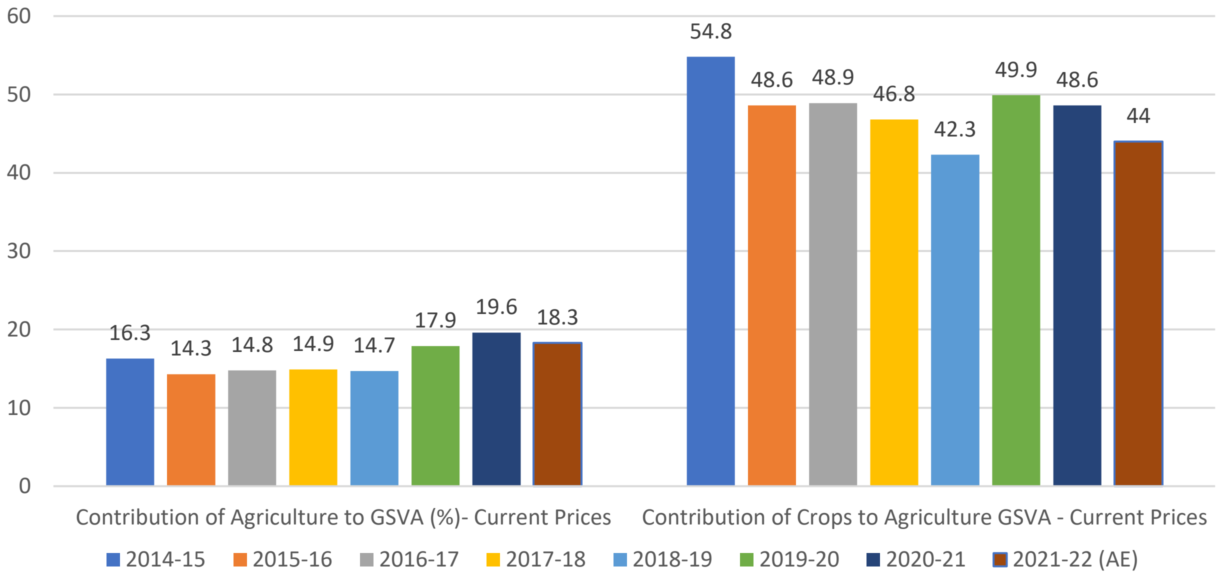


Figure 6.2(b): Contribution of Agriculture to GSVA (%)- Current Prices



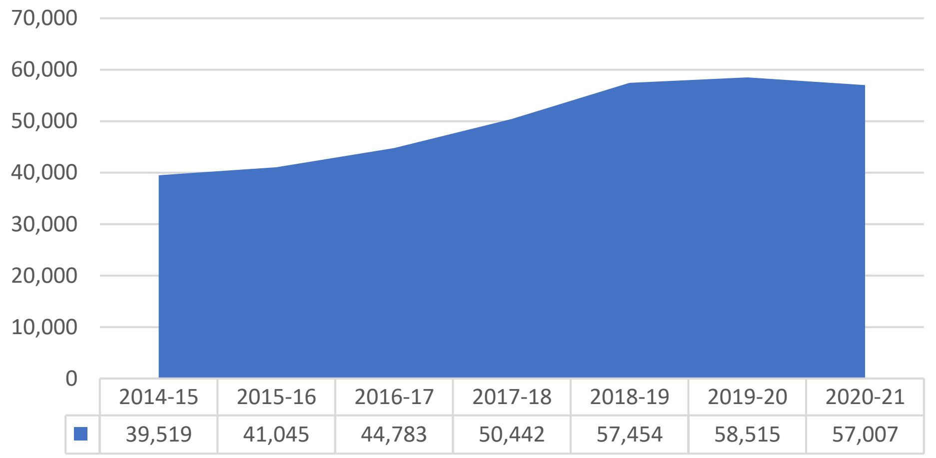
Source: Telangana Socio-Economic Outlook (various editions)

6.3.2 Electricity Demand and supply position in Telangana

The utilisation of infrastructure entitlements is decisive in a region's current and future economic activities. Telangana emerged as one of the highest energy intense states in the country in the initial years. In terms of per capita electricity consumption, the state has been above the all-India level since its formation. In 2014 it was 985 against all India level of 917 which progressed over the years to 2,071 kWh and 1,208 all India in 2019-20. The task force on energy constituted by the government of Telangana after the formation of the state in 2014 to study electricity demand and supply management in the state projected a significant increase in energy requirement due to various factors, including an increase in domestic and commercial power demand, urban development in cities of Hyderabad, Warangal, Nizamabad and Karimnagar, major projects such as Hyderabad Metro Rail, Hyderabad ITIR region, Lift

Irrigation Schemes (LIS), Hyderabad-Nagpur industrial corridor etc. This projection was materialised as we can see the Total energy consumption in the state has had steady growth since 2014 (Figure 6.3). The increasing demand in both energy consumption and Gross domestic product of the state gives an encouraging impression on the dispatch of the sector and economy.

Figure 6.3. Electricity consumption in Telangana (Million Units)

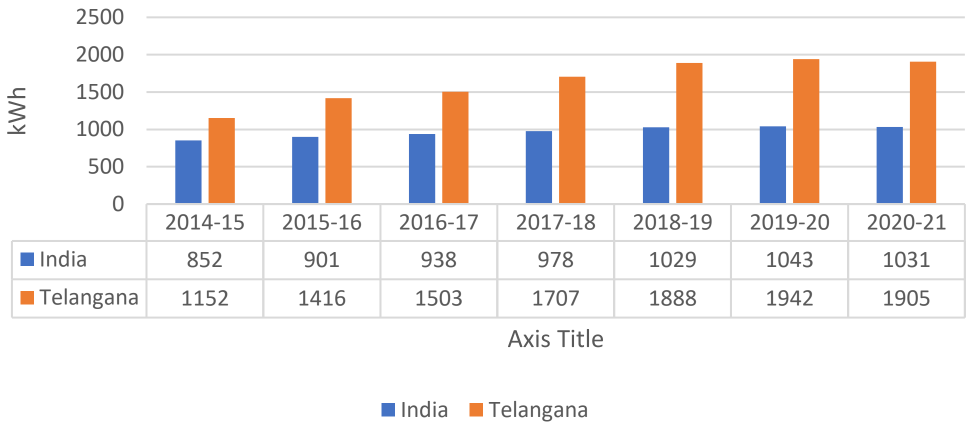


Source: Telangana Socio-Economic Outlook (various editions)

The state's energy supply infrastructure and performance were not propitious as the demand side. The state was equipped with an energy sector facing a peak demand shortage of 2,700 MW, four to eight hours of load relief to domestic and other consumers, and a 2-day power holiday to industries in 2014. Against this backdrop, along with the projected rise in the electricity demand, the government prioritised the power sector in the initial years. This resulted in providing 24-hour electricity to domestic connections, no load relief to any category of consumers from November 2014 and 9 hours electricity supply for farmers from 2016, which was later upgraded in 2018. The flagship programs in the electricity sector of the state include supply chain augmentation as one of the pilot states for 24x7 hours Power for All scheme (PFA), 24-hour free electricity for the agriculture sector, Telangana State Rural High Voltage Distribution System Project and the achievement of 100% electrification of households 2020. Since the formation of the state, electricity supply infrastructure has been enhanced by the addition of 112 Nos EHT Substations, 833 Nos. 33/11 KV Substations and 2.54 Lakhs of Distribution transformers.

These interventions helped the state achieve the country's second-highest growth in the per capita availability of power between 2014-15 and 2020-21, at a CAGR of 8.74%, where the all-India value is just 3.24%. In addition, the state's electricity transmission and distribution loss was the third lowest in the country (in the 2018-19 period), which was 14.85% compared to the all-India value of 20.66%.

Figure 6.4. Per Capita Availability of Power (kWh): Telangana vs. India

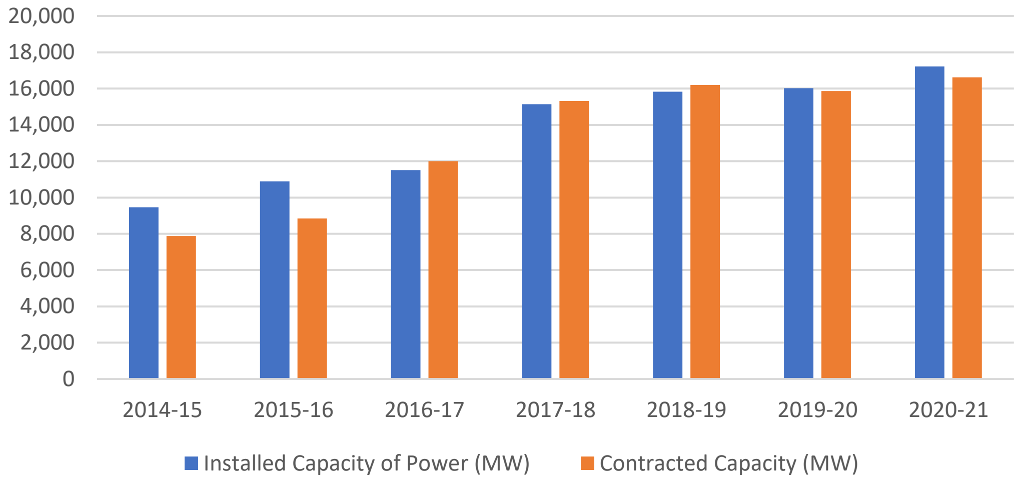


	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
India	852	901	938	978	1029	1043	1031
Telangana	1152	1416	1503	1707	1888	1942	1905

Source: Telangana Socio-Economic Outlook (various editions)

The figure 6.4 shows this positive growth in per capita power availability in the state compared to all India levels. Despite the stagnation in the Covid-19 hit period, the state's per capita availability and per capita electricity consumption followed a similar path. The electricity sector is primarily managed by government-owned companies such as Telangana State Power Generation Corporation Limited (TSGENCO) for generation, Transmission Corporation of Telangana Limited (TSTRANSCO) for transmission, Telangana State Southern Power Distribution Company Limited (TSSPDCL) and Telangana State Northern Power Distribution Company Limited (TSNPDCL) for power distribution.

Figure 6.5. Installed capacity of Power in Telangana (MW)



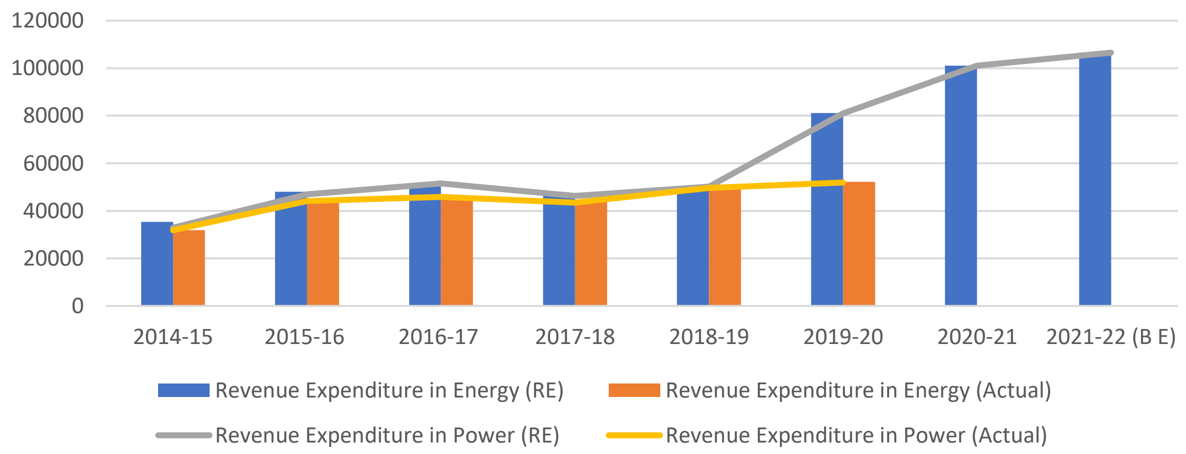
Source: Telangana Socio-Economic Outlook (various editions)

According to the Andhra Pradesh Re-organization Act of 2014, the state's total installed capacity was divided between the newly formed Telangana state and the remaining Andhra Pradesh region in the proportion of 53.89 per cent and 46.11 respectively. Since then, the TSGENCO has carried out several capacity addition programs in different development stages. The installed capacity of electricity in Telangana has increased from 9,470 MW in 2014-15 to 17,218 MW in 2020-21 at a Compound Annual Growth Rate (CAGR) of 10.48% (Figure 6.5). The capacity argumentation projects by TSGENCO aiming at a total of 5880 megawatts were pushed after the state formation, which includes projects at Manuguru (4x270 MW), Kothagudem (1x800 MW) and Damerachela (5x800 MW), with an investment of Rs 37,938 crore. TSGENCO has commissioned 1760 MW since the State formation, including the the 800 MW KTPS-VII (supercritical), 600 MW Kakatiya TPP Stage II,the 240 MW (6x40 MW) Lower Jurala Hydro Project, and the 120 MW (4x30 MW) Pulichinthala Hydro Project. Thus, in total, the demand and supply side interventions by the government in the electricity sector of Telangana increase the hope. But the question of sustainability and further expansion, as the state proceeds to the next stage of development, needs keen scrutiny.

6.3.3 Public spending in the electricity sector of Telangana

The nature and progression of public spending in a sector can reflect government policy orientation for that sector. Theoretically, following the endogenous growth theory, which states investment in infrastructure will promote economic development in a region, government expect public investment in infrastructure can help to attain a higher output level by Keynesian demand stimulus in the short run and Neo-classical supply stimulus in the long run (Ramey,2020). Like any other Indian state government, the fiscal resources at the dispose of are constrained for the state of Telangana also. But energy sector development is included in the development requirements of the state in the initial years. As counted as one of the indicators showing the regional discrimination against the Telangana region in the erstwhile Andhra Pradesh, energy generation projects were part of the aspiration of Telangana protests to be included in the higher priority category after state formation (Seshan, 2018). In Telangana, high public spending was essential in the supply side of the electricity sector, including capacity addition and transmission chain enhancement, as mentioned in the last section. The spending on commissioned projects of TSGENCO and other activities of TRANSCO were part of higher public investment in the sector (detail in the last section) from 2014 to 2022. Soon after the formation of the state, a technical action plan was implemented for the improvement of the service delivery mechanism of the sector, which includes agriculture feeder segregation with an investment of 1458 crore, phased implementation of HVDS with an estimated investment of 43780 per pump set and metering of DTSs and feeders and phasing out of old mechanical meters at the consumer end.

Figure 6.6. Revenue Expenditure in Energy sector with power sector seperate



Source: Telangana Socio-Economic Outlook (various editions)

In the Indian context, at the state level, planned public expenditure in the energy sector can be traced by three major measures; capital expenditure, revenue expenditure and finally, expenditure on electricity subsidies. Figure 0 6.6 and Table 06.1 presents the revenue and capital expenditure of Telangana state from 2014-15 to 2021- 22 period in the energy sector, with a special focus on power projects as the revenue expenditure is related to expenditure in the normal functioning of the sector, which includes salaries of employments, grants and most importantly subsidies. It is evident from the table that the revenue expenditure has had an increasing trend since 2014. As we took the actual expenditure amount in our analysis, the revised estimate is also included in the table to indicate the government expenditure nature. As the Indian public finance system works, the budget estimate reports the amount government indented to spend in a sector. In contrast, the revised estimate shows the corrected expenditure after reconsidering the sector's needs; finally, actual expenditure figures show the final realised spending. The case of Telangana is interesting in that, throughout the seven years, the actual revenue expenditure in the energy sector, especially the power sector, was below the budget estimates and revised estimates.

Table 6.1. Capital Expenditure in Energy and Power projects from 2014-15 to 2021-22 (₹ Million)

FY	2014 -15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21 (RE)	2021-22 (BE)
Energy	3477.7	5237.3	104976.2	27212.7	24000	20000	–	–
Power Projects	0	2739.2	1752.1	2937.87	2496.711	3448.34	2947.2	3747.84

Source: Telangana Socio-Economic Outlook (various editions)

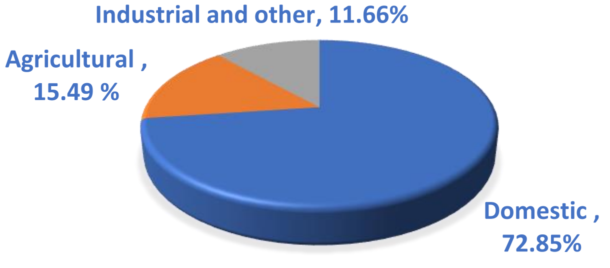
The revenue expenditure has a recurring disposition, whereas capital expenditure is non-recurring and directed towards asset and capacity creation, which is vital for infrastructure development. But here also, the discrepancy observed in the case of revenue expenditure is detected. For example, the budget estimate of capital expenditure in the energy sector was 10101.6 and 10064.1 million rupees in 2014-15 and 2015-16, respectively, but the actual expenditure was 3477.7 and 5237.3 million rupees, respectively. Along with the lesser spending on capital expenditure throughout the years compared to revenue expenditure, this mismatch between intended or declared capital expenditure and actual spending is exposed as discreditable action of the government. As the subsidies are included in revenue expenditure, its increasing trend describes the progressing space of electricity subsidies in the state's public spending through various schemes. The projected agricultural subsidiary requirements for Telangana by the Task Force on Energy in 2014 are presented in the Table 0 6.2. The direction of the Agricultural subsidiary required and projected agriculture subsidy by the government proposes the expanded fiscal demand for agriculture power subsidy in the state. On the subsidies to the agriculture sector for free electricity supply, the government has spent Rs 39200 crore since 2014-15 in the state.

Table 6.2. Projected agriculture subsidy needs for Telangana DISCOMS						
Item	**Unit**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Avg. CoS	Rs / Unit	5.72	6.09	6.43	6.69	6.99
Agl. Sales	MU	11939	12536	13163	13821	14512
Agl. Subsidy Required	Rs Cr.	6832	7640	8467	9248	10141
Projected Agl. Subsidy by Govt.	Rs Cr.	3331	3522	3904	4264	4676
Cross subsidy through tariffs	Rs Cr.	3501	4117	4563	4984	5465
Source: Report of Task Force on Energy						

6.3.4 Agrarian electricity demand in Telangana

The agricultural sector-specific government initiatives in the electricity sector of Telangana prove the recognition of the sector's demand. This demand is self-explanatory of the dependence of a large section of people in the state on the agricultural sector. Understanding the development of agriculture electricity demand is required for policymakers to appraise existing programs and introduce new ones. Even though erstwhile Andhra Pradesh was out of the major focus region of green revolution-led mechanisation and the following power demand of agriculture, electricity subsidies attained a special status by their potential vote gain power. This politically motivated dispersal of subsidised electricity along with the machinery, including electric pump sets, is the foundation of agricultural electricity demand in the state. The rural electrification drives and popularisation of electricity used the machinery in the production process simulated the electricity need of the sector over the years.

Figure 6.7 Distribution of electrical connections in Telangana (2020-21)



Source: Telangana Socio-Economic Outlook (various editions)

The distribution of electricity connection in the state for the period 2020-21 is presented in Figure 6.7. Agriculture connections are 15.49 % of total connections in the state, where domestic users are the majority (72.85%). The agricultural connections in terms of consumer mix of electricity in the state slightly dropped from the 2014 level, which was 17%. In Medak, Jangaon, and Nagarkurnool districts, 30% of total connections are agricultural connections.

Figure 6.8 (a). Agricultural Connections in Telangana (in lakhs)

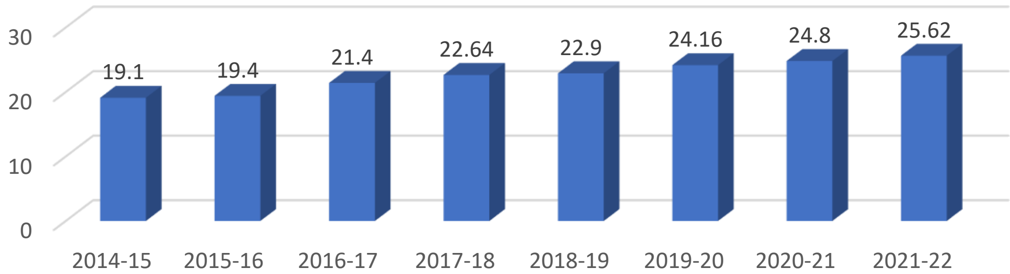
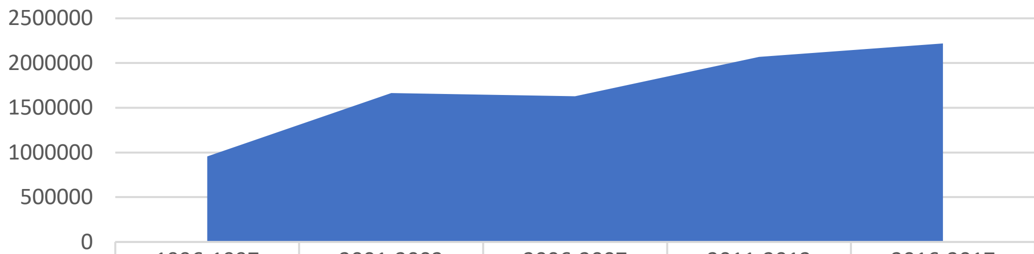


Figure 6.8 (b).Estimated number of agricultural machineries used by farmers - All India Report on Input Survey



	1996-1997	2001-2002	2006-2007	2011-2012	2016-2017
Electric Pump Set	957863	1662928	1628446	2070430	2219295

Source: All India Report on Input Survey

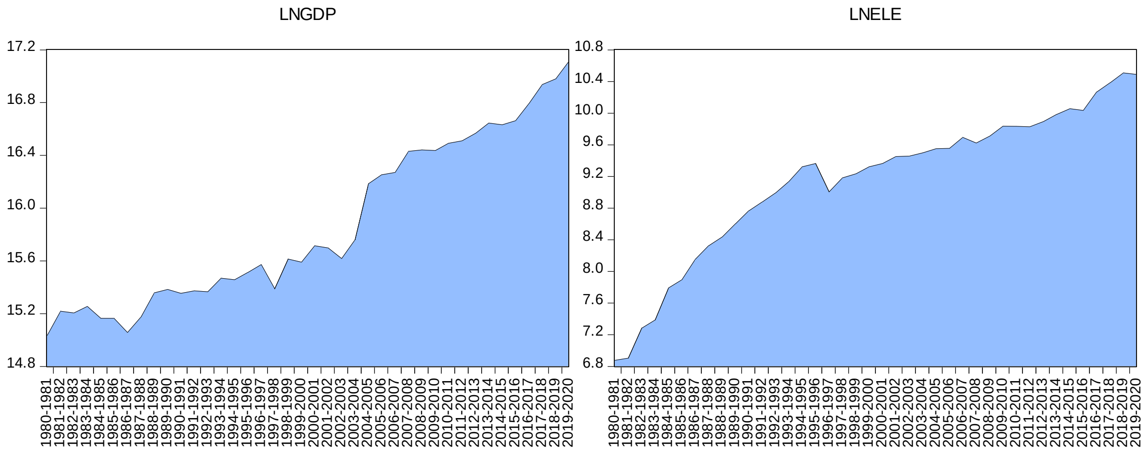
The growth of agriculture electricity demand can be visible from the progression of agriculture connections in the state from 2014-15 to 2021-22 (Figure. 6.8). Starting from 19.1 lakh connections in 2014, the government interventions like an extension of supply hours, increased subsidies and energy infrastructure development especially in rural areas has supplemented the growth of agriculture connections in the state. As on August 2022, TSNPDCL serves electricity to 1268460 agricultural users and TSSPDCL supplies to 135633 agriculture connections in the state. This progressive trend in agriculture electricity demand can be further dissected with the help of all India input survey where Electric pump sets as an agricultural machinery used by farmers are analysed. The five-year survey shows the number of electric pump sets used (both owned and hired by the farmers) in the state has increased over the years, which directly proves electricity demand has intensified in the state (for the years before 2014 data from Adilabad, Karimnagar, Khammam, Mehboobnagar, Medak, Nalgonda, Nizamabad, Rangareddy and Warangal districts are taken. In the latest survey held in 2016-17, it is observed that among other irrigation machinery, electric pump sets are widely used by the farmers in the state, which can be associated with the large share of small and marginal farmers in the state.

6.3.5 Econometric Estimation of agrarian electricity demand in Telangana

An empirical estimation of the association between electricity consumption and the economic output of the agriculture sector in Telangana is needed to validate the ongoing discussion. The time series data of GDP from agriculture and allied sector (Rupees lakh) and agrarian electricity consumption (GWH) sourced from different editions of Statistical yearbooks and Economic outlooks of both Andhra Pradesh and Telangana are used for the analysis. To accommodate the long-run behaviour of the variables and the evolution of the power dependence of agriculture, data is collected from 1980 to 2020. The availability of energy consumption data constrained the starting period's choice.

A graphical presentation in Figure 6.9 captures the initial apprehension about study variables. The trend and shape of both variables illustrate an upward trajectory from 1980 to 2020. This can be accepted as primary evidence for a possible positive correlation between the variables. This impression will be verified based on the results of appropriate econometric techniques.

Figure 6.9 Graphical representation of study variables



The second level of analysis starts with a descriptive summary of the variables in the study. Table 6.3 presents the summary statistics of the variables. The agrarian output variable shows a higher average among the variables, whereas both are skewed differently.

Table 6.3. Description of variables

	LNGDP	LNELE
Mean	15.87568	9.154283
Median	15.62028	9.371837
Maximum	17.11817	10.51639
Minimum	15.0407	6.88462
Std. Dev.	0.633001	0.950993
Skewness	0.429475	-0.87918
Kurtosis	1.72995	3.049341
Jarque-Bera	3.918036	5.157045
Probability	0.140997	0.075886
Sum	635.0271	366.1713
Sum Sq. Dev.	15.6269	35.27112
Observations	40	40

To start the empirical estimation, a univariate model is used to analyse the relationship between the variables under study. The following is proposed as the functional form of the variables examined in this study:

$$AGR\ GDP -= f(ELE)$$

In equation, GDP= GDP Agriculture and Allied Activities (Rs Lakh) and ELE = Agricultural Consumption Quantum:(GWH)

The model mentioned in the first equation is based on past studies on the causal link between the independent variables mentioned and the energy consumption in the sector. The variables are converted to the natural logarithm to facilitate the interpretation of estimated coefficients as elasticities.

To establish significant interdependence between two-time series data, they must be integrated in the same order (more than zero), or both series should contain a deterministic trend (Granger,1988). The standard Augmented Dickey-Fuller (Dickey & Fuller, 1979) and Phillip-Perron (P. C. B. Phillips & Perron, 1988) are applied to test the problem of the unit root of variables. The alternative hypothesis, which contends that the series is stationary, is tested against the null hypothesis, which claims that the series is non-stationary. Both the ADF and P-P tests use the Akaike information criterion (AIC) to determine the number of lag lengths. The findings of unit roots are shown in Table 0 6.4, demonstrating that the two series are stationary in first differences (integrated of order one, I (1) but non-stationary at their levels.

Table 6.4(a)UNIT ROOT TEST TABLE (PP)

		At Level		**At First Difference**	
		LNGDP	**LNELE**	**d(LNGDP)**	**d(LNELE)**
With Constant	t-Statistic	1.1651	-3.5268**	-6.5519***	-6.1175***
	Prob.	0.9974	0.0124	0.0000	0.0000
With Constant & Trend	t-Statistic	-1.7424	-2.9144	-7.4246***	-6.9544***
	Prob.	0.7129	0.1693	0.0000	0.0000
Without Constant & Trend	t-Statistic	3.9678	3.5488	-5.4749***	-4.2254***
	Prob.	0.9999	0.9998	0.0000	0.0001

Table 6.4(b)UNIT ROOT TEST TABLE (ADF)

		At Level		At First Difference	
		LNGDP	LNELE	d(LNGDP)	d(LNELE)
With Constant	t-Statistic	0.5580	-3.1307**	-6.5343***	-6.0148***
	Prob.	0.9866	0.0324	0.0000	0.0000
With Constant & Trend	t-Statistic	-1.8926	-2.6768	-6.8433***	-7.0335***
	Prob.	0.6392	0.2512	0.0000	0.0000
Without Constant & Trend	t-Statistic	3.1771	4.2386	-5.4227***	-4.1233***
	Prob.	0.9994	1.0000	0.0000	0.0001

As the two series are integrated into the same order, these variables can be cointegrated if one or more linear combinations exist.

6.3.5.1 Johansen's Cointegration Test

The cointegration tests of Johansen and Juselius (1990) are performed in the next stage to find potential constant long-run linear relationships between the two series. The test is based on the null hypothesis of non-cointegration against the alternative hypothesis of the presence of cointegration.

Table 4 shows the results of Johansen's cointegration test. The Trace and Max.-eigenvalue tests' results suggest one cointegrating equation at a 5% significance level. This indicates a statistically significant long-run relationship between agricultural output and electricity consumption in the state.

Table 6.5. Johansen cointegration estimation results between series of LNGDP and LNELEC

Rank Test (Trace)				Rank Test (Maximum Eigenvalue)			
0 of cointegration	Eigenvalue	Trace Statistic	5% Critical Value	0 of cointegration	Eigenvalue	Max-Eigen statistic	5% Critical Value
None *	0.482984	25.09106	15.49471	None *	0.482984	25.06792	14.26460
At most 1	0.000609	0.023141	3.841466	At most 1	0.000609	0.023141	3.841466

6.3.5.2. Granger causality test

After establishing at least one cointegrating relationship, the Granger causality test (Granger, 1988) is conducted to identify the direction of dependence of study variables. The Granger causality test is the preferred method to determine the direction of influence between two series for a small sample size (Geweke et al., 1983). The pairwise Granger Causality test results are presented in Table 7, Where two null hypotheses: LnELE does not the Granger cause of LnGDP and LnGDP does not Granger cause LnELE. The test results show that both null hypotheses are rejected, and a bi-directional causality between agricultural GDP and power consumption is observed. This results forward feedback hypothesis for the state where the increase in electricity consumption in the agricultural sector will boost agricultural output, stimulating a further rise in agrarian electricity demand.

Table 6.6. Granger causality tests		
Null Hypothesis:	F-Statistic	Prob.
LNELE does not Granger Cause LNGDP	4.41217	0.02
LNGDP does not Granger Cause LNELE	3.09012	0.0589

6.4. Conclusion

The quasi-federal system of government structured by the Indian constitution recognises the importance of local-level realities in development planning. The state-level differences at the receiving end simultaneously guide the policymakers at both union and state governments. The socio-economic and political factors, along with the natural resource availability and utilisation, combine to form these "realities" for the states. Thus, research to study these existing relationships and structures for each sector at the state level becomes fundamental for policy-making and implementation. The current study attempts a comprehensive understanding of the electricity sector and agricultural sector of Telangana state in south India. The emergence of mechanised farming and the energy needs of rural agrarian communities moulded the energy policy of union and state governments in India. This study's objective was to examine rural agrarian power dependence in Telangana state, which was formed in 2014. With a substantial agricultural sector equipped with a struggling power sector, the development of the state since 2014 has attracted attention, especially considering the historical factors behind the fight for independent statehood.

The overarching impression unveiled after analysing different aspects of the agriculture sector and electricity sector development since state formation is positive. It is found that the economic significance of the agriculture sector in the state is not based on the sector's contribution to the GSDP but on its share in the state's total workforce. The higher contribution of the service sector to the GSDP can be misleading and results in identifying the state as a service sector-driven economy, despite the presence of an agriculture sector that directly affects the lives of more than half a percentage of rural households. The consistency in the sectoral contribution of the agricultural sector to GSDP can be understood as stagnation or in a positive aspect. The energy intensity of the state was found to be critical in the energy sector planning. The per capita electricity consumption of the state has been above all India levels since its formation. The positive growth of energy infrastructure in the state catering to this higher consumption is commendable. The flagship programs in the power sector since 2014 have given significant output, including 24-hour power supply to domestic connections and free electricity to agriculture connections, thus covering almost 90% of total users in the state. The achievement in per capita electricity availability, transmission and distribution losses, installed capacity etc., inscribes the state government's effort in the sector. But the appraisal of state government efforts in a public finance domain exposes certain frailties. The capital expenditure is way less than the power sector's revenue expenditure. In addition, the actual expenditure in the sector always remained below the proposed or declared funds throughout the years. The higher share of revenue expenditure captivates the mounting subsidy figures in the agricultural sector. From the first state to introduce electricity subsidies in the country to the 2018 declaration of 24-hour free electricity for the agriculture sector, public spending for the sector is highly steered by subsidies. The growth of agricultural connections and the increase in the use of electric farm equipment, including water pump sets, over the years proves that agricultural power demand will be on the rise in the future. The fiscal preparation for serving this growth will be decisive for the state's future regarding agriculture output and sustainability.

Against this backdrop, a few steps must be taken for sustainable development and enhanced efficiency in both sectors. From the financial management perspective, there should be a higher capital expenditure in the sector, specially intended to develop supply infrastructure in the state to achieve self-reliance. The subsidy-oriented energy policy for the agriculture sector will struggle to survive in the long run. So, the objectives of electricity subsidies should be restructured beyond populism. Thirdly, aggressive steps are needed to achieve higher technical efficiency on both the demand and supply side, starting from metering the power consumption. The predominance of crop production in the agricultural sector output calls for the inclusion of a specialised energy policy for the sub-sector. The redesigning of the subsidy system should also take care of this high output-producing sub-sector, thus stimulating future growth. The feedback hypothesis forwarded by the estimated results of the econometric analysis also backs this demand. Finally, at the consumption end, the increasing number of agriculture connections to use subsidised and free electricity necessitates incorporating sustainability concerns. Beyond conventional awareness programs, grassroots-level state machinery should operate to train farmers on energy conservation practices. Along with the huge fiscal cost, programs like 24-hour free electricity programs will affect the environment in terms of groundwater extraction, pollution, etc. The farmers should be sensitised to the judicious use of this free electricity and increase their productivity at the minimum possible cost.

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Chapter 7

FREE ELECTRICITY PROGRAMME AND FARMER'S ATTITUDE; A STUDY ON TELANGANA

7.1. Introduction

The aspirations of a welfare state in guarding the hopes of different sections of people shape the public policy in that country. In a democratic country like India, periodic elections at different levels of government urged ruling parties to embrace populism in their public policy-making (Wyatt, 2013). Beyond the intuitions on sustainability concerns, a series of such policies will mould people's expectations over the years. The unfulfilled expectations of these policies coupled with organic grievances grown over the period in any sections and sectors will emerge as unrest. The Indian agriculture sector is one such domain where different orientations and approaches were employed in making policies. This includes achieving food security to tackle absolute hunger and ensuring minimum subsistence for agriculture labourers. After many of these celebrated agricultural schemes, the revelations on productivity and other real indicators indicate that the state support was not providing the determined objectives. The failure of periodic upgrades in the production process and the emergence of the service sector as a major revenue-generating sector pulled the agriculture sector on the back foot in the policy tables. But the higher share of the rural population engaged in the sector ensured political parties did not ignore the sector but started grooming the sector into a benefit-receiving one. The massive input augmentation carried out in the mid-1960s as the much-celebrated green revolution helped meet higher output targets, but the rapid growth in the agricultural sector ushered then did not sustain. Along with the regional imbalances in delivering the benefits of the green revolution in terms of infrastructure development and other production capability enhancements, the agricultural sector started losing its prominence as the leading sector in most regions of the country. The farmers' unions and groups that enjoyed higher political bargaining power earlier also lost their strength as communal forces drove the country's political environment from the 1980s.

The policies and schemes operated on 'incentive for farming' habituated the farmers to different production and allied activities supported by the government. From fuel and fertilizer subsidies to loan waiver schemes, the underline approach of the government was to rely on temporary solutions ignoring real supply-side constraints in the sector. In the recurrence of high food inflation episodes, the government depended on populistic measures in the sector, which can be aimed only at securing votes. These incentives, which in all their character appear to be 'freebies', have shaped the aspirations of farmers in the country over the years. The demands of major agrarian protests in the country in recent years validate this shift in farmers' approach towards the majority of their solutions for the problems in the sector. Subsidized electricity schemes are among the most sorted schemes with multi-level implications. Beginning in 1980, after irrigational facilities took to progress in Indian farming, electricity demand for agricultural uses started rising. The mechanization of the production process also further increased the role of electricity in the farmers' lives. As the rural electrification was low, the percentage of Agricultural users was comparatively low in the sectoral composition of electricity connections in the initial years. Identifying this fact, political parties started subsidies for electricity. The extent of subsidized electricity progressed after every election as it became a major promise in the election manifestos. States like Andhra Pradesh and Punjab came up with evidence of election successes that free electricity schemes can produce. Ignoring the damage these schemes created to state-owned Electricity distribution companies, the schemes continued as farmers were acclimatized to this free electricity. Along with the potential vote gaining, it was also inevitable for the government to ensure the cost of production stays low, considering the pressure they exert on the food prices and thus on the country's food security.

The Telangana state government inaugurated a 24-hour quality-free electricity scheme to the farming sector on 1st January 2018 that targeted 23 lakh agriculture pump sets in this south India state. The current study analyses farmers' attitudes toward 24-hour free electricity programs in Telangana state as the first-of-its-kind program introduced in a newly formed agrarian state attracts questions in many aspects. This study is based on the results of the primary survey conducted on farmers from Nalgonda districts of Telangana state regarding their preparedness for the 24-hour free electricity program, which was their first experience, along with their sustainability and conservation concerns. As the youngest state in India, which was formed after years of protests based on socio-economic and political reasons, the Telangana state deserves special recognition. According to NSSO 77th Round (2019), around 54.2% of rural households in the state are agrarian, which gives government schemes targeting the agriculture sector greater economic importance. As a newly formed state with a higher budget allocation for the agricultural sector, opting for a free electricity scheme as one of the flagship programs of the state, beyond the fiscal sustainability, deeper examinations at different levels are needed on the scheme. The case of Telangana is unique as the state consumes the highest proportion of electricity for agricultural purposes at all India levels. Since the state was formed in 2014–15, the government has spent 39200 crore Rupees on subsidies to the agriculture sector to provide a free power supply. (Planning Department, 2022). The paper approaches the scheme from the farmers' perspective, as they are beneficiaries of the scheme. The field survey was conducted to study the farmers' attitudes towards the free electricity program and their concerns associated with the scheme's operation.

The following section of this paper includes a review of the literature on major agricultural incentive schemes in India that shaped farmers' expectations from the government, followed by a profile of the study area. The primary survey results are presented in the next section, which is concluded along with the policy suggestion in the following section.

7.2.Context and literature review

The emergence of electricity as an essential input in the Indian agricultural sector resulted from the transition of the sector from a feudal system to a modern structure supported by the state. The shift from animal and human forces to mechanized farming made agriculture more energy intensive in India (Jha et al., 2012). As Schultz (1964) explained, this transition is by adopting quality inputs and technology for production processes that can raise agricultural productivity. The energy needed for direct field operations like farming, machinery, irrigation, and transportation comes under the category of Direct energy consumption in agriculture, whereas energy consumed for producing material inputs like fertilizers and field operation equipment is Indirect energy consumption (Ali et al., 2019).

The association between electricity consumption and agriculture output in the domain of energy-economy causality is well studied in the literature for different economies in the world. To note a few examples from Asian economies, Zaman et al. (2012) investigated the causal link between energy use and value-added. The study's findings served as proof for the neutrality hypothesis in Pakistan from 1975 to 2010. The results of the structural vector auto-regression (SVAR) model of Ahmed & Zeshan (2014) found bi-directional causality between energy consumption and agriculture value added. Unidirectional causality between electricity consumption and agricultural production was estimated for the case of the Turkish economy by the studies of Dogan et al. (2016) and Türkekul & UnakItan (2011) with the same econometric methods. For a panel of 12 areas in Turkey between 1995 and 2013, Dogan et al. (2016) investigated the link between agricultural electricity use and agricultural output. The authors noticed a bidirectional relation between agricultural output and electricity consumption for the entire panel and coastal regions using the Dumitrescu-Hurlin Granger causality test. However, they found distinctive unidirectional causality for non-coastal regions.

In India's case, there are also few notable studies in the literature regarding the causal relationship between these variables. From 1972 to 2008, Abbas & Choudhury (2013) identified a causal link between agricultural electricity use and the agricultural GDP in India. Jha (2013) analyzed the interaction between energy consumption and agricultural output in India's major states. According to the study, states with high production rates, like Punjab and Haryana, use energy more than seven times as much as states with low rates, like Odisha (4GJ/ha). From 1985 to 2017, Inumula et al. (2020) observed a long-run equilibrium relationship between agricultural economic growth and key energy inputs such as electricity, gas, and oil consumption. According to Kumar et al. (2022), the GSDP and power consumption have a long-term, positive co-integrated association. The study used data from 17 states for the period 1993–2017 for the electricity–GSDP interactions and country-level data for the period 1980–2018 for the relationship between electricity and technology factors to identify short- and long-term unidirectional causality from electricity consumption to agricultural output.

In the evolution of Agricultural sector policies in India, subsidies were always part of them for various reasons. The governments at different levels provide subsidies on fertilizers, irrigation facilities, electricity, seeds, crop insurance schemes, price support schemes, etc. For example, To boost agricultural efficiency and growth in the economy, particularly for the rural poor, the government offers agricultural power subsidies of around 85% of the average cost of supply (R. Badiani et al., 2012). The rationale behind subsidies in different forms changed over the period, but political motives were incontestable. A massive intervention was necessitated in the agricultural sector by the 1960s because of the poor state of the rural economy and food scarcity. The union government recognized this necessity and started adopting aggressive policies for tackling this phase. The holistic agricultural productivity enhancement efforts of the 1960s in the name of the Green Revolution included subsidizing key agricultural inputs as a major implement (Badiani et al. (2012); Rosegrant & Evenson (1992). The governments introduced several programs of subsidies for several agriculture inputs to aid the farmers considering their weak entitlements (Kaur & Sharma, 2012). Recognizing as an essential input, groundwater irrigation was encouraged by the government to develop needed infrastructure and distribution of pump sets with the supply of subsidized electricity (Briscoe & Malik, 2006; Repetto, 1994). From this point, two distinct expeditions were forwarded; first, the farmers who benefited from the free electricity supply and other input subsidies organized themselves and started demanding more such state support. Second, the competing political parties, recognizing the desires and strength of organized farming sections, began to use electricity subsidies as campaign material for their elections.

In Andhra Pradesh in 1977, electricity subsidies appeared in all major election manifestos of political parties in agricultural states after that (Dubash & Rajan, 2001). The progression of electricity from Subsidized production input to a freebie was not slow. In 1991, the Tamil Nadu government started providing free electricity to farmers, which Punjab followed around the same period. In India, almost one-third of the states offer free power, while the other two give farmers significant subsidies (Badiani et al., 2012; Rasul, (2016); Badiani-Magnusson & Jessoe (2018).

The findings of different studies on the effects of electricity subsidies on the agricultural sector show the positive impact on (through their expansion of irrigation) agricultural production (M. et al., 2018), food security (Singh, 2000), and rural incomes (Briscoe & Malik, 2006). Electricity subsidies have been highly instrumental in the growth of irrigation, especially groundwater irrigation, along with irrigation technologies. The net area of irrigated land expanded due to the introduction of agricultural electricity subsidies, going from 21 million hectares in 1950–1951 to 56 million hectares in 2001–2002 (Fosli et al. (2021); Gandhi & Namboodiri (2009). Based on a field survey in the state of United Andhra Pradesh (AP), Fosli et al. (2021) asserted that free power for agriculture is the lifeline in drought-prone areas since it helped them increase the area under irrigation and increase incomes.

The appraisal of electricity subsidy schemes in different states exposed the several flows in the operation and delivery of the scheme. According to Mukherji et al. (2010) and Jain (2006), only big farmers in West Bengal gained more from electricity subsidies than small farmers. This was similar in the case of Karnataka state also because farmers in the large category are far more likely to have pump sets than those in the small category. Thus larger farmers who have pumps use more power than small size category farmers who have pumps (Howes & Murgai, 2003). Both studies suggested that subsidies should be targeted at marginal and small-size farmers.

In the case of Andhra Pradesh, Dossani & Ranganathan (2004) explain that despite being massively subsidized, electricity tariffs are, on average, 15 per cent of farmers' income. Jain (2006) revealed disparities in the distribution of power subsidies across Punjab's advanced and underdeveloped areas. The poor small farmers, especially those in underdeveloped areas, are left out of the subsidy program. In contrast, medium and large farmers benefit greatly from it due to non-possession energy connections. Badiani-Magnusson & Jessoe (2018); Kaur & Sharma (2012) also concluded similar findings in Punjab, which suggested the imposition of flat rates on electricity supply to farming households as the study uncovered the willingness of farmers to pay for the electricity. The effect of energy prices on groundwater extraction and agricultural productivity was evaluated by Badiani-Magnusson & Jessoe (2018). Using district-level panel data for 1995 - 2004, The estimated results show that groundwater extraction will be lowered by 4.3% if the electricity subsidy is reduced by 10%.

Beyond the productivity rise and other positive externalities, electricity subsidies also heavily cost the state governments and the environment. The heavy burden of these subsidies out of public funds restricts real capital expenditures for the sector and funds available for other social programs (M. R. Badiani & Jessoe, 2018; Fosli et al., 2021) (Birner et al., 2011). The primary environmental costs are higher groundwater extraction for irrigation that resulted in higher depletion in the groundwater levels, increasing water-intensive crops like paddy even in places with limited water resources and borewell failures adding to the anguish of farmers (M. R. Badiani & Jessoe, 2018; Fosli et al., 2021; Kaur & Sharma, 2012).

The current study on 24 hours free electricity scheme draws special attention due to many factors. Firstly, in June 2014, the Andhra Pradesh state of Southern India was bifurcated to form Telangana state. It was the victory of long-standing demands and protests for autonomy in the socio-economic and political realm of the people in the region (Melkote et al., 2010). So, with the creation of the new state, especially with the large and significant agrarian sector in terms of workers employed and households engaged, the expectations for agriculture policies are high (Rao, 2015). Among other reasons for the demand for a separate state of Telangana, the discrimination against the region in erstwhile Andhra Pradesh in terms of expenditure of public funds, especially on the development of infrastructure like the creation of power generating capacities and surface irrigation facilities were critical (Seshan, 2018). Secondly, Telangana, part of Andhra Pradesh till 2014, was the first state where subsidized electricity schemes were introduced in India. In the 1984 election campaign, promises to implement a slab system based on the horsepower (HP) of irrigation pump set replacing the metering-based charges deconstructed the electricity policy in the state, as that helped the Telugu Desam Party to win the election. This shift to populistic policies marked the beginning of the transformation of electricity from a subsidized production input to a free service provided by the government (Price, 2011). The drought-prone agricultural sector of the Telangana region secured people's confidence in demanding higher subsidies served by ruling parties since then (Baskaran et al., 2015; Kondepati, 2011). This reached its expected stage in 2004 when Indian National Congress Party promised free electricity to farmers and won the election with huge support from rural voters. The current scheme under this study is the next phase, as a 24-hour supply to farmers is a first-time experiment in the country. Thirdly, the history of subsidies and free electricity schemes in the region makes the attitude of farmers towards the scheme worth an evaluation. This study attempts to tap the mindset of farmers towards the free electricity program in general and sustainability and conservation concerns in particular.

7.3. Profile of study area

Telangana state was formed in 2014 as the 29th state in India by bifurcating Andhra Pradesh state. The geographical area of 112,077 km2 is divided into 33 districts with a population of 3,50,03,674 (Census, 2011). 213.95 lakh people live in rural areas, or 61.12% of the state's population. The state's agricultural sector holds prominence as the leading sector of the state economy despite its share in the state's gross domestic product. More than fifty per cent of the state's workforce is employed in the agriculture and related sectors for sustenance (Periodic Labor Force Survey, 2019-20). 54.2 per cent of total rural households are agricultural households in the state; thus, the rural agrarian economy is highly significant for the political economy of the state. After the new state's formation, the agriculture and allied sector followed a progressive growth of 9.75% for the last seven years, from 2014-15 to 2021-22 (Planning Department, 2022). The major food crops produced in the state are paddy, followed by maize, cotton, mango, and sugar cane.

The primary survey for the study was conducted in the Nalgonda district of Telangana. The geographical area of the district is 7,122 sq. km. with a population of 161846 people. The selection of the Nalgonda district for the primary survey was based on different criteria. As the fundamental objective of the study is to evaluate the 24-hour free electricity supply to the farmers, the first criteria were the number of agricultural electricity connections in the district. Nalgonda district has the highest number of agriculture connections in the state (203323 - 27% of total connections). The gross area irrigated and area irrigated more than once are also the highest in the Nalgonda district. Considering the irrigation facilities like a tank and total wells (including medium tube well, shallow tubes, and dug wells), Nalgonda is one of the top 3 districts in the state. Among districts with more rural agricultural economic activities, the Nalgonda district generates the highest GDP (at the constant 2011-12 prices). One among the oldest district as part of former Andhra Pradesh, the experience and approach of farmers towards consequent agriculture policy changes are also worth noticing.

The study was conducted in the Mandra village in the Narketpally Mandal of Nalgonda district. According to the 2011 Census, the total population of the village is 1533, with 385 households majorly engaged in agriculture and allied activities. Data was collected from 340 households willing to respond to the field investigators, of which 90.8% were male-headed households. More than 60% of respondents are aged above 40 years, whereas above 50 years old 33 per cent. Even though the total literacy rate of the village is 55.5%, the education qualification of 68.5 of the households is below metric, and 20% is metric level. The caste composition of the village is as follows; backward caste (61.6), general category (21.7), and SC/ST category (16.8). The major crops cultivated are paddy and cotton.

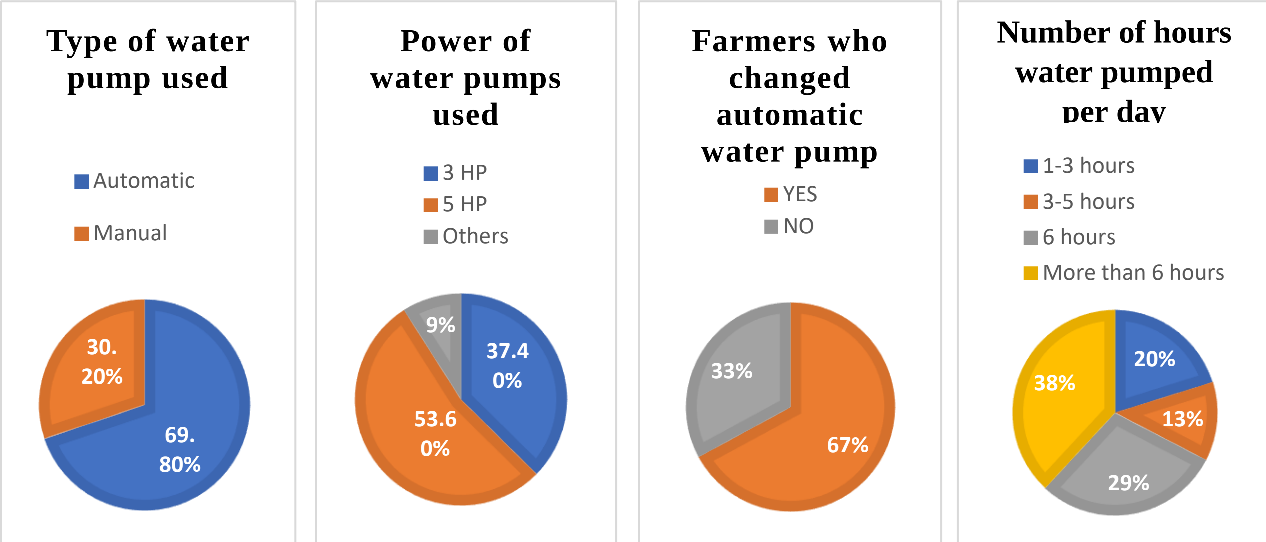
In contrast, vegetables and pulses are also produced as secondary crops, which explains why 64.8% of farmers cultivate in the Rabi and Kharif periods. The major agricultural allied activity in which farmers in the village are involved in livestock and poultry. The village's major irrigation source is the borewell (82%), which makes the study results ideal for evaluation.

7.4. 24-hour free electricity supply to agriculture sector scheme: an examination of farmers' attitudes

7.4.1. Farmers' preparedness for 24-hour free electricity program

Telangana state's energy sector condition was not promising at the state formation. On one side, being one of the energy-intensive states in India with a per capita energy consumption of 988 units against a national average of 917 units at the time of formation itself, whereas, on the other side, the power deficit of the state was around 5%. In that scenario, the power sector that should cater to the development needs of a newly formed state was an ambitious future path. The state started from a point where peak demand shortage was 2700 megawatts, 4 to 8 hours of load shedding to domestic and other connections, and two days of power holidays for industries. On the agrarian electricity supply front, the government initially ensured 7 hours of supply which was later upgraded to 9 hours (April 2016 onwards), and finally, with 24 hours power supply program. The effectiveness of any program primarily depends upon the existing structure on which the program will be implemented and how that will work with the change. Secondly, how positively the people at the receiving end address the changes expected to be delivered by the program. As mentioned earlier, the existing structure of agriculture power usage was based on a 9-hour power supply, where farmers were equipped with automatic water pumps. The Automatic pump starts working when the power supply is switched on from the distribution line, for which the time of supply varies. The first operational challenge to the 24-hour electricity supply was to change these automatic motors to manual motors; otherwise, usage would not be under control and result in wasteful usage. The government took initiatives to encourage farmers to change these water pumps before the announcement of 24 hours power supply program, which continued even after the program was in action.

Figure 7.1: Details of irrigation equipment and usage

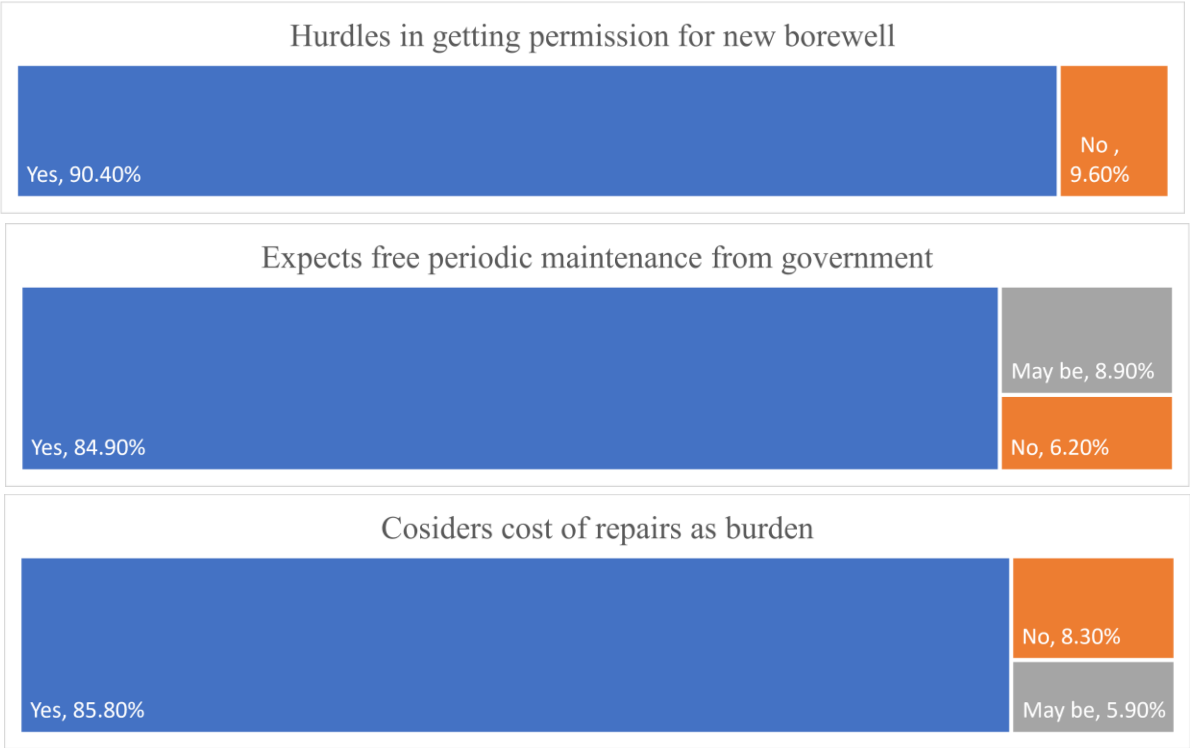


The study shows that 67.1 per cent of farmers changed their water pumps, were 32.9 continued to use their automatic pumps (Figure 7.1). It can be concluded that when a farmer changes the motor, he or she trusts the government with the new policy change, where they expect this to be a permanent change in the electricity supply's functioning. This positive acceptance of change comes with a cost where government support is insignificant. The cost of new motor pumps was 3 to 5 lakhs on average, as a significant 32.9% of farmers hesitated to change whatsoever the reason it explains a distrust which will have a severe impact on the environment regarding groundwater depletion and wasteful consumption. This was evident from the pilot program of a 24-hour free electricity program in 2017 in the Medak and Nalgonda districts, where motor pumps working around the clock resulted in the groundwater level drop. The majority of water pumps used are 5 HP power or 3 HP power in the village. The transition from automatic to manual water pumps fundamentally enables controlled water pumping. The survey shows that 60% of farmers used electricity to pump water for up to 6 hours (20.2 percentage 1-3 hours and 29.3 percentage 6 hours). This implies that farmers are judiciously using the free electricity supplied to them, which also endorses the success of the awareness programs conducted by the government. The most significant implication of this rational usage of electricity by farmers, which was early automatically running for 9 hours, is regarding the program's sustainability in terms of the power demand of the agricultural sector.

7.4.2. Ease of doing farming

In this section, we evaluate the facilitation by government machinery in implementing the scheme and farmers' attitudes towards the scheme's functioning, monitoring, and appraisal. The presence of a borewell as the major irrigation facility, enhanced by the power supply, is common in Telangana villages. The implementation of 24 hours power supply makes farmers realize the potential productivity augmentation, which encourages them to dig more borewells. Prior permission from the village and water authorities is needed to dig new borewells for the existing ones. It is also true that borewells used for years may face dry-up, necessitating farmers to dig new borewells. Ninety per cent of farmers face problems in getting this permission. This administrative hurdle without ample reasons has resulted in digging illegal borewells by farmers, which is common in villages. The basic objective of the government behind providing electricity to farmers is to help them to use electricity in production activities and increase production. At the operation level, this includes the periodic maintenance of the equipment they use, which will increase as they utilize more. The same pattern will have appeared post-implementation of 24-hour free electricity to farmers. The farmers affirm the occurrence of repair and failure of the motors, which is on an average two times in a month, and the average cost incurred for this repair works differs from case to case, but on an average cost is around 5000 per repair, which is high for farmers. 89.9 per cent of farmers reaffirm that the cost of repair and maintenance is a heavy burden on the farmers in the village, in which they expect the government to support them. 85.8 % of farmers expect the government to arrange free periodic services. This can be considered an addition to the program as a pro farmers' upgradation in the coming years. Regarding the monitoring of power supply, farmers' satisfaction is neutral, even though a significant 40 per cent of farmers were satisfied. The monitoring involves the quality of the power supply and responsiveness during power failures and other disruptions (Figure 7.2).

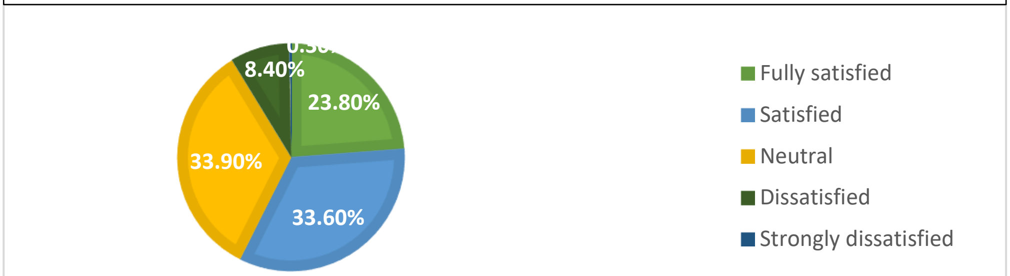
Figure 7.2 Ease of doing farming – Farmers' Perspective



7.4.3. 24-hour power supply appraisal from a farmer's perspective

Customer satisfaction is considered critical for products and services available in the market. In that sense, how satisfied farmers regard the 24-hour free electricity program is relevant to understanding their attitude. Fully satisfied 23.8 per cent and Satisfied 33.6 per cent validate the positive impact of the scheme and favour the government initiative (Figure 7.3). Even though 33 per cent of farmers are neutral about the program, the absence of a strictly dissatisfied category indicates the general acceptance and behaviour of farmers towards the freebies.

Figure 7.3: Farmers' satisfaction with 24 hours free electricity program



The significant share of farmers visible in Table 7.1(A) shows that it is relevant in farmers of Telangana under the study also, as 48.7 per cent of farmers think electricity should be fully free for farmers. In addition, the reluctance towards a common or usage-based tariff and unwillingness to pay more than the current rate for electricity used can also be considered as evidence of freebies expecting or seeking behaviour of farmers (Table 7.1(B & C). But from another perspective, farmers' willingness to pay (21.3 per cent) or accept common or usage-based tariffs (49.6%) should be accepted as evidence of change in the attitude of farmers.

Table 7.1: Farmers' attitudes on free electricity supply.

A. **Farmers' presumption of fully free electricity supply**		
Yes	No	Neutral
48.70%	42%	9%
B. **Farmers' acceptance of common tariffs or usage-based tariff**		
Yes	No	Neutral
49.60%	37.50%	12.90%
C. **Farmers' willingness to pay more than the current rate for electricity used**		
Yes	No	Neutral
21.30%	68.70%	9.90%

7.4.4. Sustainability and environmental concerns

In the first phase of concern, the program's sustainability resulted from the misuse of subsidized electricity supplied to farmers, commonly reported along with the theft in agrarian regions in states like Punjab and Uttar Pradesh (Gaur & Gupta, 2016). The farmers' assessment of fellow farmers and general perspective on farmers regarding the misuse of freebies is eloquent. Thirty-one per cent of farmers see possible misuse of freely provided electricity, whereas 36 per cent of farmers think in the opposite direction. With an optimistic approach, following the neutral 35 per cent with a positive 36 per cent category, it is relevant to know whether these farmers practice energy conservation in using the free electricity program. Here our optimism is uprooted, as the majority of farmers are either not following any sort of energy conservation practices or are very minimal (Table 7.2 -B).

Table 7.2: Sustainability and environmental concerns of Farmers

A. **Farmers' perception of misuse of the 24-hour free electricity?**				
Very likely	Likely	Neutral	Unlikely	Very Unlikely
12.50%	14%	35.80%	36%	1.70%
B. **Farmers following any energy conservation practices in usage of 24-hour free electricity**				
Not at All	Little	Moderately	Very Much	
35.40%	26.40%	34.20%	4.00%	
C. **Farmers' apprehension about the need for government-organized awareness drives energy conservation.**				
Very much needed	Needed	Neutral	Not needed	
42.30%	31.30%	21.40%	5.00%	
D. **Famers' intuition about the end of the scheme after some time.**				
Very likely	Likely	Neutral	Unlikely	Very Unlikely
16.70%	19.60%	40.10%	19%	4.60%

The surveyed farmers' attitude towards governments' responsibility in providing needed awareness among farmers on energy conservation adds their merits as 42.3 per cent and 31.3 per cent of them realize the urgency and need of such awareness on energy conservation. This implies that farmers value the worth of electricity the government supplies them freely. This positive attitude of farmers, along with their willingness to pay for the energy they will consume, should be recognized as evidence of behavioural transformation in Indian farmers towards freebies provided to them. This should be analyzed along with their expectations of the scheme's sustainability, where 36.3 per cent of farmers foresee the possible end of the free electricity program. If we add the neutral thoughts of farmers 40.1% to either mentioned pessimistic category or the category that trusts and wishes to receive free electricity forever, farmers' expectations of freebies are perspicuous.

7.4.5. The election results in Telangana's post-24 hours free electricity program

The election results as a complete manifestation of peoples' impression of economic policies are yet to be established in India. Just as the policy-making structure is complicated, the conduct of elections for different levels of government also makes such an evaluation inconclusive. Moreover, socio-economic and political factors play a crucial part in the voting decisions of individuals, from which appraisal of any individual policy or program cannot be dissected. Claiming an instrumental role in the Telangana state movement, the Telangana Rashtra Samithi (TRS) emerged as the strongest party in the state after the formation, which secured 63 out of 110 seats in the state legislative assembly. In a series of populist policies, the first government tried to meet people's expectations of the government. The 24-hour free electricity program was also among them, announced on 1st January 2018. The first major election that came after the program's implementation was the second state legislative assembly election held in January 2019, in which TRS won with a thumping majority. In 2019, the general election to the parliament of India also witnessed this trend, where TRS became the leading party in the state. Even though this result can't be comprehended directly as an appraisal of a scheme, it certainly testifies to a general notion that people accept the policies and programs of the incumbent government. The Mandra village where the primary study was conducted comes under Nakrekal legislative constituency and Bhongir parliament constituency. The election results contradict the general current as the opposition party, Indian National Congress (INC), won the constituency in the state legislative assembly elections in 2019, which had a TRS legislative member earlier. In the parliamentary election, the candidate from the opposition party won the constituency.

On a district level, in the Nalgonda district, 9 out of 12 constituencies were won by candidates of TRS, which shows peoples' mandate in favour of the previous government. The first Panchayat election, to the grassroots-level governing body was held in the newly formed state in January 2019. The TRS candidate was elected from the village in this local self-government election, which can be considered acceptance of the pro-farmer policies of the ruling party, like the 24-hour free electricity program.

7.5.Conclusion

The significance of electricity as a critical factor in the production process of the agriculture sector in India was comparatively leaden. But the socio-economic and political importance of the sector tantalized the political leadership to accept this progressive growth of electricity used in rural agrarian life betimes. This acceptance, which was not principally driven by the mechanization thrive of the sector, was quickly transformed into energy subsidy programs and included in the government's agriculture policy. The foundational rationale for state governments with subsidized or free electricity programs, including Punjab, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, etc., needs evaluation as the question of sustainability of such programs is under threat for various reasons.

The current study on the newly formed state of Telangana became relevant as it executed a first-of-its-kind program, i.e., the 24-hour free electricity program for the agricultural sector in the state. The new 24-hour free electricity program replaced 9 hours of electricity for the agriculture sector, mainly based on automatic motor pumps. The first structural change required for implementing the program was the decision of farmers to change their automatic pumps to manually operating motors. The study found that 67% of farmers have changed their motors, trusting the government's promise of a 24-hour electricity supply. The majority of pumps used by farmers are 5 or 3 HP power which is comparatively less than the motors used by farmers in states with free electricity schemes like Punjab. One of the first notable findings of the study is that the farmers in the studied households pumped water for only six or lessor hours. Secondly, considering the maintenance cost of these motors as a heavy burden, farmers expect the government to include provisions for periodic maintenance. This can be a vital addition to which the free electricity program in the next phase. Thirdly, a notable change in the attitude of farmers towards a freebie like free electricity is observed. A significant percentage of farmers are willing to pay a common usage-based electricity tariff. Along with their concern for energy conservation, this willingness deserves endorsement from the government side, which should embrace in future policy-making.

The studies on various free electricity programs in the country show there are three major impacts of the programs. First, the operation cost of these programs increases over the years, which burdens the State exchequer and deteriorates the financial health of electricity transmission companies. Secondly, free electricity-induced irrigation impelled change in cropping patterns, followed by heavy depletion in groundwater, and finally, the rise of disparities or inequalities in the delivery of the service in the program. The classic example of all these is the case of Punjab, where the burden of the free electricity program on the state exchequer is one of the reasons that made the state among the top indebted state in India. The increase in the number of tube wells in the state throughout the free electricity scheme is also a caution board for the states like Telangana, where it increased from 2.8 lakhs in the 1980s to 14.5 lakhs last year. This pattern is visible in the case of the power of motors used, where farmers moved from 5 HP to 20-25 HP motors in the same period. Even though farmers studied in this study expressed dissatisfaction with the bureaucratic hurdle in getting permission for new tube wells, Telangana state is urged to have a high level of monitoring on these implements for the program's sustainability.

The political economy around the freebies is inspired by the potential vote gaining power, which is not expected to stop soon. The freebies-based agriculture policies are receiving greater public reception as their financial status is hurt by various reasons, including the Covid-19 crisis. The political leadership in India has already inducted freebies as a solution for the poor status of the Indian agriculture sector, starting from energy and fertilizers subsidies to loan wavier in the last few decades. The recurrence of freebie announcements, especially before elections, turns public policy into a 'populist trap' where despite the problems they invite, no one can amend or withdraw from such programs. The basic nature of freebies, considering the Indian realities, like the fiscal position of states, is unsustainable. But a one-time withdrawal from these programs will be hard for these states. An ideal plan will be to replace these programs with high-technology induction and infrastructure development to reduce farmers' fixed costs. A more pragmatic approach will be based on mitigation measures like a gradual removal which allows a smooth transition. For example, conditional services like restricting free electricity to farmers who own less than 4 hectares of land or pay Income tax, as proposed in the draft policy of the Punjab state farmers and farm workers' Commission in 2018. Even though the definition and motivation of freebies are fluid, the attitude of benefit-receiving farmers is critical. The conscience among them on these types of freebies, moving above the short-run positive impacts, will be the stage where the government can come out of these populist traps. But that could be attained by collective action led by genuine political leadership who sails the people's minds.

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Chapter 8

CONCLUSION

8.1 Introduction

India is home to more than 1.4 billion people and is projected to be the most populous country in the world during 2023 (UN estimate). Since its independence from colonial rule, the development and aspirations of the people have been guided by the government at national and sub-national levels. Centralised and decentralised planning and policy implementation at different levels thrived in developing different sectors in the country. Through periodic elections at different levels, people extended their mandate for policymakers. Appraising 75 years of these exercises shows hope and despair across the sector. The comprehensive evaluation of different sectors will be necessary for any significant appraisal of developmental endeavours in the 75 years and to build a new foundation for the people's future aspirations. The fundamental objective of this study is to serve both of these necessities. Theoretical and empirical studies establishing the positive association between infrastructure development and different types of macroeconomic variables observe the direct impact on production and consumption along with many direct and indirect externalities they create (Buddhadeb Ghosh and Prabir De (2005). The output produced, income generated, employment growth, and general quality of life are these variables that can be positively manipulated by superior infrastructure in any region. The seminal works of (Aschauer, 1990) and few studies on development theories embodied infrastructural development concerns to general economic planning and policy making. In India, the public sector dominated infrastructure development since independence, which has undergone radical changes in the last 30 years.

Energy infrastructure is an essential component in the sub-structure of every nation. Developing energy infrastructure is critical for every other sector as it expands the level of development other sectors can achieve. This study attempted an in-depth analysis of energy infrastructure in India at both macro and micro levels. The study discussed different aspects of infrastructure development in three major energy sources: electricity, coal, oil, and gas. In the chapters with macro-level orientation, four domains are covered; they are the evolution of these three energy sectors since 1991, sectoral level electricity consumption, upcoming changes in the regulatory framework, and analysis of the high energy-intensive transportation sector with the focus on infrastructure performance, manufacturing sector, and public expenditure. It was organic that the study focussed on public sector involvement as the state is the major stakeholder in all sectors with the capacities of owner, regulator, and planner. As mentioned in the introduction chapter, the electricity sector occupies substantial attention in the study as it is recognised as the most convenient energy source directly involved in people's normal life. Considering the constitutional position of electricity as a subject in the concurrent list where both state and union governments share the governance responsibility, a state-level analysis is forwarded in the study. The youngest south Indian state of Telangana was selected for the study based on multiple criteria discussed in the relevant chapter.

8.2 Findings and Conclusions

In Chapter 2, a detailed review of Indian energy infrastructure development since 1991 is attempted. This foundational chapter examined public spending in the energy infrastructure development in the given period, which concluded that a significant upward progression is observed for the entire sector. The sectoral level examination of electricity, oil & gas, and coal also records steady improvement in their performance and structure with varying degrees in embracing reforms in governance. The study divides the period into 3 phases based on the general trend in public spending in the sector, where the first phase is with low public investment, followed by a revamp in public spending. The third phase is the ongoing trend where public spending shows growth through different programs and gives significant space for potential growth of the private sector. This is visible from the expenditure growth in the last two five-year plans and the year after that but calls attention to mounting revenue expenditure instead of desired capital expenditure.

The third chapter was assigned for the demand analysis, where output produced by different core sectors of the economy and their relationship with electricity consumption is studied. The Combined co-integration and Frequency domain causality tests were employed on annual data from 1971 to 2019. As unidirectional causality from three sectors to economic growth has been observed at least in a frequency in the short- to medium-term, the study extended the Growth hypothesis in India. The negative relationship between agriculture consumption and GDP growth raises multiple questions about where a productivity-enhancing role for the industrial and service sectors was expected.

Chapter 4 discusses the existing regulatory framework of the Electricity sector and the long-standing demand for holistic reform. The proposals of the recently introduced Electricity Amendment Bill (EAB) 2021 by the government of India are the main focus of the study. Evaluating the implications of major provisions in EAB 2021 regarding the new distribution model, pricing and subsidies, etc., it is found that opposition raised against the bill by major stakeholders, including state governments, employees, and farmers, are real concerns. The constitutional questions on the implementation of the proposed structure are also significant. Revising these proposals is necessary where these provisions will undergo changes and be reintroduced as more convincing for these stakeholders.

The interdependence and complexities in and around the energy sector call for innovative sectoral-level research to explore new insights into existing interactions between different sectors. In Chapter 4, a novel approach is taken to explore transport sector energy consumption recognising the transport sector as a vital infrastructure and a high energy-consuming sector. One of the objectives of economic reforms was to boost the manufacturing sector, which will have immense repercussions on the transport sector as a component of growth and subsequent demand. Here the study brings transport sector energy consumption, energy-intensive manufacturing output, transport infrastructure performance, and finally, the role of government in terms of public infrastructure investment to the discussion for the period from 1987 to 2019. The estimated results of the ARDL bound test found that transport infrastructure performance and manufacturing sector outcome are related to energy use in the sector. The long-run co-integration estimated by FMOLS, DOLS, and CCR tests endorsed the positive association between public investment in transport infrastructure and manufacturing sector output.

In Chapters 5 and 6, the electricity consumption of the agricultural sector in the south Indian state of Telangana is discussed. Chapter 5 examined different aspects of agricultural electricity demand in the 2014 formed state, which validated the state government's effort to develop the electricity sector. The increasing demand for electricity in the agricultural sector and high public expenditure are driven by revenue and subsidies that need careful assessment. The estimated co-integration and causality test results verified the significant relationship between agriculture sector output and electricity consumption in the state. On this foundation, the most celebrated electricity sector programs for farmers in the state were appraised based on primary survey data. The study concludes that farmers initiated the structural changes needed to implement the program from their side by changing their equipment. In contrast, the efforts from the side of the government are still inadequate. The changes in the attitude of farmers towards the freebie, like free electricity, along with their concern for the sustainability of the program, are appreciable.

8.3 Policy suggestions

The existing democratic structure of India ensures space for discussion and debate on public policies. The result of these discussions is the restructuring and reforms in different sectors. The different aspects of energy infrastructure development discussed in this study are also part of this larger scope of democracy and thus contribute to the literature. The changes in policy orientation and the need for new policies in different domains are discussed in relevant chapters. At the policy level, the study submits a few general concerns which should be incorporated into the future planning and development of energy infrastructure in India. The demand pressure on energy infrastructure in India will be driven by the demographic shift happening in the country, for which expansion of the current stock of infrastructure facilities is inevitable. The predominant role of government in this process will bring huge public expenditure. A systematic review of these infrastructure projects, including their sustainability objectives, will be critical here.

The institutional and economic risk these infrastructure development programs pose will be highly specific to their spatial and temporal contexts; thus, a review mechanism at both the union and state government levels will be needed separately for different energy sources. Even though the growth of the private sector in the energy sector was out of the scope of this study, the transition in the sector where government pushes for higher participation of private players is recognisable, and it is expected to increase in the future. But it is undeniable that private participation (even in Public-Private Partnership ventures) is skewed toward financially attractive projects and high-value locations. This will further contribute to the regional disparities in India now and result in the unbalanced development of different sectors. Here the role of the public sector becomes more relevant as a provider of "impure public good" like infrastructure. But the economic history of India shows that such a complete reliance on the public sector will give unfavourable outcomes.

The study also suggests that an energy infrastructure service should be developed through the optimum integration of public and private sectors. The public sector's central role will thus progress as the economy moves forward. The increasing revenue expenditure figures need to be checked in energy infrastructure development. The encouragement for the private sector should not be the excuse for shrinking public capital expenditure. Redesigning subsidies is essential for the sustainability of government intervention in the sector. This reshaping should consider the ground realities and be humane in principle; only they can convince the common people. The orientation of energy policy and public infrastructure development based on vote-gaining populism is a reality. If these populism-driven policies can address the sustainability questions, it is worth promoting nationwide, considering the direct benefit people will receive. In the end, the purpose of all planning and policies is to provide what people need and assist them in attaining a higher quality of life themselves.

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Strides for aberrations: The Electricity (Amendment) Bill, 2021 of India

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ABSTRACT

The article evaluates the provisions of the newly introduced Electricity (Amendment) Bill, 2021 by the government of India. As a holistic reform package for the electricity sector is coming after a long time, the bill deserves scrutiny regards its merits and other issues raised by various stakeholders. This article is an attempt to assess the bill with a focus on its implications for India's electricity sector. It examines the major features in the bill including the Renewable Purchase Obligation (RPO), the establishment of ECEA, enhanced payment security mechanism, the distribution Sublicense model, and the reforms in electricity pricing and subsidy system in the country. The repercussions of revamps in electricity pricing and subsidy system on farming communities and free electricity programs in many states incited opposition from stakeholders. It is found that the bill attempts to trespass the limits of the quasi-federal system in India, where it affects certain privileges of the state governments. The paper concludes that persisting crisis in the operations of the current regulatory paradigm in the electricity sector deserves a comprehensive renovation, but the abortive approach of the Bill on certain critical issues of the sector needs to be addressed.

1. Introduction

The electricity sector in India shares many features with the Indian agricultural sector in terms of the magnitude of operational complexities and ceaseless problems. The progressive transitions in the sector on both demand and supply sides in recent years are associated with the socio-economic development of the country. (Abdoli et al., 2015; P. Dasgupta and Chaudhuri, 2020). The government reform interventions in this sector are always aimed at making it a robust structure with sufficient flexibility. Any such reforms are evaluated based on positive future implications on the stakeholders including the public as public service, workers as the employer, and traders as an industry. The current discussion was actuated by the government with the release of a set of amendments to the Electricity Act, 2003 as the draft of the Electricity (Amendment) Bill, 2020 (EAB) by the Ministry of Power, Government of India on April 17, 2020, and later tabled on the parliament of India as the Electricity (Amendment) Bill, 2021 without any modifications. As the recurring problems in the sector have compelled many periodic reforms, a holistic reform package is coming after a long time. It should be noted that those periodic reforms have minimal impact on many institutional and operational disabilities of the sector as a whole. The failure of the much-celebrated Ujwal DISCOM Assurance Yojana (*UDAY*)[1] is a notable example in this regard (Kaur and Chakraborty, 2018). In that sense, the government has enough justification to bring a new level of reforms for a structurally stabilized electricity sector that is growth-oriented and welfare-oriented simultaneously. But strong disagreement and opposition were raised by the stakeholders regarding some of the new approaches and solutions in the proposed bill. Critics say that the central government misused the Covid-19 lockdown period to introduce the bill which earlier failed to get the parliament's node twice in 2014 and 2018 (Kanitkar et al., 2020).

India as a nation is the third-largest producer and consumer of electricity in the world, with a national electric grid of an installed capacity of 3,88,134 MW (as August 31, 2021, Central Electricity Authority). The regulatory paradigm of the sector dates back to pre-Independence with the Indian Electricity Act of 1910. It was followed by periodic legislation and programs which shaped the sector. The Electricity (Supply) Act (1948) and the Electricity Regulatory Commission Act (1998) are the major predecessor of the Electricity Act of 2003. The Electricity Act of 2003 was the first attempt to transform the power sector in India which covered provisions regarding generation, distribution, transmission, and trading in power. The newly introduced

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[1] UDAY is a scheme to provide financial turnaround and revival of indebted power distribution companies in the country launched by the Government of India in 2015.

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Economic growth and sectoral level electricity consumption nexus in India: new evidence from combined cointegration and frequency domain causality approaches

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ABSTRACT

The re-assessment of energy – economy nexus in developing economies like India is necessitated by the constant evolution of their growth path and sectoral progression. This sectoral level examination is intended to find new evidence for the dependence of economic growth on the electricity sector in India. Using annual data of per capita real GDP and sectoral level consumption of electricity from 1971 to 2019, the combined co-integration test and Frequency domain causality approaches are employed. The estimated results show the negative impact of agricultural sector electricity consumption on growth, whereas both the Industrial and service sector enhances the production. In addition, the results of the Frequency domain causality approach support the Growth hypothesis for the study period in India, as Uni-directional causality from three sectors to economic growth were found at least in a frequency of short run to medium run. The sustainability of the growth-enhancing role of electricity consumption will depend on more sector-specific energy policies and public spending on energy infrastructure development than bland subsidies.

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KEYWORDS
Electricity consumption; sectoral level analysis; energy-economy nexus; CCR; frequency domain causality

1. Introduction

The evolution of sectoral contribution to the Gross Domestic Product (GDP) and the growth process of the economy is associated with the progression of the production pattern of the country. To this end, the predominance of the agricultural sector to the growth of the industrial and service sector is a widely observed path. The invincible role played by the energy sector in this development is traced by the pattern of energy consumption in the mode of production. Energy – Economy interaction thus brought a new arena of investigation, which was crucial in the planning and development of the countries. In the last four decades, the relationship between energy consumption and economic activities became a widely studied topic in economic literature. The prime objective of these studies is to establish the cause-and-effect relationship between various variables and the direction of that link to augment the energy sector and economic activities. One of the early attempts was by Kraft and Kraft (1978) in which output and energy consumption for the United States from 1947 to 1974 were studied and concluded that there is unidirectional causality from the former to the latter. The series of empirical studies followed employed different econometric analytical approaches and proxy variables for different countries and periods but failed to present identical results.

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Transport infrastructure and manufacturing sector: an energy perspective from India

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Abstract

Purpose – The purpose of this study is to dissect the transport infrastructure performance, public spending in transport infrastructure development and the manufacturing sector in determining the transport sector energy consumption.

Design/methodology/approach – An analysis of transport energy consumption with the transport infrastructure performance, public spending in transport infrastructure and manufacturing sector output in India using annual data for the period 1987–2019. The study used the autoregressive distributed lag (ARDL) bounds test approach along with FMOLS, DOLS and canonical cointegration regression (CCR) methods.

Findings – The results of the ARDL bounds test provide evidence for the long- and short-run relationships among study variables. It evidenced that transport infrastructure performance reduces transport energy consumption by using FMOLS, DOLS and CCR methods. Furthermore, the inference of the positive impact of value added in the manufacturing sector on transport energy consumption validates the higher energy demand of the manufacturing sector from a mobility perspective.

Practical implications – The estimated finding of this study is expected to be contributing to policy-making discussions on transport infrastructure and manufacturing sector development in an emerging economy like India with insights on energy consumption.

Originality/value – To the best of the authors' knowledge, this is the first study that integrates the impact of manufacturing sector output on transport sector energy consumption along with transport infrastructure performance and public investment in the transport infrastructure.

Keywords Transport infrastructure, Public spending, Manufacturing sector, Transport energy consumption, ARDL bounds test, FMOLS, DOLS, CCR

Paper type Research paper

1. Introduction

The development of transport infrastructure is a critical step in the process of overall development of any region. Thus, it is argued that transport infrastructure enhances the mobility of people, goods and information which ensures the operation and progression of the economy (Mohmand *et al.*, 2021). In this vein, the important role of transport infrastructure is established on many parameters in the literature, such as resource

JEL classification – R4, O2, H5

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ACADEMIC PAPER

Emprising revival of Telangana power sector: Analysis from an Indian state

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The paper discusses the new 24-hr power supply to agricultural sector scheme of Telangana state in India. The first of its kind scheme that is fully funded by the state government set a new example for agrarian states in India. The paper explains the energy demand and supply management, fiscal and infrastructural preparedness of the scheme along with environmental concerns. The primary survey report from two villages testifies people's aspirations about the new scheme. Rational power consumption by farmers is identified as key factor of this scheme that will enable government to overcome challenges on sustainability of the scheme.

1 | INTRODUCTION

Energy is a pervasive element in the process of development for all countries where the levels of economic activity, population, and technology determine its magnitude. Country's energy needs and priority changes with the different stages of economic development it achieves. Countries like India where identification of such stages of development is imprecise are difficult for the formulation of energy policies that involves the development of interrelated policies at different levels. Central and state governments jointly endeavor the development objectives of power sector in India. Rural agrarian households are still the target for many of the energy policies in India. Electrification targets and modernization of agricultural production system are the foundation for these policies. Telangana as a newly formed state in India was equipped with a trailing power sector. Beyond the additional energy demands of a new state, Telangana was managing with 4–8 hr of load relief to domestic and other consumers and 2-day power holiday to industries. With a rural population of 213.95 lakh (61.1% of total population) in which 40% of households (26.5%—self-employed and 12.5% agricultural labor households) are directly employed in agricultural sector, the energy policies focusing on them are critical in the process of development of the state.

The year 2018 started with the joy of having free power to rural agrarian households in Telangana. The much-awaited scheme of 24×7 free electricity to farmers was started on new year eve. The new year gift by the state government calls for deep analysis regarding fiscal and energy sustainability of this "first in the country" scheme. The scheme came into action far before the implementation of another much-celebrated project of central government, "Saubagya" that was planned to ensure free electricity to rural households launched in September 2017. The new free electricity scheme in Telangana that started from January 1, 2018 at 00.01 hr aims at 24×7 power supply to 23 lakh agricultural connections in the state. The state was facing severe power crisis since its formation in 2014 with a deficit of about 2,700 MW. The first experience of this government's "magical" steps for the energy crisis came within 6 months by successfully providing 24×7 power supply to domestic connections and ensuring electricity supply to farmers from 7 to 9 hr (initiated from April 1, 2016 onward). The next mark of progress in this sector was by successfully supplying quality power—free of cost for 24 hr to the agriculture sector. Telangana has become the only state in the country to achieve this rare distinction in the power sector to end the despair of farmers. The new scheme needs attention as it is just about three and half years after the state formation the government was able to provide additional 9,500 MW to agricultural sector for free.

The study will bring the discussion on this new scheme by an Indian state in energy management for the first time to the literature. The successful implementation with cohesive evaluation on sustainability in fiscal and energy terms of the scheme will be critical as the potential success can be a model for other agrarian states.

2 | REVIEW OF LITERATURE

The causality between energy consumption and economic growth in India is established by various studies. Sajal (2002) explained that

CERTIFICATE

This certifies that **MOHAMMED SHAMEEM P** presented the paper *Emprising revival of Telangana power sector* at the **4th Annual APEEN Conference | Energy Demand-Side Management and Electricity Markets**, held at the University of Beira Interior (Covilhã, Portugal), on the 17th and 18th October, 2019.

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This is to certify that you have presented the paper with Conference Maker ID **417,** titled **"Public infrastructure development and energy consumption: A study on the Indian transport sector"** at the conference with your ticket order ID **4536516DF2**.

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Yours sincerely,
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This to certify that Mr. **Mohammed Shameem P** of **University of Hyderabad** has participated/presented a paper entitled "**Public Infrastructure Development and Energy Consumption: A Study on The Indian Transport Sector**" at **National Seminar as a part of Azadi Ka Amrit Mahotsav** organised by School Of Economics & DSW office, University Of Hyderabad, on 18th and 19th march,2022.

आज़ादी का अमृत महोत्सव

Dr. Krishna Reddy chittedi
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Two-Day National Seminar on
Federalism:
Cooperative or Coercive?
Debating Recent Developments

DEPARTMENT OF ECONOMICS AND POLITICAL SCIENCE

MES Mampad College (Autonomous) in collaboration with the

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Coordinator

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Institute of Parliamentary Affairs

FARMERS SURVEY ON

24 - HOURS FREE POWER SCHEME OF THE GOVERNMENT OF TELANGANA

(Questions for Google form)

Name of the Interviewer: ____________________ Date: __________

1. Name of head of the household:
2. Village:
3. Gender:
4. Age:
5. Educational Qualifications:
6. Category:
7. Agricultural-allied activities involved:
8. Size of landholding for agriculture (Acres)
9. The major period of Cultivation:
10. Major crops cultivated
11. The major source of Irrigation
12. The number of borewells dug in the last ten years:
13. Type of Water Pump used in major irrigation source:
14. Power of Water Pump used
15. How many hours Water is pumped per day?
16. The capacity of Water storage (Tank size)
17. Under 9 hours electricity Scheme, the schedule of the Water Pump used:
18. Did you change the automatic Water Pump to a manual Water Pump for the 24-hour free electricity?
19. Cost of New Motor installed for the 24-hour electricity :

20. Did you notice a significant change in the average depth of the borewell after the free electricity program?
21. The number of new bore wells dug and got permission after 2018:
22. Do you think the procedure to get permission should be simplified?
23. Did any bore well dry up after the free electricity program?
24. How many times has repair work happened to the water pump in a month?
25. Average repair cost year of these water pumps per year?
26. Do you think the cost of water pump repair is high for an average farmer?
27. Do you expect the government to arrange free periodical service of the water pump?
28. Do you agree that the Quality of electricity supplied has increased under the new scheme?
29. Did the government install any new transformers after the free power scheme?
30. Did the government increase electricity lines/ increase connectivity after the scheme?
31. How often do power cuts/interruptions occur in a month?
32. How often power failures have happened due to Transformer failure per season?
33. The average time taken to repair failed transformers by TSSPDCL?
34. Did you pay the cost of the Transformer failure or other supply interruption repair works?
35. Are you satisfied with the current monitoring of the electricity supply by the Corporation?
36. Do you think the electricity supply for farmers should be fully free?
37. Are you willing to pay more than the current rate for the electricity used?
38. Do you think the government should make a common tariff for all farmers or it should be based on usage?
39. Did the free electricity program increase your irrigated area?
40. Do you think 9 hours electricity supply was better than a 24-hour supply?

41. If yes, why?
42. Do you think 24-hour electricity supply enhanced daily life activities other than those related to farming?
43. Are you using electricity for any storage facilities of agricultural products?
44. Are you using electricity for any other agriculture-allied activities?
45. If yes, please specify:
46. Ownership of land cultivated:
47. If you are a tenant farmer, did the free electricity scheme reduce your lease amount?

Farmers' attitude to the 24-hour free power supply scheme:

48. Are you satisfied with the 24-hour free power scheme?
49. Do you agree that 24 hours free power scheme increased agricultural production?
50. Do you think farmers are misusing the 24-hour free electricity?
51. Do you think the government should make awareness among farmers on energy conservation?
52. Do you follow any energy conservation practices in your usage of 24-hour free electricity?
53. Do you think the government will stop this scheme after some time?
54. Are you aware of renewable energy-based farming practices?
55. Are you willing to shift to solar energy products in agriculture, if the government provides support?
56. What are the changes needed in the 24 hours electricity scheme?

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DECLARATION

This is to declare that the research conducted in this thesis entitled "Pu blic **Energy Infrastructure Development in India: An Empirical Analysis"** by Mohammed Shameem P (Registration no. l7SEPH09) is an original work carried out by him under my supervision for the award of Doctor o'1Philosophy degree from the University ot Hyderabad. This is to certify that the plagiarism shown in the plagiarism report is mainly from his own published work, which is chapters (3,4,5) from this thesis.

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