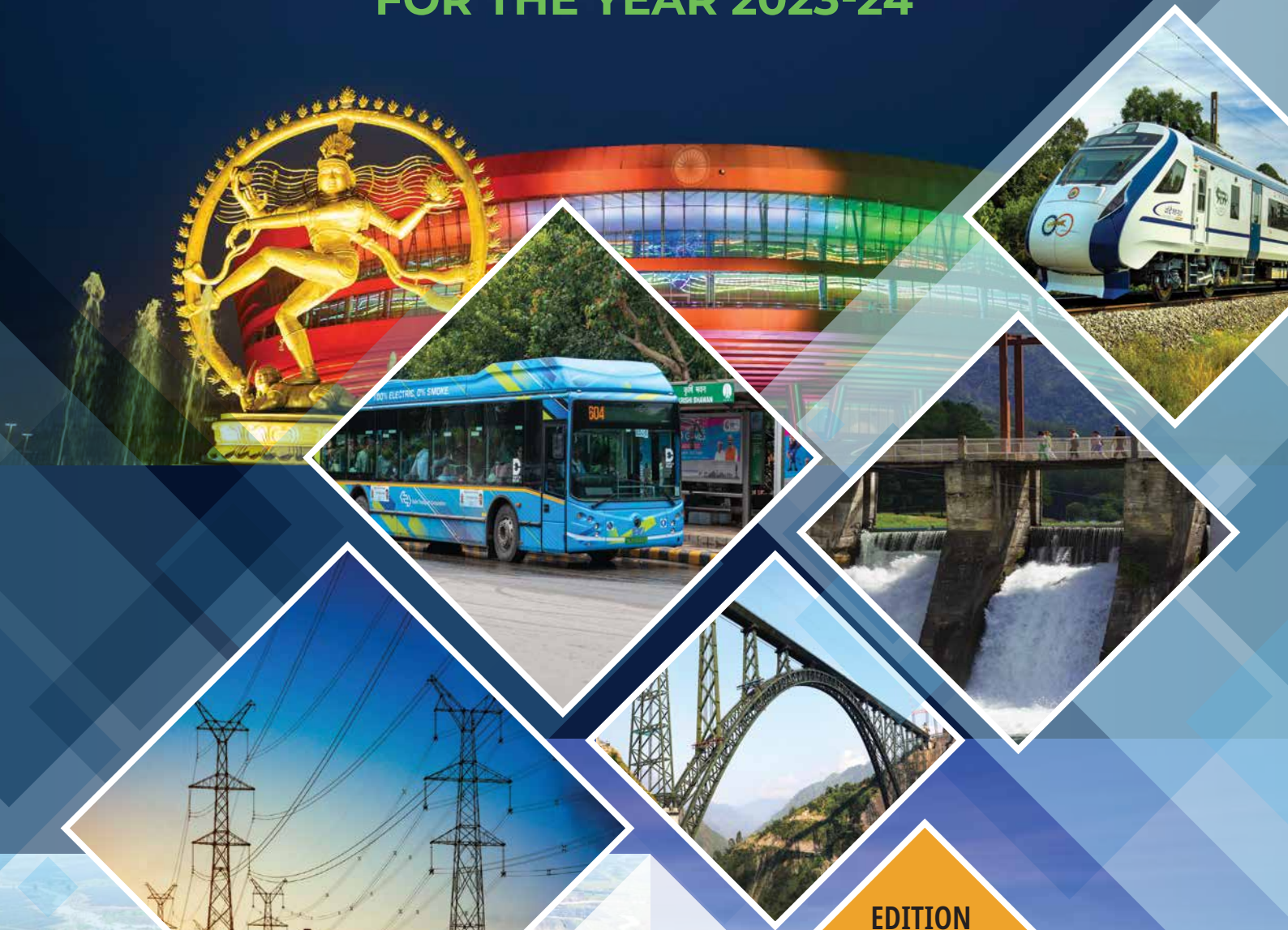
सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF POWER

INDIA ENERGY SCENARIO

FOR THE YEAR 2023-24



EDITION
II

ऊर्जा जीवन है, संरक्षण करें
Energy is Life, Conserve it

Bureau of Energy Efficiency

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MINISTRY OF POWER

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EDITION
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Bureau of Energy Efficiency

Imprint

Study by

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Commissioned on behalf of

Bureau of Energy Efficiency
Ministry of Power, Government of India
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Version
New Delhi, December 2024

मनोहर लाल
MANOHAR LAL

सत्यमेव जयते

विद्युत मंत्री एवं
आवासन और शहरी कार्य मंत्री
भारत सरकार
Minister of Power and
Minister of Housing and Urban Affairs
Government of India

MESSAGE

Clean, reliable, and affordable energy is essential for achieving India's vision under the *'Viksit Bharat 2047'* initiative. As our economy grows, industries expand, and critical infrastructure develops, it is vital that this growth is powered by clean energy with lower emissions. This will help India achieve its Sustainable Development Goals (SDGs) and meet its global climate commitments, including the goal of Net Zero Emissions by 2070.

Under the guidance of The Prime Minister, India is playing a key role in addressing climate change and promoting sustainable development. We have made remarkable progress in adopting clean technologies and protecting the environment. India's ambitious targets to triple renewable energy capacity and double energy efficiency by 2030 reflect our strong commitment to a sustainable future. We are confident that India will achieve its updated Nationally Determined Contributions (NDCs) ahead of schedule, setting an inspiring example for the world.

The Government is focusing on strong policies, innovation, data-driven planning, and global partnerships to accelerate the transition to a low-carbon economy. The timely release of the *India Energy Scenario for the year 2023-24* showcases India's progress using the latest data and trends from various Government Ministries and Departments. I congratulate the Bureau of Energy Efficiency (BEE) and its Energy Data and Management Unit (EDMU) for this valuable publication and encourage the creation of more such reliable data to track India's journey toward its climate and environmental goals.

(MANOHAR LAL)

New Delhi
December 2024

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श्रीपद नाईक
राज्य मंत्री
विद्युत एवं नवीन और नवीकरणीय ऊर्जा
भारत सरकार

सत्यमेव जयते

SHRIPAD NAIK
Minister of State for Power and
New and Renewable Energy
Government of India

MESSAGE

India's energy and climate approach is guided by the principle of *Vasudhaiva Kutumbakam*, meaning "One Earth, One Family, One Future." This reflects our belief that the Earth's limited resources must be used wisely and fairly so that everyone benefits and a sustainable future is ensured. India's ambitious energy and climate goals for 2030 and 2070 showcase this commitment to global harmony and shared responsibility.

India has made remarkable progress in this direction and is emerging as a global leader in energy and climate discussions. Initiatives like the International Solar Alliance (ISA) and Lifestyle for Environment (LiFE) at COP21, adoption of the Net Zero Emissions Goal at COP26, and the significant boost to renewable energy capacity and energy efficiency under our G20 Presidency in 2023 are clear examples. Today, India is ranked fourth globally in renewable energy installed capacity and has become the third-largest solar power generator, surpassing Japan last year. Many Indian states are also actively transitioning to clean energy by investing in renewable infrastructure.

This progress has been possible due to the visionary leadership and progressive actions of the Government of India. The *India Energy Scenario for the year 2023-24* highlights these achievements by providing insights into the changes in India's energy landscape compared to the first edition. This report will serve as a valuable resource for tracking India's journey toward its energy and climate goals.

Shripad Naik

(Shripad Naik)

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पंकज अग्रवाल, भा.प्र.से.
सचिव
Pankaj Agarwal, I.A.S.
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सत्यमेव जयते

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MESSAGE

India's energy landscape is transforming rapidly to meet its global environmental and climate commitments. Over the past decade (2013-14 to 2023-24), India has increased its energy supply by 54.5% and more than doubled its renewable energy capacity, with rooftop solar installations growing at an impressive annual rate of 45% since 2017-18. Additionally, 95% of India's railway network is now electrified, making it the largest green railway system in the world. As of October 2024, India's total electricity installed capacity has reached 454.5 GW, with non-fossil fuel capacity contributing 46.5%.

Efficient energy data management is key to monitoring and managing these achievements. Reliable data helps track progress and also enables better planning by forecasting future demand and identifying low-carbon energy alternatives tailored to specific sectors and energy uses. Ministries and Departments across India collect various datasets related to energy production, distribution, and consumption. Synchronizing this data ensures consistency, quality, and comparability across fuels and sectors.

The *India Energy Scenario for the year 2023-24* provides detailed insights into India's evolving energy landscape. It includes updated and granular data on key themes like electricity generation, biofuels, and emerging areas of interest. As India continues on its development path, accurate and timely energy data, along with trend and policy analyses, will play a crucial role in tracking progress, identifying best practices, and addressing areas needing improvement.

I encourage everyone to make the best use of this report to drive informed decision-making and support India's energy transition.

(Pankaj Agarwal)

श्रीकांत नागुलापल्ली, भा.प्र.से.
अपर सचिव, एमओपी एवं महानिदेशक, बीईई
SRIKANT NAGULAPALLI, IAS
Additional Secretary, MoP & Director General, BEE

सत्यमेव जयते

Azadi Ka Amrit Mahotsav

ऊर्जा दक्षता ब्यूरो
(विद्युत मंत्रालय, भारत सरकार)
BUREAU OF ENERGY EFFICIENCY
(Ministry of Power, Government of India)

FOREWORD

Energy security is crucial to meet the country's growing energy needs. This requires increasing the use of renewable energy sources, improving energy efficiency, and ensuring energy access for everyone. The Energy Data and Management Unit (EDMU) under the Bureau of Energy Efficiency (BEE) plays a vital role in this effort by providing insights into India's energy sector through its *India Energy Scenario for the year 2023-24.* I am pleased to note that the second edition of this report is being launched with updated and new datasets.

This report comes at an important time, as the world watches India fulfil its commitments to achieve 50% of its installed capacity from non-fossil sources and reduce the emissions intensity of its economy by 45% by 2030 (compared to 2005 levels), on the path to achieving Net Zero Carbon Emissions by 2070.

I hope this publication will provide valuable data to strengthen India's energy data management system. Building a robust system will require enhanced coordination and capacity-building across various Ministries and Departments. I believe that organizations already working closely with these entities can lead this effort, and I look forward to more such collaborations in the future.

I extend my appreciation to all line Ministries / Departments and Energy Data Management Unit team of BEE (Arijit Sengupta, Deepshikha Wadhwa, Abhishek Kumar Yadav, Anju R Singh and Payal Kumari) involved in bringing out this edition and look forward to seeing its data and insights guide energy initiatives across the country.

11-12-24

(Srikant Nagulapalli)

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ Save Energy for Benefit of Self and Nation
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RIGHT TO INFORMATION

स्वच्छ भारत एक कदम स्वच्छता की ओर

Contents

List of Figures

List of Tables

List of Annexure

Abbreviations

APEDA	Agricultural and Processed Food Products Export Development Authority
ATF	Aviation Turbine Fuel
ATUFS	Amended TUFS
BCM	Billion Cubic Metres
BEE	Bureau of Energy Efficiency
BEEP	Building Energy Efficiency Programme
BG	Broad Gauge
BPOs	Business Process Outsourcing
BU	Billion Units
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
CIL	Coal India Limited
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CPPRI	Central Pulp & Paper Research Institute
DAP	Di-Ammonium Phosphate
DBTL	Direct Benefit Transfer of LPG
DCPC	Department of Chemicals and Petrochemicals
DCs	Designated Consumers
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DG	Diesel Generator
DGCA	Directorate General of Civil Aviation
DISCOMs	Distribution Companies
DPIIT	Department for Promotion of Industry and Internal Trade
ECBC	Energy Conservation Building Code
ECSBC	Energy Conservation and Sustainable Building Code
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited

EIA	Energy Information Administration
ENVIS	Environmental Information System
EPI	Energy Performance Index
EV	Electric Vehicles
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicle
FDI	Foreign Direct Investment
FO	Furnace Oil
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GJ	Gigajoules
GoI	Government of India
GRIHA	Green Rating for Integrated Habitat Assessment
GVA	Gross Value Added
GW	Giga-Watt
HSD	High-Speed Diesel
ICED	India Climate Energy Dashboard
IR	Indian Railways
kWh	kilo-Watt hour
LDO	Light Speed Diesel Oil
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSHS	Low Sulphur Heavy Stock
MMSCM	Million Standard Cubic Metres
MNRE	Ministry of New & Renewable Energy
MoC&I	Ministry of Commerce and Industry
MoC	Ministry of Coal
MoEFCC	Ministry of Environment, Forest, and Climate Change
MoH&FW	Ministry of Health and Family Welfare

MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of Road Transport & Highways
MoSPI	Ministry of Statistics and Program Implementation
MSME	Micro, Small & Medium Enterprises
MT	Million Tonnes
$MTCO_2e$	Metric tons of carbon dioxide equivalent
Mtoe	Million Tonnes of Oil equivalent
NDAP	The National Data and Analytics Platform
NITI	National Institution for Transforming India
NOx	Nitrogen Oxides
NPP	National Power Portal
PARIVESH	Pro-Active and Responsive facilitation by Interactive, Virtuous and Environmental Single-window Hub
PAT	Perform, Achieve and Trade
PAT Cycle I	Perform, Achieve and Trade Cycle- I (from 2012-13 to 2014-15)
PAT Cycle II	Perform, Achieve and Trade Cycle- II (from 2015-16 to 2018-19)
PAT Cycle III	Perform, Achieve and Trade Cycle- III (from 2016-17 to 2019-20)
PAT Cycle IV	Perform, Achieve and Trade Cycle- IV (from 2017-18 to 2021-22)
PAT Cycle V	Perform, Achieve and Trade Cycle- V (from 2018-19 to 2021-22)
PAT Cycle VI	Perform, Achieve and Trade Cycle- VI (from 2019-20 to 2022-23)
PAT Cycle VII	Perform, Achieve and Trade Cycle- VII (from 2021-22 to 2024-25)
PAT Cycle VIII	Perform, Achieve and Trade Cycle VIII (from 2022-23 to 2025-26)
PIB	Press Information Bureau
PLI	Production-Linked Incentive
PM	Particulate Matter
PMAY	Pradhan Mantri Awas Yojana
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PMUY	Pradhan Mantri Ujjwala Yojana
PPAC	Petroleum Planning and Analysis Cell

PRAAPTI	Payment Ratification and Analysis in Power Procurement for bringing Transparency in Invoicing of Generators
RBI	Reserve Bank of India
RES	Renewable Energy Sources
RTS	Roof-top solar
S&L	Standards and Labelling
SAF	Sustainable Aviation Fuel
SAUBHAGYA	Sahaj Bijli Har Ghar Yojana
SIDBI	Small Industries Development Bank of India
SME	Small and Medium Enterprises
SOx	Sulphur Oxide
SSP	Single Super Phosphate
T/tcs	Tonnes per tonne of crude steel
TARANG	Transmission App for Real Time Monitoring and Growth
TCDS	Textile Cluster Development Scheme
tCO_2e	Tonnes of carbon dioxide equivalent
TMT	Thousand Metric Tonnes
TUFS	Technology Upgradation Fund Scheme
TWh	Terawatt hours
UDAY	Ujwal DISCOM Assurance Yojana
UJALA	Unnat Jyoti by Affordable Light-emitting diodes for All
UNIDO	United Nations Industrial Development Organization
US	United States
WB	World Bank
WRIS	Water Resource Information System

Executive Summary

Energy services are essential for economic development. Today, India stands at a point where the increasing energy requirements needs to balance the ambitious climate goals to improve the efficiency of its economy. India's efforts to increase its share of clean energy in the total installed capacity and reduce its emissions intensity are significant steps towards achieving its commitments on sustainable development and climate action. As on October 2024, India installed 203 GW of renewable energy and reduced the emission intensity of its GDP by 33 percent (from 2005-2019); inching it closer to meeting its 2030 NDC targets. As India strives to achieve a developed nation status by 2047 under its 'Viksit Bharat 2047' initiative, it is committed to provide clean, reliable and affordable energy to all its citizens.

However, energy sources are currently dominated by fossil fuels, which accounts for 75 percent of total Greenhouse Gas (GHG) emissions. This underscores the urgent need to transform energy production and the consumption patterns to achieve net-zero emissions and effectively mitigate the climate change impacts. India plans to implement a multi-layered strategy in order to achieve its ambitious climate targets, through a combination of conducive policy environments, improved data regimes, and greater collaboration amongst stakeholders.

The transition towards cleaner energy sources is crucial to India's energy strategy. While fossil fuels like Coal and Oil dominate the energy mix, there is also a growing emphasis on Renewable Energy Sources (RES) such as Solar, Wind, and Biomass along with battery energy storage and new technologies like green hydrogen, green ammonia towards greening the energy mix. Policies promoting tripling RES & doubling Energy Efficiency (EE) coupled with technological advancements, market transformation and investment incentives, play a crucial role in accelerating this transition.

However, the energy transition isn't just about replacing fossil fuels with cleaner options. It's a fundamental shift in our understanding of how energy interacts with the economy, society and systems. This interconnectedness demands a holistic approach in technology, policy, finance and most importantly, data. The role of accurate and timely energy data is instrumental in formulating informed policies to support energy transition in the country. Robust data facilitates evidence-based decision-making, aids in monitoring progress towards climate goals, and enhances transparency in energy governance. Addressing the gaps in data and strengthening data management frameworks are essential steps towards optimising energy planning.

The second edition of the India Energy Scenario Report, serves as a comprehensive resource of useful data and trends. It offers detailed insights into India's landscape of energy across supply and demand side sectors while emphasising the critical role of data-driven strategies. The report also attempts to

provide certain value additions from the last version with varying state-level granularities, newer sections on biofuels, electricity generation, updated energy balance for 2023-24 etc. The energy balance has been prepared by converting commodities from their physical forms (e.g., tonnes) to energy unit , Tonnes of Oil Equivalent (TOE), to align energy supply and demand. In 2023-24, total primary energy supply was 910 Mtoe, with 60 percent from coal, 28 percent from oil, 7 percent from gas, and 5 percent from non-fossil energy sources. The final energy consumption was 597 Mtoe, with industry at 49 percent, buildings at 13 percent, transport at 12 percent, agriculture at 4 percent, and other sectors at 22 percent. . On the demand side, this report attempts to break down the energy consumption by industries and electricity consumption by the buildings, further unpacking the energy and electricity consumption by various industries and appliances.

In the section on Industries, the report provides insights on energy consumption patterns and trends of various industries, which is based on data captured under the various energy efficiency schemes of the Government of India. Further, the report also provides an overview of appliance wise electricity consumption patterns in the buildings sector while also evaluating gaps in data that would need to be addressed going forward in creating robust data repositories for the building sectors.

The report also highlights the impact of energy efficiency schemes, which resulted in total energy savings of 53.60 Mtoe in 2023-24, accounting for approximately 6 percent of the country's total primary energy supply for the year. This includes savings of 25.96 Mtoe in thermal energy and 321.39 BU of electricity. These savings have led to significant cost reductions of INR 200,212.84 crores.

Value Additions

While taking cognisance of the various data dashboards that is available in public domain today in India, this report has a large number of new data or data value additions. A few of the major value additions are listed below.

Supply-side Trends and Analysis

- Comprehensive data on domestic coal production, including details by company, state, and coal type. This also covers data on imported coal and provides historical monthly trends for coal and lignite production.
- Data on crude oil production and imports, featuring historical monthly import trends. Includes an analysis of region-wise crude oil imports and details on the production, import, and export of various petroleum products.
- Detailed data on natural gas production and imports, along with a share of natural gas imports by country.
- A new section on biofuels has been added to this report, which provides insights into ethanol, methanol production in addition to the various initiatives taken by the Government of India to boost domestic production of bio-fuels.
- In-depth analysis of the electricity sector, including breakdown of utility and non-utility capacity and generation. Provided detailed information of RES capacity and generation.
- Data on industry-wise captive power plant installed capacity.

Demand-side Trends and Analysis

- Key insights on sectoral energy consumption, import dependency, electricity share in final energy consumption, peak demand and electricity surplus/shortage.

- Insights on key policies, initiatives and scheme introduced by the Government.
- Industry:
  - Analysis energy consumption in non-specified industries, with sector-wise energy consumption data for sectors based on energy efficiency schemes
  - Energy intensive industries production and fuel consumption trends
  - Detailed data on fuel and electricity consumption and process wise fuel consumption by the Designated Customers (DCs)/Obligated Entities (OEs).
- Buildings:
  - Data on appliances wise electricity consumption based on appliance labelling programme
  - Fuel and electricity consumption trends in residential and commercial sector
  - Production of appliances based on star rating which includes data from the Energy Performance Index (EPI) for various categories of commercial buildings
  - Insights into the growing demand for space cooling in buildings
- Transport:
  - Segments in the transport sector are by the mode, namely, road, rail, air and shipping
  - Trends on mode-wise passenger and freight kilometres, vehicle registration and electric vehicles registration
  - Mode wise data on fuel and electricity consumption.
- Agriculture:
  - Data on diesel, electric and solar irrigation pump sets
  - Implementation status of the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyaan (PM-KUSUM scheme), with a component-wise breakdown of pump installations.
  - Fuel and electricity consumption trends in the agriculture sector.
- Developed the energy balance for the year 2023-24
  - Analysed industrial energy consumption, redefined industry subsectors and reduced the non-specified industry gap
  - Disaggregated building energy consumption based on appliances usage.
- Insights on energy and electricity sector data trends and developments for States has been incorporated in the relevant sections.
- Identification of gaps in data from various sectors has been compiled along with listing out comprehensive list of parameters to ensure robust data gathering going forward.

1. Brief Overview

1.1. India's Energy Landscape: A snapshot

India plays a pivotal role in the global energy transition. It's growing population, increasing energy needs and impressive economic growth make its journey of energy crucial not just for itself, but for the entire world. This reflects India's evolving position on the global energy and climate stage, where its development and trajectory of emissions are critical to achieving the global climate goals. The previous decade (2013-2023) was instrumental in shaping India's clean energy transition. India became the fourth largest consumer of electricity as well as the third largest renewable energy producer in the world. Here is a look at the significant progress made-

A. Rising Energy Needs: India's energy sector is experiencing tremendous growth mirrored by the country's booming population

- The primary energy supply increased by 54.5 percent over the past decade (2013-14 to 2023-24); rising from 589 Mtoe to 910 Mtoe.
- The total electricity consumption (including captive) doubled from 874 Billion Units (BU) to 1,543 BU between 2013-14 and 2023-24, growing at an annual rate of 5.8 percent.
- India's peak electricity demand surged by 79 percent, rising from 136 GW to 243 GW between 2013-14 to 2023-24. Notably; on May 30, 2024, India recorded an all-time high peak electricity demand of 250 GW.

B. A more Reliable and Cleaner Power System: Over the last ten years, India reduced electricity shortages by building a robust clean power infrastructure. The installed electricity capacity almost doubled from 248 GW in 2013-14 to 442 GW in 2023-24 (CEA b, 2024).

- Renewable energy capacity has more than doubled, rising from 76 GW to 191 GW between 2013-14 and 2023-24. This growth has further contributed to a significant increase in the share of renewable energy in India's power generation mix; rising from 18 percent to 21 percent in 2023-24.
- Roof-top Solar (RTS) recorded a phenomenal growth of 45 percent annually since 2017-18, rising from 1.06 GW in 2017-18 to 14.45 GW in 2024-25 (as of Oct-24).
- Peak demand shortages plummeted from 4.5 percent to 1.4 percent, and the overall electricity requirement shortage has been reduced to 0.3 percent.

C. Decarbonisation of the Industry Sector: The industry sector in India is the largest consumer of both energy and electricity consumption, accounting for 49.5 percent and 42 percent of the energy and electricity consumption share respectively in 2023-24.

- In the last decade, there has been a noticeable shift towards cleaner fuels in the Industry Sector, reducing coal's share in total energy consumption from 70 percent in 2013-14 to 63 percent in 2023-24.
- The implementation of the energy efficiency schemes resulted in substantial energy savings in the industry sector, achieving 25.81 Mtoe and reducing CO_2 emissions by 110.95 $MTCO_2e$ /year.
- The Iron and Steel Sector has achieved its emission intensity reduction targets, lowering emission intensity from 3.1 T/tcs (tonne of CO_2/tonne of crude steel) in 2005 to 2.5 T/tcs in 2020.

D. Transport Sector leading the Energy Demand Growth: The transport sector is the second major consumer of energy after Industry, accounting for 12 percent of the final energy consumption. The sector is indispensable for the country's socio-economic development as it provides connectivity and integrates 1.4 billion people.

- The transport sector witnessed the highest demand growth in India's energy consumption basket, rising from 35 Mtoe to 72 Mtoe between 2013-14 to 2023-24. The increase continues to be propelled by a growing vehicle usage in the road transport segment.
- Responsible for 87 percent of passenger traffic and 60 percent of freight traffic, the road transport accounted for over 77 percent of total transport-related energy consumption in 2023-24.
- In recent years, there has been a notable shift to Electric Vehicles (EVs) with EV ownership in new vehicle sales rising from 0.3 percent in 2016-17 to 7 percent in 2023-24. In the last decade, India registered a total of 39.6 lakh electric vehicles with 11.6 lakhs added between April 2024 and October 2024.

E. Surge in Residential Electricity Consumption: The buildings sector is the second major consumer of electricity after industry, accounting for 32 percent of the total electricity consumption in India.

- Improving living standards and a massive electrification drive led to a significant increase in electricity consumption in residential buildings. From 2013-14 to 2023-24, electricity consumption increased from 200 BUs to 375 BUs, taking a second highest share (after Industry) for category-wise electricity consumption in India.
- The Pradhan Mantri Ujjwala Yojana (PMUY) scheme led to an exponential rise in the use of Liquid Petroleum Gas (LPG) for cleaner cooking, increasing its share of residential consumption from 69 percent in 2013-14 to 99 percent in 2023-24. As on 01st December 2024, 10.33 crore s were released across the country.

F. Solarisation of the Agriculture Sector: India is an agriculture-based country with agriculture providing livelihood to almost 45.76 percent population in the country. Solar energy for irrigation is paving a sustainable and economical path for growing agricultural activities in India.

- Oil consumption in the agricultural sector has been steadily declining, with electricity serving as the primary energy source, accounting for 97 percent of total energy use in 2023-24.
- The number of energised pump sets has increased from 189 Lakhs in 2012-13 to 272 Lakhs in 2022-23, reflecting an annual growth rate of 4 percent. Meanwhile, solar pump adoption grew substantially during the same period, rising from 11,626 to 5.27 Lakhs, marking a 45-fold increase.

1.2 Role of Data and Information in Enabling Energy Transition

Data and analytics, empower us to predict our energy needs. As India advances towards achieving NET Zero emission by 2070, data and information can help meet our clean energy goals in an informed and secure manner. It anticipates future demand and consumption patterns, forms the basis to plan for cleaner supply-side alternatives and steer sustainable lifestyle choices for efficient energy consumption.

Transitioning to cleaner and decentralised energy systems requires a paradigm shift in how we collect, store and use data. Data is fundamental in shaping large-scale, long-term and low-carbon climate and

energy trends, which impact various facets of the environment, economy, society and geopolitics. The emerging trends would require systematic integration of data and technology for building smart cities. Some of these trends are deep decarbonisation of hard-to-abate industries, sustainable cooling solutions for buildings, effective weather forecasting for enhancing crop productivity, robust modelling assessments for building energy supply chains; amongst others. Such trends when combined with digital technologies and artificial intelligence can lead to long-lasting impacts and provide solutions for not just the energy sector but also the entire economy.

In recent years, India made a remarkable progress in enhancing the availability and transparency of energy data (Figure 1). Various Line Ministries and Departments provide reliable datasets, tracking production, distribution and use of energy, across the country. strong supply-side repository has been created over the years that has enabled informed decision making and course correction. However, accelerating data collection efforts on the consumer side remains a critical priority.

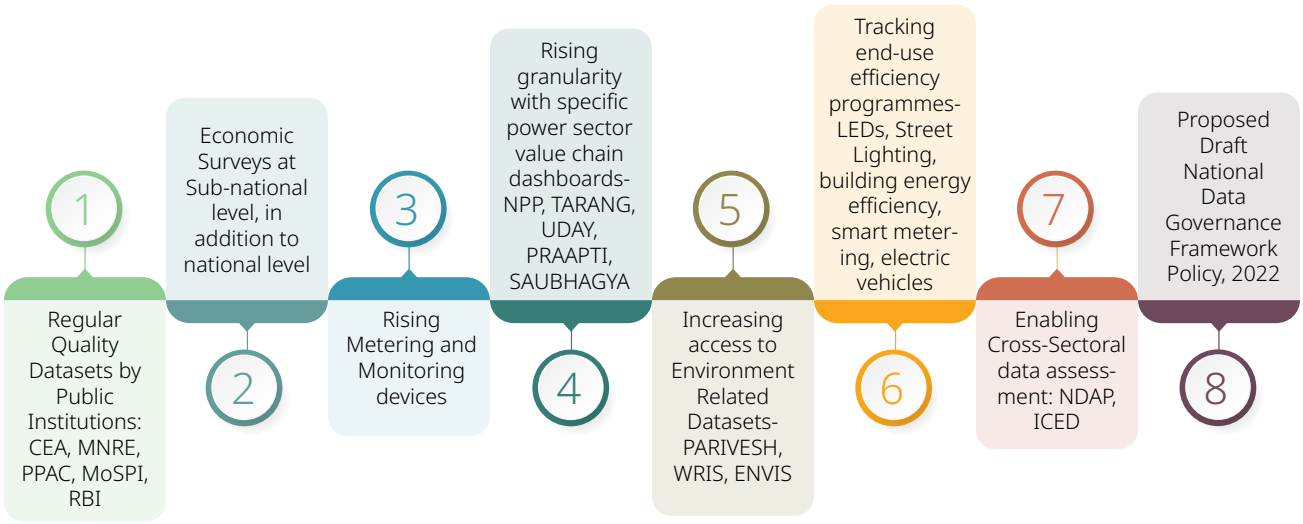


Figure 1: *The Evolving Landscape of Energy Data Management in India*

A quick overview of the report is presented below:

- The first chapter of the report provides insights of India's energy landscape and captures the key trends and developments of its energy transition journey across various sectors, in the decade of FY 2013-14 to FY 2023-24.
- The second chapter presents extensive analysis on supply and trade of various fuels from FY 2016-17 to FY 2023-24, along with comprehensive data on both electricity utility and non-utilities.
- The third chapter delves into key Government policies and initiatives, providing in-depth analysis and insights for major demand sectors such as Industry, Buildings, Transport, and Agriculture.
- The fourth chapter provides an overview of India's energy landscape, focusing on primary energy supply, the increasing contribution of renewables, sector-specific consumption trends, and efforts towards energy efficiency and sustainability.
- The fifth chapter provides an overview of energy conservation efforts in India, highlighting the impact of various energy efficiency schemes and policies implemented by the BEE.
- The sixth chapter explores the complexities of energy data management in India, focusing on sector-specific data gaps. Additionally, it showcases best practices in data collection from various countries.

2. Supply side - Trends and Analysis

The landscape of energy supply and use in India is undergoing significant transformations, driven by technological advancements, clean energy policy shifts and evolving market dynamics. India is implementing a range of policies with the aim to achieve a secure and sustainable energy trajectory. This chapter delves into compiling a detailed energy supply trends in India from various energy sources such as coal, oil, petroleum products, biofuels and electricity.

Primary Energy Supply

2.1 Coal

Coal, including lignite, with its substantial share of 61 percent of the total primary energy supply, plays a pivotal role in meeting the nation's increasing energy demand. This is evident from the fact that in the last decade, the electricity generated by coal power plants supported an average of 75 percent of the total electricity generation. This dependence on coal is primarily due to India's cheaper and substantial domestic coal reserves. India stands at number five in the global ranking MoC, Feb 2024), with a quantity of 437 billion tonnes in reserves (MoC, 2024).

In the year 2023-24, the total coal (including lignite) consumption in the country was 1,277 million tonnes (MoC, 2024). Of this, approximately 80 percent was domestically produced, while the remaining 20 percent was imported from Australia, Indonesia, and Russia. Out of the total imported coal, 58 million tonnes consumed in steel sector while 203 million tonnes attributed to other sectors. The imported coal, predominantly non-coking coal, has a superior calorific value and lower ash content in comparison to domestic coal. This makes imported coal, predominantly non-coking coal, has a superior calorific value and lower ash content in comparison to domestic coal.

Domestic Coal Production in India

In 2023-24, India's coal production reached 998 million tonnes, closely aligning with the Ministry of Coal's target of 1,000 million tonnes for coal production (excluding lignite) (MoC, 2022). When lignite is included, the total coal production for the same period amounted to 1,041 million tonnes. This reflects a Compounded Annual Growth Rate (CAGR) of 6 percent over the past decade and marks an impressive 11 percent increase compared to 937 million tonnes of production in 2022-23.

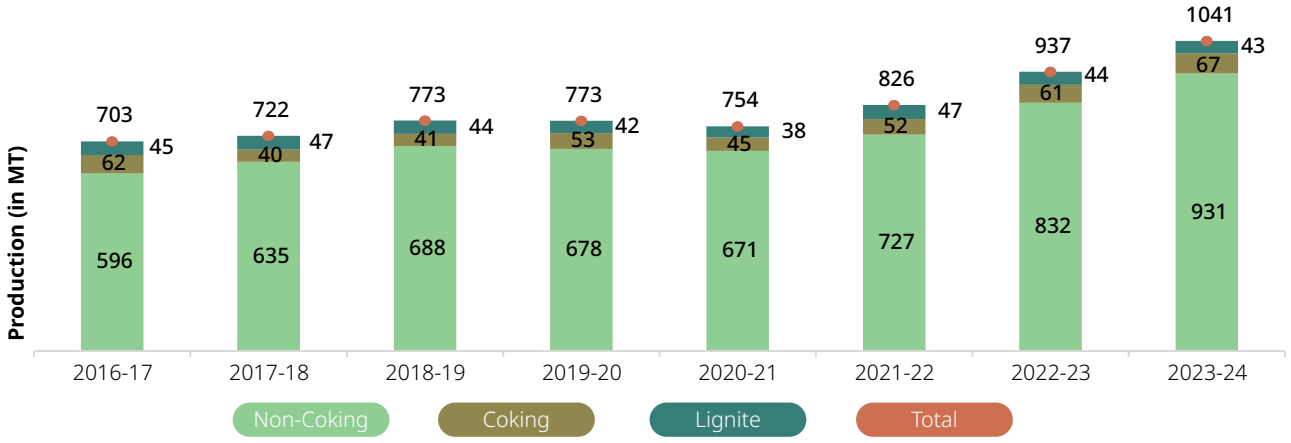


Figure 2: *Domestic Coal Production from 2016-17 to 2023-24 (in Million Tonnes)*

Source: (MoC, 2024) and (MoC, 2024a)

Furthermore, the Ministry of Coal furnishes a monthly data pertaining to coal production in the country. India achieved a new monthly peak of 122 MT coal production on March 2024, surpassing the record of 113 MT set in March 2023 (refer Figure 3). Coal production typically decreases during the monsoon season, from June to September, as heavy rainfall leads to flooding in coal mines, making coal extraction challenging. In addition to this, the roads and transport networks are impacted during heavy rains, obstructing the transportation of coal.

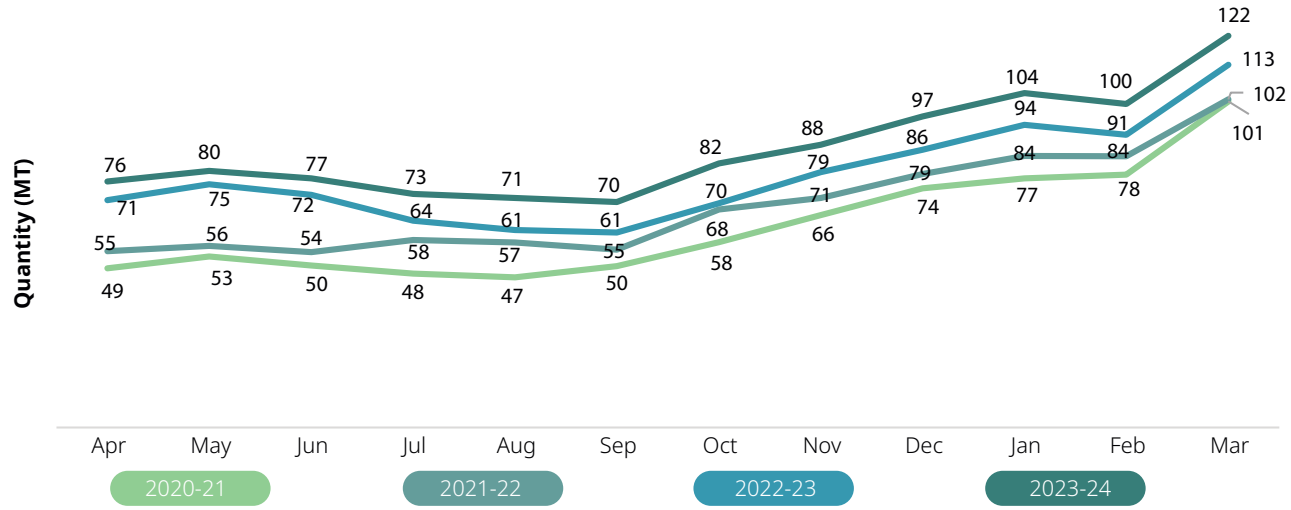


Figure 3: *Monthly Coal Production Trends (incl. lignite)*

Source: (MoC, 2024a)

Coal Production by Company

Coal production in India is primarily dominated by a state-owned company, Coal India Limited (CIL). Historically, CIL maintained a share of over 70 percent of the total coal production, followed by contributions from other public and private companies. In last six years, coal production by CIL increased from 554 MT in 2016-17 to 774 MT in 2023-24 (Figure 4).

The substantial growth in domestic coal production aligns with the vision of 'Atmanirbhar Bharat', significantly contributing to the nation's commitment to self-sufficiency and energy security. Additionally, various reforms and policy measures implemented by the Government, such as the Coal Linkage Policy, Amendments to the Coal Mines (Special Provisions) Rules 2014, the Coal Blocks Allocation Rules 2017, and

the launch of the Single Window Clearance portal for the coal sector to expedite the operationalisation of coal mines, have also contributed to this growth. CIL has eight subsidiaries namely, Bharat Coking Coal Limited (BCCL), Central Coalfields Limited (CCL), Eastern Coalfields Limited (ECL), Western Coalfields Limited (WCL), South Eastern Coalfields Limited (SECL), Northern Coalfields Limited (NCL), Mahanadi Coalfields Limited (MCL) and North Eastern Coalfields (NEC).

In 2023-24, CIL held the largest share of 74 percent in total coal production, yielding 774 MT. Among CIL's subsidiaries, MCL led the coal production with 206 MT (27 percent), followed by SECL with 188 MT (24 percent), NCL with 244 MT (32 percent). The remaining subsidiaries collectively contributed 212 MT (30 percent) in coal production (refer Figure 5). Besides CIL, other public and private companies together accounted for 26 percent of the total coal output, with public companies contributing 219 MT, and private companies producing 48 MT of coal (Figure 4).

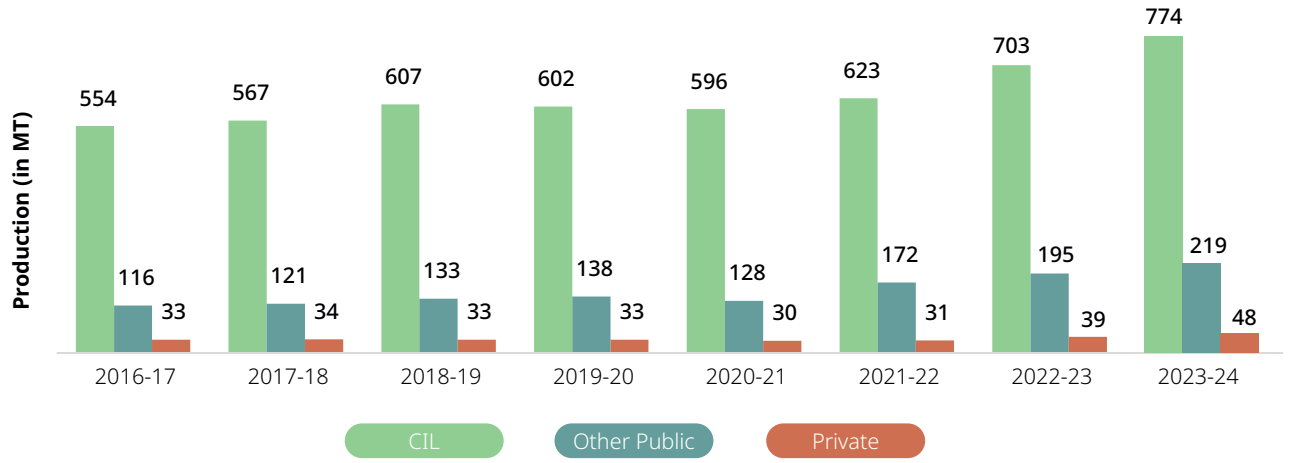


Figure 4: *Company wise Domestic Coal Production from 2016-17 to 2023-24*

Source: (MoC, 2024)

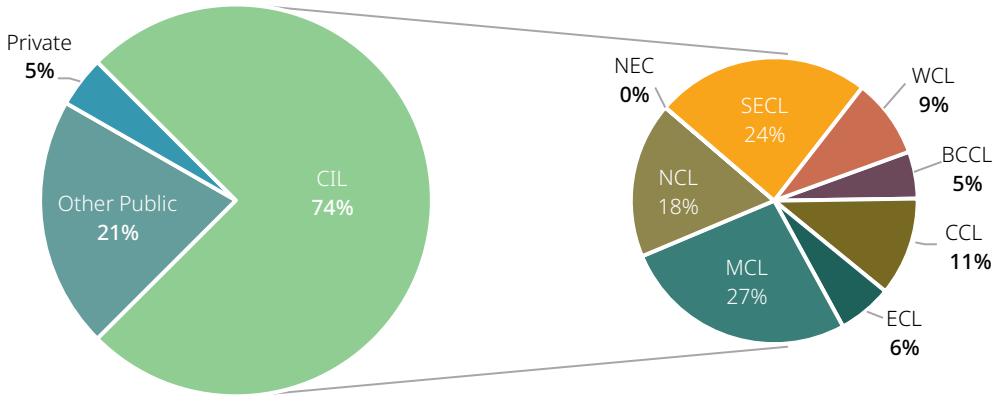


Figure 5: *Company wise Percentage Share of Coal Production in 2023-24*

Source: (MoC, 2024)

State Level Coal Production - A Glance

The major coal producing states in the country are Odisha, Chhattisgarh, Jharkhand, Madhya Pradesh, and Telangana. Figure 6 below depicts the coal production by these states during 2023-24. Odisha, produced the maximum coal at 239 MT followed by Chhattisgarh, Jharkhand, Madhya Pradesh and Telangana. These five states lead the coal production accounting for 84 percent of the nation's total produce.

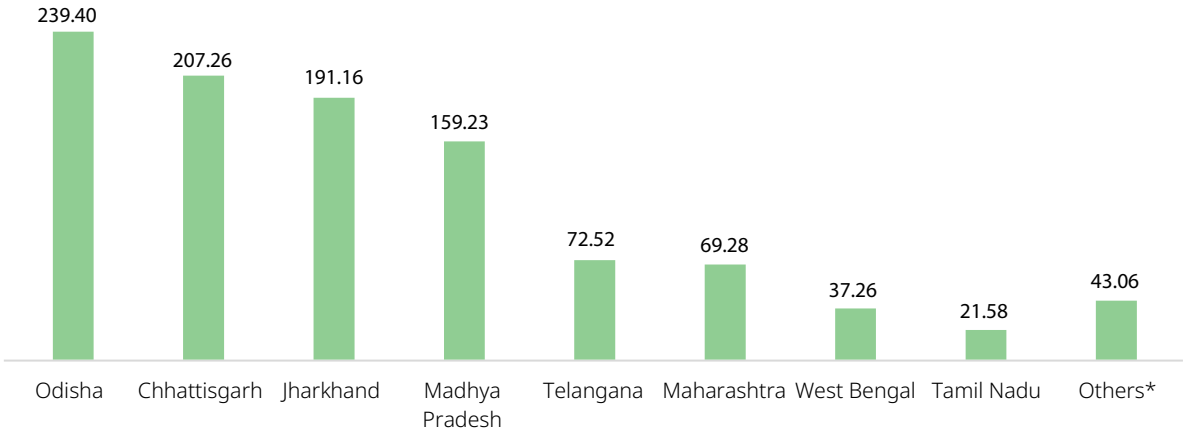


Figure 6: *State wise Domestic Coal Production during 2023-24*

Source: (MoC, 2024)
*Others include Jammu & Kashmir, Rajasthan, Uttar Pradesh, Gujarat, and Assam.

Import and Export of Coal in India

Despite having substantial coal reserves, India needs to import additional coal to bridge the demand-supply gap. India is the second largest importer of coal in the world, after China (MoC, March, 2024). The country imports various types of coal, including coking, non-coking, lignite, and coke. In 2023-24, the coal imports stood at 265 MT, primarily sourced from Indonesia and Australia, which is 10 percent increase compared to 241 MT of coal imported in 2022-23.

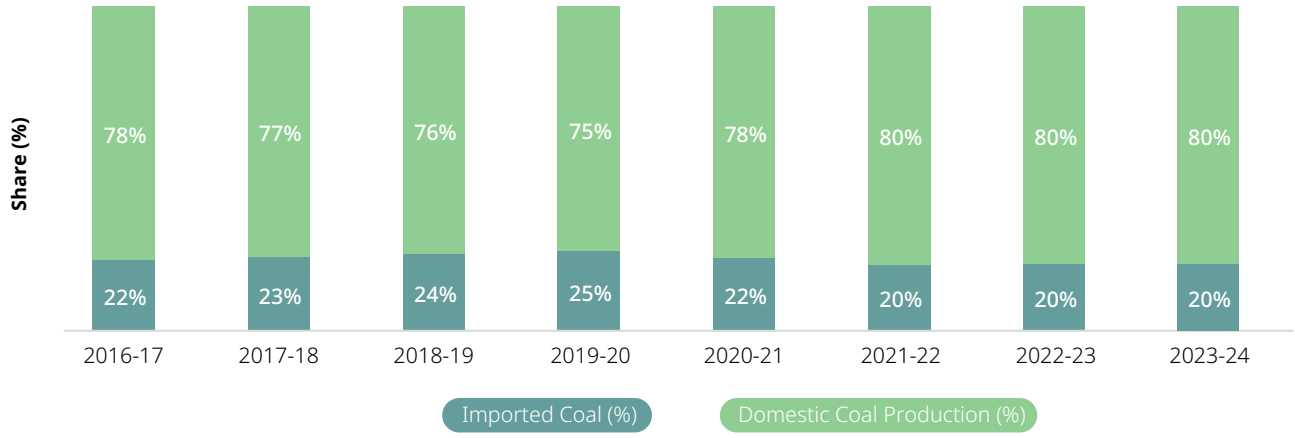


Figure 7: *Domestic Coal Production and Import Share in India from 2016-17 to 2023-24*

Source: (MoC, 2024)

Figure 7 highlights the decline in India's dependency on imported coal, from 25 percent in 2019-20 to 20 percent in 2023-24. The GoI implemented several measures to reduce coal imports and enhance domestic coal production. The Ministry of Coal established an Inter-Ministerial Committee (IMC) (MoC, March, 2024), with an aim to substitute imported coal with domestic coal by 2030. The major functions of committee include examining logistics and bottlenecks in coal transportation, monitoring coal imports from different sectors and improving the overall efficiency of coal supply chains. Other initiatives involve a single window clearance, expedited environment clearances and encouraging private sector participation in coal mining. Consequently, these endeavours led to a boost in coal production and a decline in imports, indicating India's commitment to self-reliance and energy security.

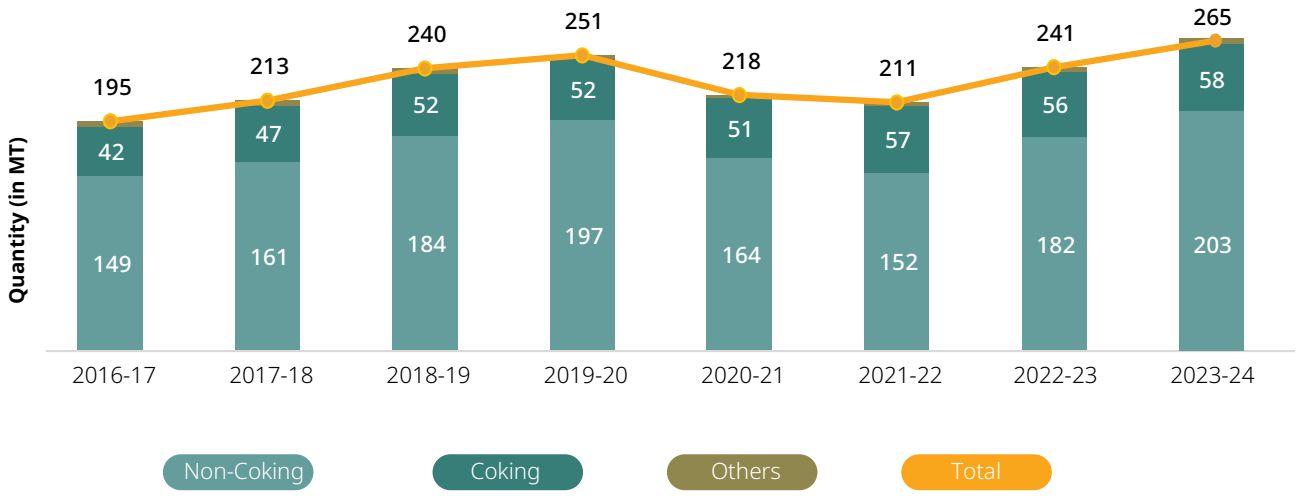


Figure 8: *Coal Imports by India from 2016-17 to 2023-24*

Source: (MoC, 2024) 'Others' include lignite and coke

Further, India exports a majority of its coal to Nepal and Bangladesh. During the year 2020-21, there was an increase in coal exports compared to previous years. This surge attributes to the significant impact of COVID-19-related restrictions on industrial production, leading to reduced domestic coal demand and a resulting increase in exports.

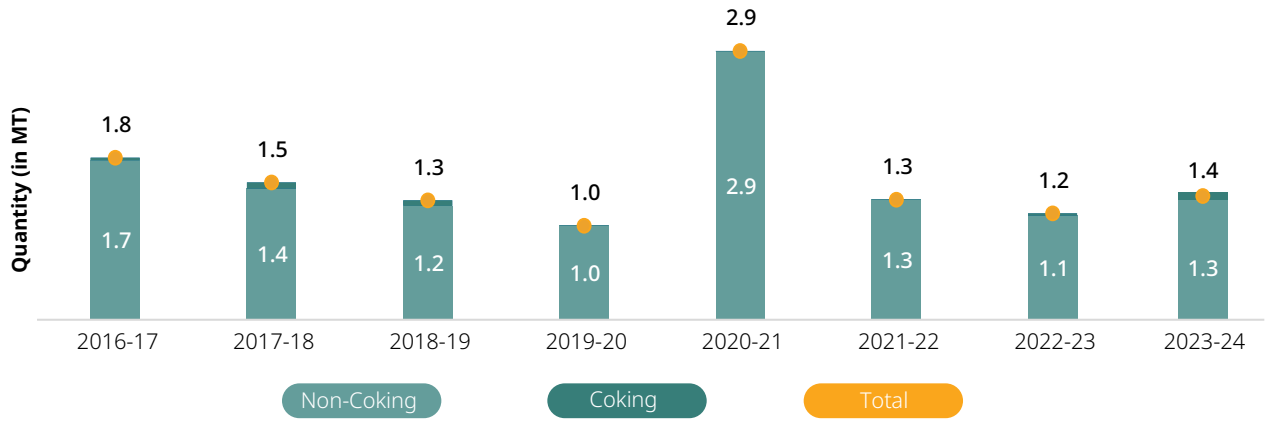


Figure 9: *Coal Export by India*

Source: (MoC, 2024)

2.2 Oil

India consumed 233 Million Metric Tonnes (MMT) of oil in 2023-24, becoming the third largest consumer of oil in the world, after China and United States. India as one of the largest consumers of oil, relies heavily on imported crude to meet the energy demands to fuel transportation, manufacturing and household consumption. Such heavy dependence on oil import is intricately linked to the nation's economic stability, ability to influence inflation rates, trade balances and nation's overall economic health. Petroleum imports was 25.1 percent of India's gross imports (in value terms) in 2023-24.

2.2.1 Crude Oil

Crude oil is a naturally occurring, unrefined petroleum product composed of hydrocarbon deposits and other organic materials. It is a vital natural resource and serves as a primary source to produce various petroleum products, including Petrol, Diesel, LPG, Naphtha, Jet Fuel, and Lubricants, among others.

India's estimated balanced recoverable crude oil reserves in the country was 671.4 MMT as of 1st April, 2024 reflecting a 0.3 percent increase from the previous year's reserves at 669.47 MMT. Geographically, the Western Offshore region holds the largest share of these reserves at 33 percent, with significant contributions from Assam, Gujarat, and Rajasthan (MoPNG, 2024). Oil contributes to 29 percent share in the total primary energy supply and plays a crucial role in meeting the nation's increasing demand of energy.

Crude Oil Production

In 2023-24, the domestic produce of oil in the country was 29.4 MMT, decreasing significantly from 36 MMT in 2016-17, declining at the annual rate of 3 percent (refer Figure 10). (This decline in production can be attributed to several factors, including the natural depletion of older and marginal fields, accessibility and technical challenges in certain reservoirs, disruptions in field activities, etc. The Government implemented several long-term and short-term initiatives, to address the declining domestic crude oil production. These initiatives include reforms in the Hydrocarbon Exploration and Licensing Policy (HELP) 2019, Policy Framework for Exploration and Exploitation of Unconventional Hydrocarbons 2018, induction of suitable technologies on selective fields, monetisation of small and marginal discoveries in onshore through service contract and outsourcing.

National companies such as Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) are the leading producers of domestic crude oil production, contributing approximately 65 percent and 11 percent respectively in 2023-24. The remaining 24 percent of crude oil is being produced by the Production Sharing Contracts (PSC) or Revenue Sharing Contracts (RSC) regime.

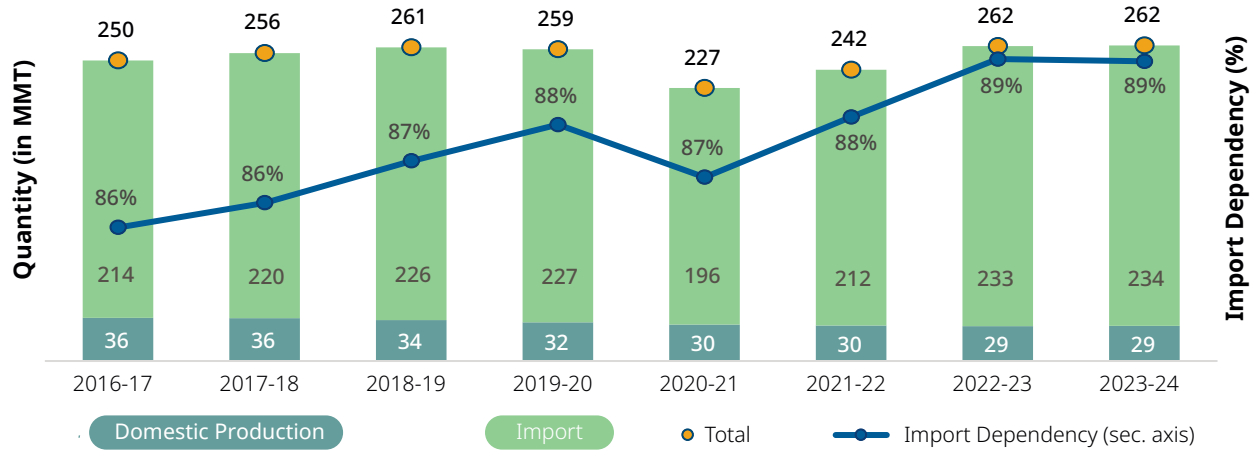


Figure 10: *Crude Oil Domestic Production and Import*

Source: (PPAC, a) (PPAC, b)

Crude Oil Imports

India ranks third globally in crude oil imports after China and United States, having imported 234 MMT of crude oil in 2023-24 (MoPNG, 2023). The country's imports accounted for 86 percent of crude oil supply

in 2016-17, rising to 89 percent by 2023-24, albeit experiencing a temporary decline during the COVID-19 pandemic in 2020-21 and 2021-22.

Table 1: Monthly Crude Oil Import in India (in MMT)

Year/Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
2016-17	18	18	18	17	19	18	18	19	18	17	16	18
2017-18	18	18	18	17	18	18	19	19	19	20	18	18
2018-19	17	20	19	20	19	18	21	17	20	20	17	19
2019-20	20	19	17	19	20	17	19	19	19	20	19	20
2020-21	17	15	14	12	17	15	15	18	20	20	15	18
2021-22	18	17	16	15	17	18	17	18	20	19	18	19
2022-23	22	20	19	21	18	17	18	19	20	20	19	21
2023-24	20	21	20	20	19	18	19	19	20	22	18	21

Source: (PPAC, b)

India imports its crude oil from diverse regions including the Middle East, North America, South America, Africa, Europe, Russia, etc. (as shown in the Figure 11). Historically, India relied on the Middle East for its crude oil supply. However, its share of total crude oil imports has decreased from 64 percent in 2017-18 to 46 percent in 2023-24. In contrast, imports from Eurasia, leaped from 3 percent in 2017-18 to 39 percent in 2023-24.

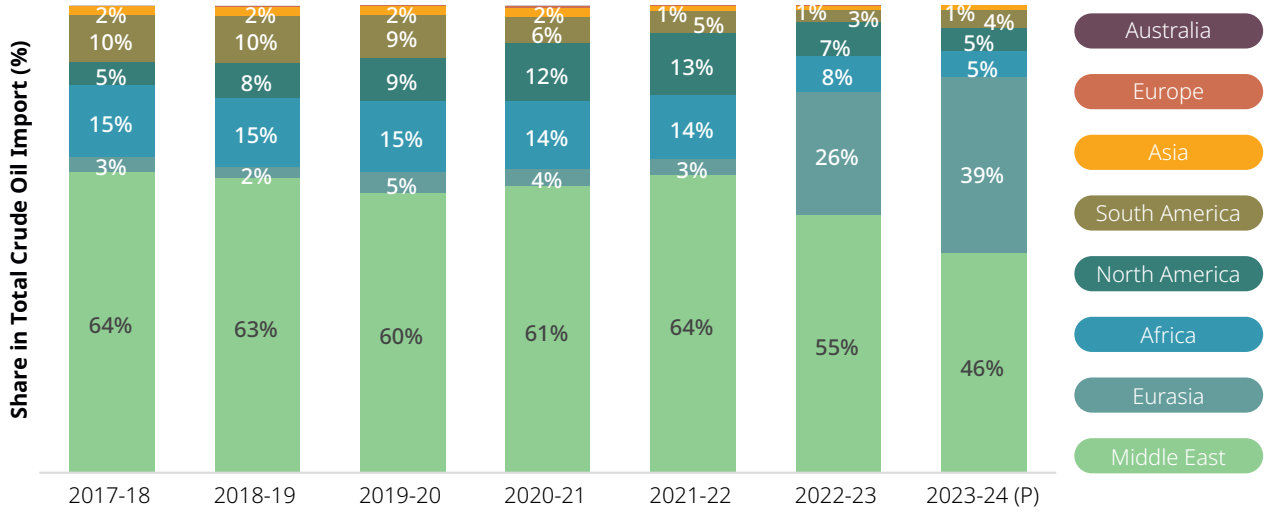


Figure 11: *Region-wise Share of Crude Oil Import in India (percent), in terms of Quantity*

Source: (PPAC, c)

The Government of India has taken a few measures to reduce the country's dependency on oil import. The measures such as the electrification of the transport sector, ethanol blending in petrol, Sustainable Aviation Fuel (SAF) in the aviation sector and the production of compressed biogas offer potential avenues to mitigate India's reliance on imported crude oil.

- India is the third largest importer of crude oil in the global market, importing 234 MMT in 2023-24.
- The Middle East market is the principal source of crude oil import in India, contributing to 46 percent share in total imports.
- Crude oil production has decreased from 36 MMT in 2016-17 to 29 MMT in 2023-24 reflecting an annual decline of 3 percent.

2.2.2 Petroleum Products

India, with a capacity of 256.8 Million Metric Tonne per annum (MMTPA), as of April 1st, 2024, stands as the third-largest refiner in Asia and fourth-largest refiner in the world, after United States, China, and Russia. The significant growth in India's refining sector is leading the nation to achieve self-sufficiency in refining. Moreover, India has emerged as a major exporter of high-quality petroleum products. The country has a total of 22 refineries. Public Sector Undertaking (PSU) companies namely, Indian Oil Corporation Limited along with subsidiaries, Hindustan Petroleum Corporation Limited and Bharat Petroleum Corporation Limited, Mangalore Refineries and Petrochemicals Limited, and Numaligarh Refinery Limited are involved in refining. Private sector companies in refining are Reliance Industries Limited (along and Nayara Energy Limited). There is one refinery in Joint Venture of PSU and Private by the name of HMEL. These geographically dispersed refineries are interconnected through cross-country pipelines.

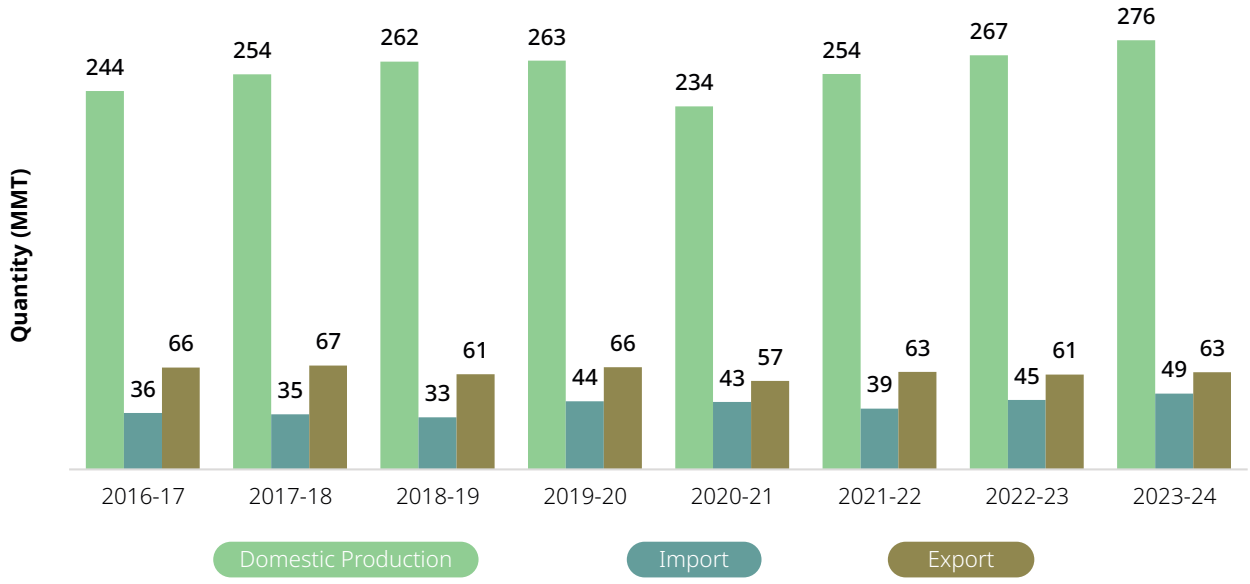


Figure 12: *Total Petroleum Products Domestic Production, Import and Export in India*

Source: (PPAC, d) and (PPAC, b)

- Production of petroleum products increased from 244 MMT in 2016-17 to 276 MMT in 2023-24, with a 2 percent annual increase
- Over the last seven years, imports of petroleum products increased annually by 4 percent while exports declined by 1 percent due to rising domestic demand.

Table 2: Domestic Production, Import, Export and Consumption of various Petroleum Products in India in 2023-24 (in MMT)

Petroleum Product	Production	Import	Export	Net Availability	Consumption
Diesel (HSD+LDO)	116.60	0.04	28.20	88.44	90.41
Petrol	45.08	0.72	13.47	32.33	37.22
Naphtha	18.27	1.21	5.28	14.21	13.81
Aviation Turbine Fuel	17.12	0.00	8.58	8.55	8.25
Petroleum Coke	15.05	10.96	0.03	25.98	20.32
Liquefied Petroleum Gas	12.78	18.51	0.53	30.77	29.66
Furnace Oil & Low Sulphur Heavy Stock	10.44	9.05	2.10	17.39	6.52
Bitumen	5.24	3.24	0.02	8.47	8.81
Lubes	1.35	2.41	0.02	3.75	4.09
Kerosene	0.98	0.00	0.01	0.97	0.48
Others	33.13	2.54	4.36	31.31	14.70
Total	**276.06**	**48.69**	**62.59**	**262.16**	**234.26**

Source: (PPAC, b), (PPAC, d) and (PPAC, e)

2.2.2.1 Liquefied Petroleum Gas

Liquefied Petroleum Gas (LPG) known for its high heating value, making it a preferred option for various heating applications. LPG is most commonly used among domestic consumers for meeting their cooking and heating requirements. Beyond domestic use, LPG plays an essential role, as a vital raw material in chemical and metallurgical plants, facilitating diverse industrial processes. Furthermore, its application is also found in the transport sector, highlighting its versatility and widespread utility.

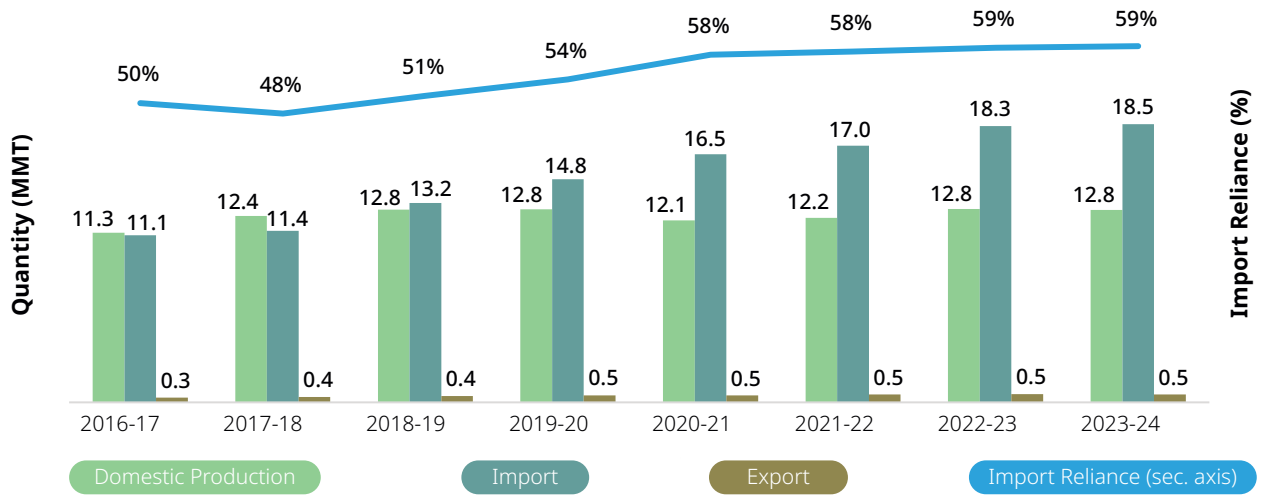


Figure 13: *Domestic Production, Import and Export of LPG in India*

Source: (PPAC, b) and (PPAC, d)

Figure 13 illustrates the trends of domestic production, import, and export of LPG in the last seven years. India's LPG import increased from 11.1 MMT in 2016-17 to 18.5 MMT in 2023-24, exhibiting an 8 percent increase annually. This escalation in import is driven by the growing demand for LPG leading to an increase in import dependency from 50 percent in 2016-17 to 59 percent in 2023-24.

The increasing dependency on imported LPG significantly influences the pricing dynamics of LPG in the country. The Government launched PAHAL (Pratyaksh Hanstantrit Labh) or Direct Benefit Transfer of LPG (DBTL) scheme in 2014 to address the rising price of domestic LPG. Under this scheme, LPG cylinders (14.2 kg) for domestic consumers are sold at non-subsidised prices, and the applicable subsidy is directly transferred into the bank accounts of consumers. This approach ensures that consumers receive the financial benefit without distorting the market price of LPG.

2.2.2.2 Naphtha

Naphtha is typically used in industries such as petrochemicals, solvents, fuel blending. It is also used as a raw material to produce gasoline, plastics, and chemicals.

The production of domestic naphtha was 18.3 MMT in 2023-24. Additionally, India's export in naphtha was at 8.7 MMT in 2016-17 which reduced to 5.3 MMT in 2023-24.

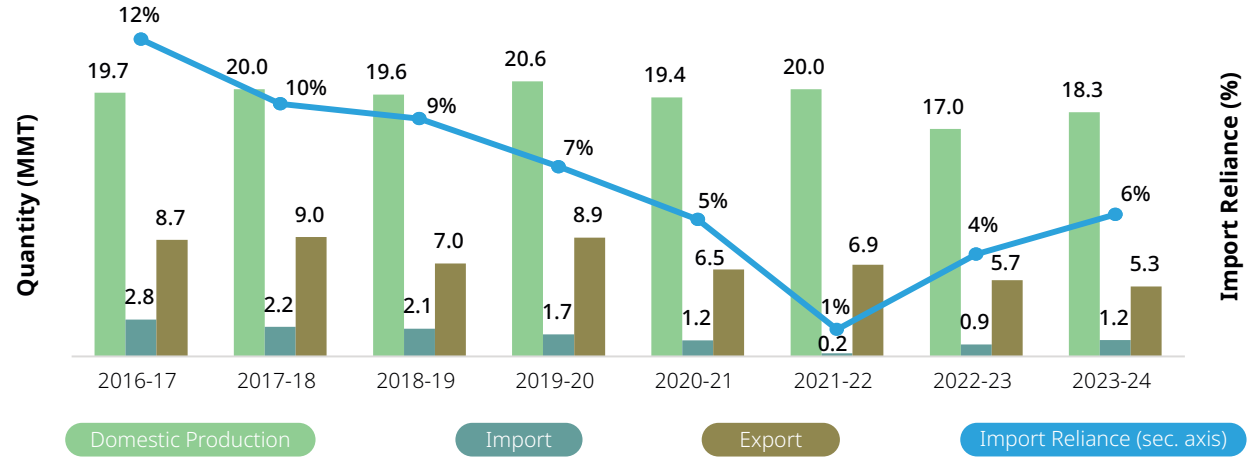


Figure 14: *Domestic Production, Import and Export of Naphtha in India*

Source: (PPAC, b) and (PPAC, d)

2.2.2.3 Kerosene

Kerosene, a flammable hydrocarbon liquid, serves as fuel for lamps, heaters, and jet engines, as well as a solvent for greases and insecticides. The households consume about 80 percent of the total kerosene.

In the last seven years, there is a substantial drop in the production of kerosene in the country. This is because of the alternative choice for sources of energy by individuals. The PM UJJWALA Scheme was a catalyst in reducing the production of kerosene by substituting its usage with LPG in the domestic sector.

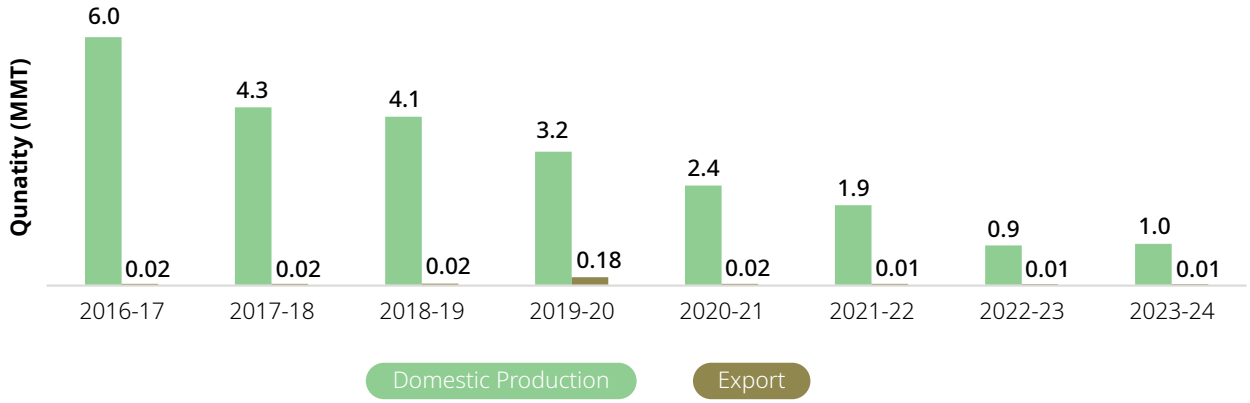


Figure 15: *Domestic Production and Export of Kerosene*

Source: (PPAC, b) and (PPAC, d)

2.2.2.4 Aviation Turbine Fuel

Aviation Turbine Fuel (ATF) are petroleum-based fuels, or petroleum and synthetic fuel blends, also known as jet fuel, is used to power aircraft. It is also utilised as a hydraulic fluid in engine control systems and for cooling specific fuel system components.

ATF production surged to 17 MMT in 2023-24, showcasing the rapid growth in nation's air travel sector. It marked a 14 percent increase from the previous year. The advent of COVID-19, resulted in border closure and travel restrictions till 2021-22. The nation experienced a significant decrease of 53 percent in domestic production and 49 percent in exports in 2020-21 (as compared to the previous years), Moreover, India became self-sufficient in ATF production and achieved zero percent dependence on ATF imports starting from 2020-21.

In 2023-24, India was a key player in the global export market with ATF exports reaching to 8.6 MMT. Netherland, United Arab Emirates, United Kingdom, Togo, etc., forms the major markets for Indian ATF export.

The aviation sector aims to produce Sustainable Aviation Fuel (SAF) using sugarcane molasses as one of the indigenous feedstocks and technologies. India plans to use 1 percent blending of SAF for its international commercial flights by 2027, which would require around 140 million litres of SAF per year, with an aim to increase this to 2 percent blending by 2028 (PIB, Nov, 2023).

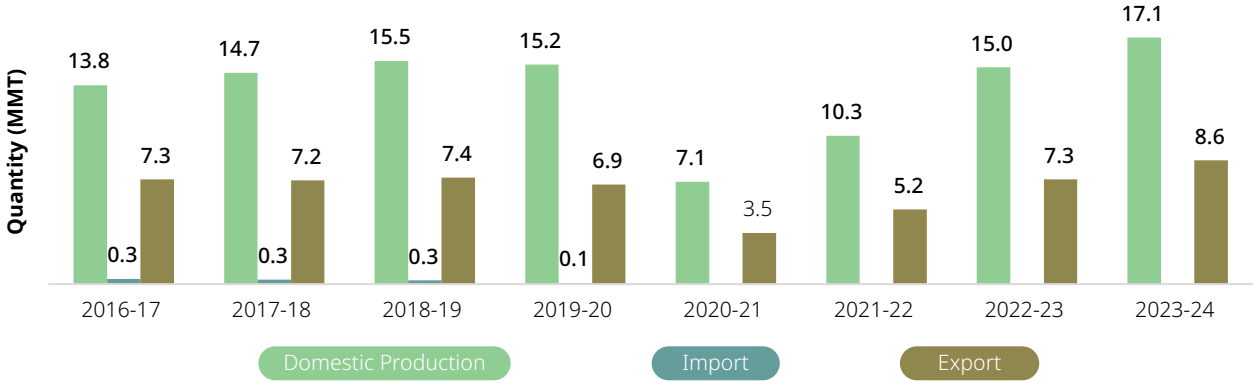


Figure 16: *Domestic Production, Import and Export of ATF*

Source: (PPAC, b) and (PPAC, d)

2.2.2.5 Diesel

Diesel is commonly used to power diesel engines, which are more prevalent in machinery and vehicles. The high energy density makes diesel an efficient choice to power various machinery, demanding heavy-duty performance such as trucks, buses, trains, ships, and some types of generators. This section covers both High-Speed Diesel (HSD) and Light Speed Diesel (LSD).

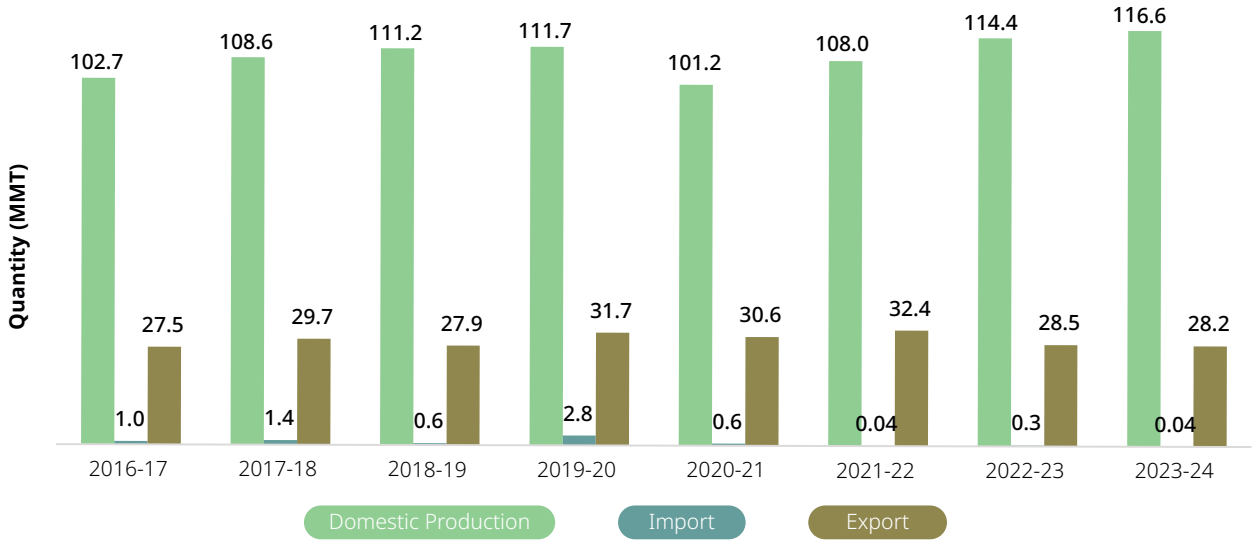


Figure 17: *Domestic Production, Import and Export of Diesel*

Source: (PPAC, b) and (PPAC, d)

The Figure 17 shows the trends in domestic production, import, and export of Diesel from 2016-17 to 2023-24. India's demand for diesel is predominantly met through domestic production, indicating the increased capacity of oil refineries and self-sufficiency in refined fuel. From 2019-20 onwards, diesel imports have experienced a sharp decline by 65 percent annually, signalling reduced reliance on imported diesel.

Table 3 displays the seasonal variation in production of domestic diesel from 2016-17 to 2023-24. It illustrates that diesel production predominantly peaked during the winter season as compared to other months. During winter, the performance of diesel engines diminishes as operating and igniting the cold machinery in low temperatures becomes a challenge, impacting the transportation, agriculture, and industrial sectors.

Table 3: Monthly Domestic Production of Diesel (in MMT)

Year/ Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
2016-17	8.1	8.1	8.7	9.1	8.6	7.9	8.8	8.5	9.2	8.6	7.9	9.3
2017-18	8.5	9.0	8.5	8.7	9.0	8.9	9.5	9.0	9.8	9.8	8.7	9.2
2018-19	8.4	9.7	9.8	9.6	9.0	8.7	9.6	9.5	9.0	9.4	8.6	10.0
2019-20	9.1	9.4	9.0	10.0	9.4	8.3	9.7	9.5	9.2	9.5	9.0	9.8
2020-21	6.7	7.4	8.1	8.6	7.6	7.7	8.1	9.6	9.6	9.8	8.5	9.6
2021-22	8.8	8.4	8.4	9.0	8.4	7.8	9.2	9.5	9.4	9.6	8.8	10.6
2022-23	9.9	10.1	9.6	9.4	8.9	8.8	9.1	8.5	10.0	10.3	9.4	10.4
2023-24	9.5	10.1	9.8	9.6	9.6	9.0	9.5	10.0	10.3	9.6	9.5	10.1

Source: (PPAC, d)

2.2.2.6 Petroleum Lubricant

Petroleum-based lubricants are used to reduce the friction between the surfaces. It comes in various forms, including motor oils, gear oils, hydraulic fluids, and greases, and are widely used in automotive, industrial and commercial applications to maintain the efficiency and longevity of the machinery.

The trends in the domestic production, import and export of Petroleum Lubricant in India are represented in Figure 18.

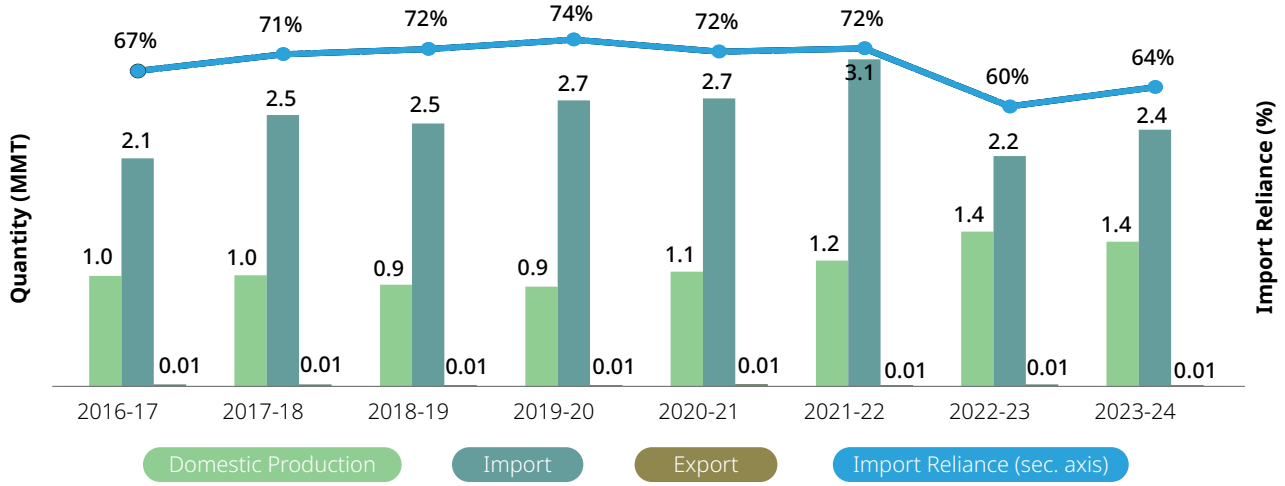


Figure 18: *Domestic Production, Import and Export of Petroleum Lubricants*

Source: (PPAC, b) and (PPAC, d)

- Domestic production grew by 4 percent from 2016-17 to 2023-24, annually.
- Imports increased by 2 percent every year over the same period.
- Imports of petroleum lubricants were twice the output of domestically produced lubricants, reflecting a heavy reliance on imports to meet the demand. The exports on the other hand remained constant for all the years.

2.2.2.7 Petroleum Coke

Petroleum coke, also known as pet coke, is used as a carbon source or feedstock in various industrial applications, including cement, iron & steel, power generation, and metal smelting.

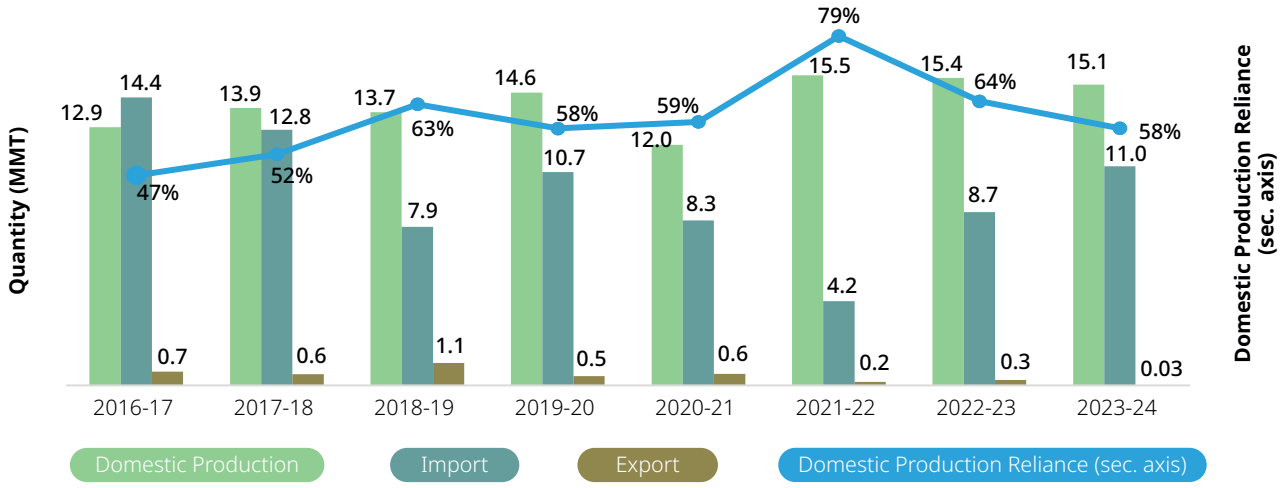


Figure 19: *Domestic Production, Import and Export of Pet coke*

Source: (PPAC, b) and (PPAC, d)

- In 2023-24, 58 percent of the total pet coke available was produced domestically
- From 2016-17 to 2023-24, imports of pet coke gradually dropped by 3.8 percent each year. Exports in pet coke declined by 37 percent during the same period due to rising demand from industrial sectors and a relatively higher focus on domestic consumption.

2.2.2.8 Bitumen

Bitumen is primarily used in the construction industry, as a binding agent in the production of asphalt concrete for road construction and maintenance. It is also utilised in waterproofing products and roofing materials.

The data in Figure 20 illustrates a significant reliance on imports to meet the country's bitumen demand over the last seven years. India is the third largest importer of bitumen worldwide, reaching 3.2 MMT in 2023-24 from 1 MMT in 2016-17. This surge reflects a notable 19 percent CAGR. However, domestic production has remained similar throughout 2023-24.

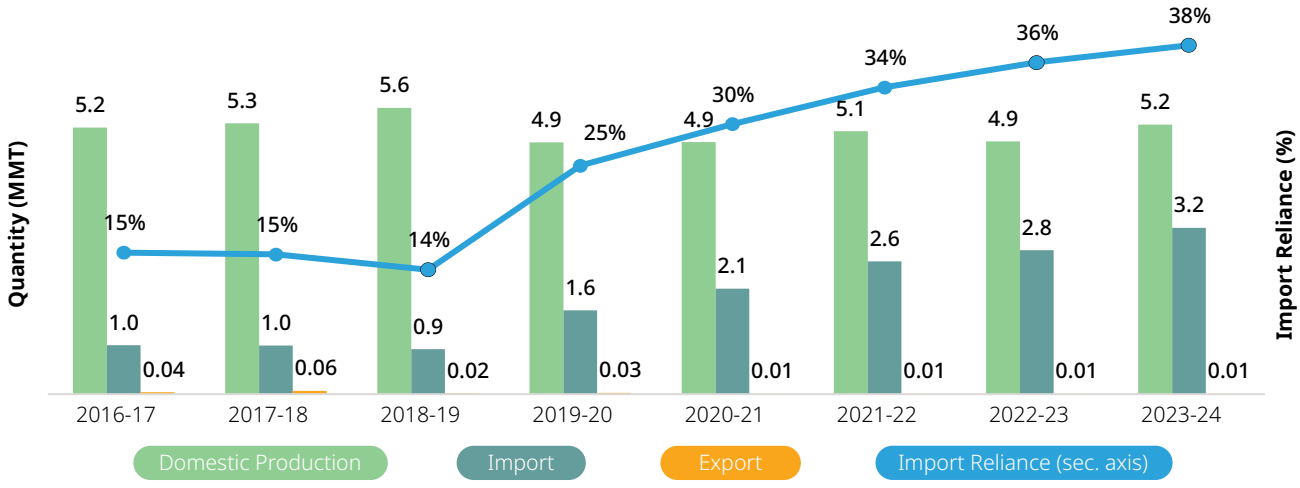


Figure 20: *Domestic Production, Import and Export of Bitumen*

Source: (PPAC, b) and (PPAC, d)

2.2.2.9 Petrol

Petrol or gasoline, is widely used as a transportation fuel, though also used in other applications, such as powering small engines, generators, and lawn mowers.

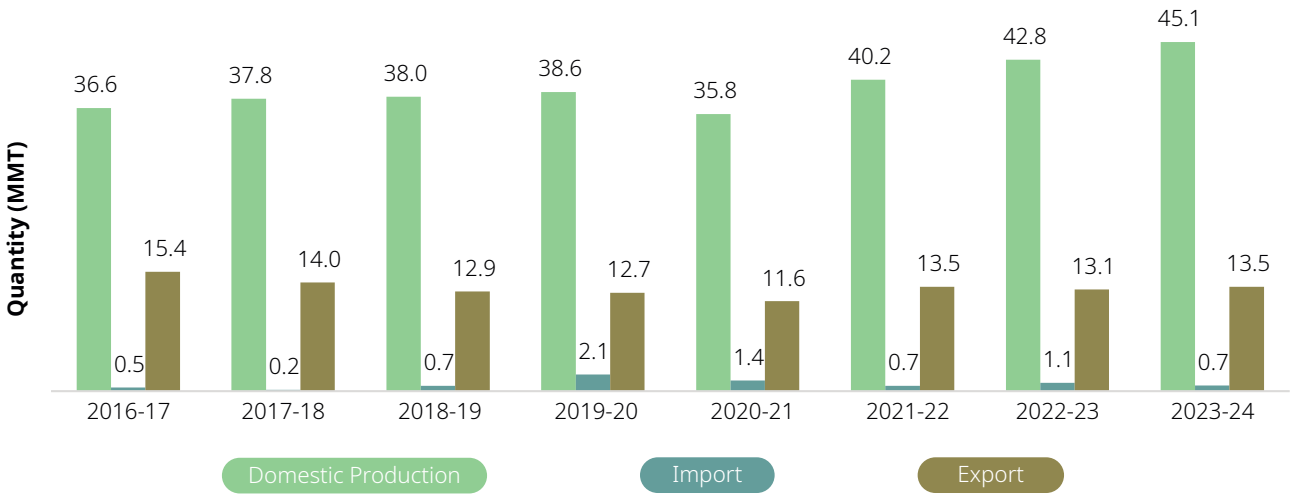


Figure 21: *Domestic Production, Import and Export of Petrol*

Source: (PPAC, b) and (PPAC, d)

- Domestic petrol production has increased by 3 percent CAGR over the past seven years.
- The imports grew by 6 percent CAGR, while the exports declined by 2 percent CAGR at the same time.
- The decline in exports and increase in both domestic production & imports of petrol shows the urge of the country to fulfil its internal demand.

2.3 Natural Gas

Natural Gas, plays a significant role in India's energy landscape. Known for its cleaner attributes as compared to coal and petroleum, it has gained prominence in recent times as a possible bridging fuel to minimise Greenhouse Gas Emissions from the Energy Sector. In 2023-24, the gas share in India's primary energy mix was 7 percent. The Government of India (GoI) aims to increase the share of Natural Gas to 15 percent by 2030 as part of the nation's energy transition (PIB, Dec, 2023). In order to achieve this objective, the Government has implemented several measures. These include providing support for compressed biogas, expanding the National Gas Grid pipeline infrastructure, expanding the city gas distribution network, and allocating Liquefied Natural Gas (LNG) regasification terminals.

The industrial sector consumes the largest share of natural gas (38 percent) followed by the residential and transport sector (20 percent), power generation (13 percent), refinery (8 percent), and others (20 percent). In terms of production, India relies on both domestic sources and imports to meet its growing demand. Domestic production primarily occurs in gas fields located across various regions, including the Krishna-Godavari Basin, Mumbai High, and Assam. The estimated balance recoverable reserves of Natural Gas in India as of 1st April 2024, stood at 1094.2 Billion Cubic Metres (BCM) against 1,141.73 BCM in the previous year.

Figure 22 shows the domestic production and import of natural gas in India from 2016-17 to 2023-24[1]. Natural gas domestic production has grown by 2 percent every year in the last seven years. In order to increase domestic production, natural gas infrastructure encompasses a network of pipelines, LNG

1 To maintain uniformity in data, sources of natural gas have been quantified in BCM.

terminals, and storage facilities. The country has been steadily expanding its pipeline network to transport gas from production sites to consumption centres, facilitating efficient distribution across the nation. Additionally, LNG terminals, located mainly on the western and eastern coasts, serve as crucial entry points for imported natural gas, supporting India's energy needs.

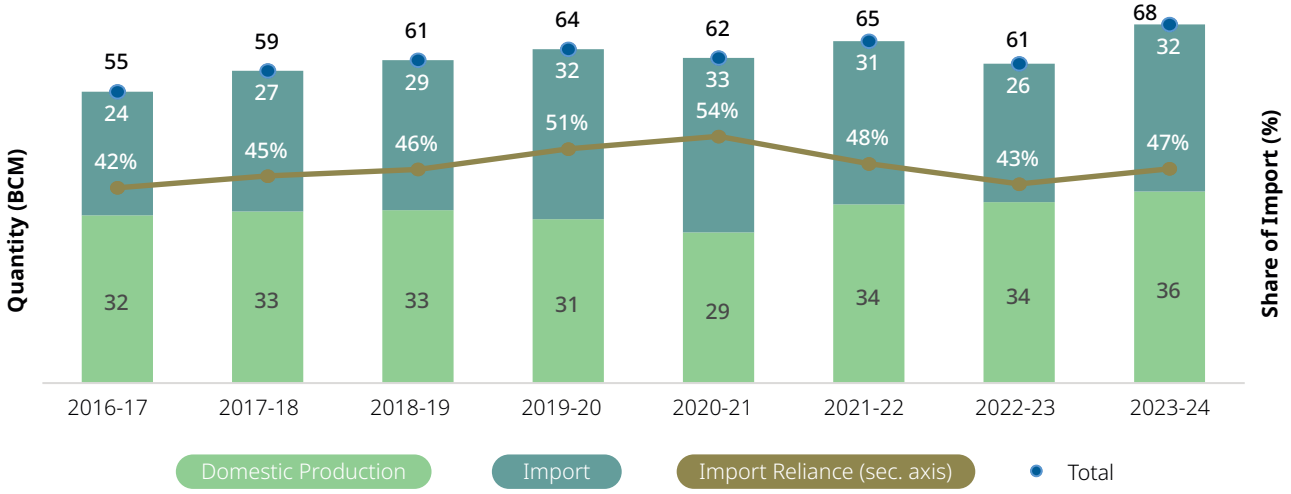


Figure 22: *Natural Gas Domestic Production and Import*

Source: (PPAC, f) and (PPAC, g)

However, despite efforts to enhance domestic production, India still imports a considerable amount of natural gas (47 percent of the total gas supply in FY 2023-24), primarily through LNG terminals. Globally, India is the 4th largest importer of LNG. India imports natural gas from Qatar, the United States of America (USA), the United Arab Emirates (UAE), Oman, Angola, Nigeria, etc. The maximum share of it, is imported from Qatar, making up to 45 percent of total imports in 2023-24. India has a contract with Qatar to import LNG until 2028, with an extension now in place until 2048 at prices below the current rates.

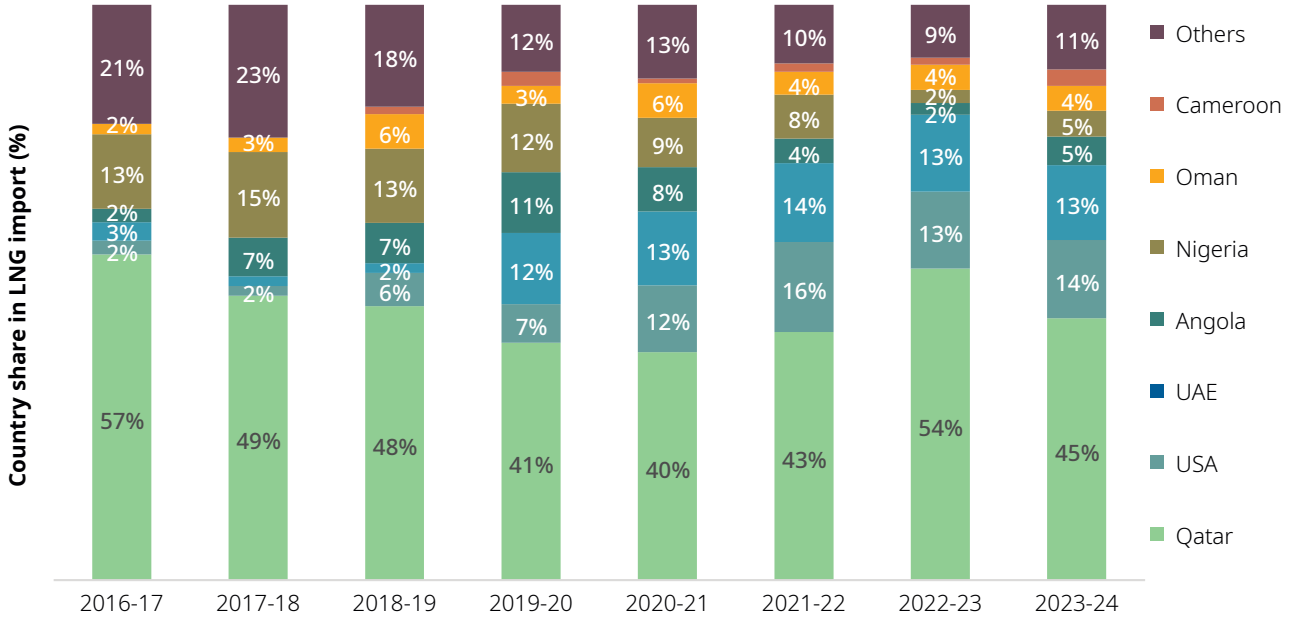


Figure 23: *Region-wise Share in Import of Natural Gas in India (Percentage)*

Source: (MoC&I, 2024)

2.4 Renewable Energy Sources

2.4.1 Renewable Energy Sources of Electricity

RES in primary energy supply mix

Renewable energy is playing an increasingly significant role in India's energy supply, reflecting a shift towards cleaner energy sources. The sector shows substantial potential for rapid growth and is poised to meet India's rising energy demand. The share of renewables, particularly solar and wind, has been steadily increasing. This transition is driven by various state and national initiatives, ambitious targets, technological advancements, and substantial investments. From 2013-14 to 2023-24, primary energy supply from renewable energy sources increased from 17.4 Mtoe to 31.1 Mtoe, raising its share in the overall primary energy supply mix to 3.4 percent.

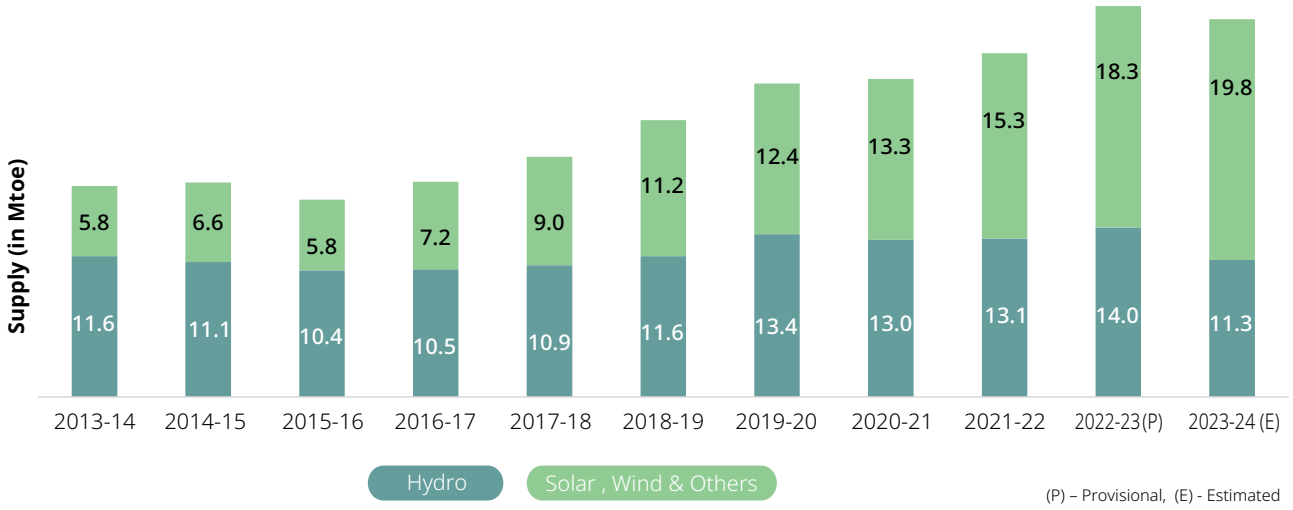


Figure 24: *Primary Energy Supply from Hydro and RES (in Mtoe)*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

Given the favorable policies and the Government's push for the adoption of renewable energy, supply from renewable energy sources is expected to continue growing. The Government of India has introduced several initiatives to meet its 2030 targets, including the establishment of ultra-mega and mega solar parks, the solar rooftop policy, PM Surya Ghar Muft Bijli Yojana, Renewable Purchase Obligations (RPOs), Renewable Generation Obligations (RGOs), Production-Linked Incentive (PLI) Schemes, and the Green Energy Corridor, among other measures.

Resource Potential

India is endowed with vast potential of renewable energy sources. The National Institute of Solar Energy (NISE) has estimated the country's solar potential to be around 748 GW, assuming that 3 percent of the wasteland area is covered by solar PV modules. Additionally, a recent study by the National Institute of Wind Energy (NIWE) indicates that India's wind potential, at 150 meters above ground level, is approximately 1164 GW. Beyond solar and wind, additional renewable resources include 133 GW from large hydro, 42 GW from biomass, and 21 GW from small hydro.

To support the effective integration of these renewable sources, the Government has emphasized the development of Energy Storage Systems, particularly through pumped storage projects. India has an estimated potential of 176 GW for pumped storage, which can economically convert non-dispatchable renewable energy like wind, solar, and run-of-the-river hydro into reliable base/peak load power.

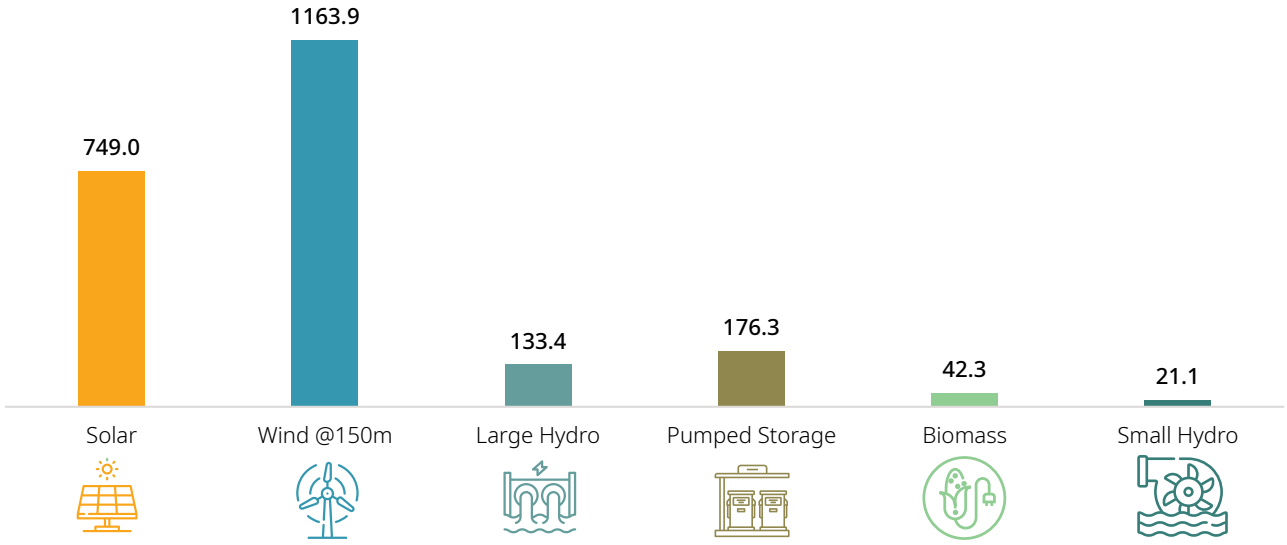


Figure 25: *Resource potential for various renewable energy sources (in GW)*

Source: (ICED, 2024)

2.4.2 Biofuels

India's energy needs are currently met by fossil fuels relying heavily on its imports to satisfy the growing demand. In response, the Government is prioritising energy security intending to reduce dependency on fossil fuel imports. India imports 89 percent of its crude oil to meet its energy needs, which makes it the third largest importer of crude oil in the world. With the heavy reliance on crude oil, India acknowledges the importance of alternative fuels that are better for the environment and cost-competitive with fossil fuels. This envisions the importance of biofuels in the Indian energy basket. Biofuels are increasingly recognized for their potential to reduce dependency on fossil fuel imports, achieve savings on foreign exchange, enhance energy security and promote rural development. Biofuels are derived from plants, algae, or organic waste offering sustainable alternatives to conventional fossil fuels. The most common types of biofuels include bio-alcohols such as ethanol, methanol, propanol and butanol, along with biodiesel and bio-oils. Further, the biofuels are also categorised as (Das, S., 2020):

- First Generation (1G) 'Basic Biofuels' – Ethanol from molasses and biodiesel from edible oilseeds
- Second Generation (2G) 'Advanced Biofuels' – Produced from non-edible plants, agro-residues and Municipal Solid Waste (MSW)
- Third Generation (3G) – Bio-CNG.

The Government of India implemented the National Biofuel Policy (NBP) in 2018 and further amended it in 2022, to reduce import dependency of fossil fuels by boosting the domestic biofuel production. Government is promoting blending of ethanol in Petrol under the Ethanol Blended Petrol (EBP) programme. The Government has decided to advance the blending target of 20 percent bioethanol in petrol by ESY 2025-26, from earlier target of 2030. Target has been set for blending of 5 percent biodiesel in HSD by 2030. In addition, Government is also exploring blending of ethanol with diesel.

Following schemes/ policy measures have been taken to augment supplies of ethanol;

- Government is providing multiple financial assistance to promote availability of ethanol for blending in Petrol including ethanol from surplus sugarcane, damaged food grains. Long term offtake agreements are also being done by OMCs to ensure offtake of ethanol. To help sugarcane farmers in realizing the better price, Government has been revising MSP of sugarcane and also coming out with assured offtake prices which are also revised from time to time.

- **Pradhan Mantri Jaiv Indhan- Vatavaran Anukool Fasal Awashesh Nivaran (PM JI-VAN Yojana):** Govt is promoting development and demonstration of technologies for production of advance biofuel under PM JI-VAN Yojana. Under the scheme Government is providing financial assistance of ₹1800 Cr for setting up of about 12 Commercial Projects and ₹150 Cr for 10 Demonstration Projects.
- **Financial Assistance for Biomass Aggregation Machinery (BAM)- CBG:** Total financial outlay of ₹564.75 Cr (FY 23-24 to FY 26-27) to 100 CBG producers for production of CBG from agri-residue.
- **Development of Pipeline Infrastructure (DPI) for Injection of CBG in CGD network:** Total financial outlay of ₹994.50 Cr for the period of FY 2024-25 to FY 2025-26 has been made for providing Subsidy for laying pipeline between CBG plant and CGD network for upliftment of biogas. The portal for submission of application was made live on 1st Sept-24.

Ethanol

Ethanol, a primary fuel, derived primarily from sugarcane molasses is blended with petrol to create ethanol-blended petrol. In the graph below, the share of ethanol blended with petrol escalated to 607 crore litres (13.8 percent) in 2023-24 (Nov'23 to Sep'24) from a mere 67 crore litres (2 percent) in 2016-17, making India the third largest producer of Ethanol in the world. The Government's support enabled India to achieve 10 percent ethanol blending in petrol by June 2022, five months ahead of its target[2]. Encouraged by this achievement, the Central Government has advanced the target of achieving 20 percent ethanol blending in petrol from 2030 to 2025.

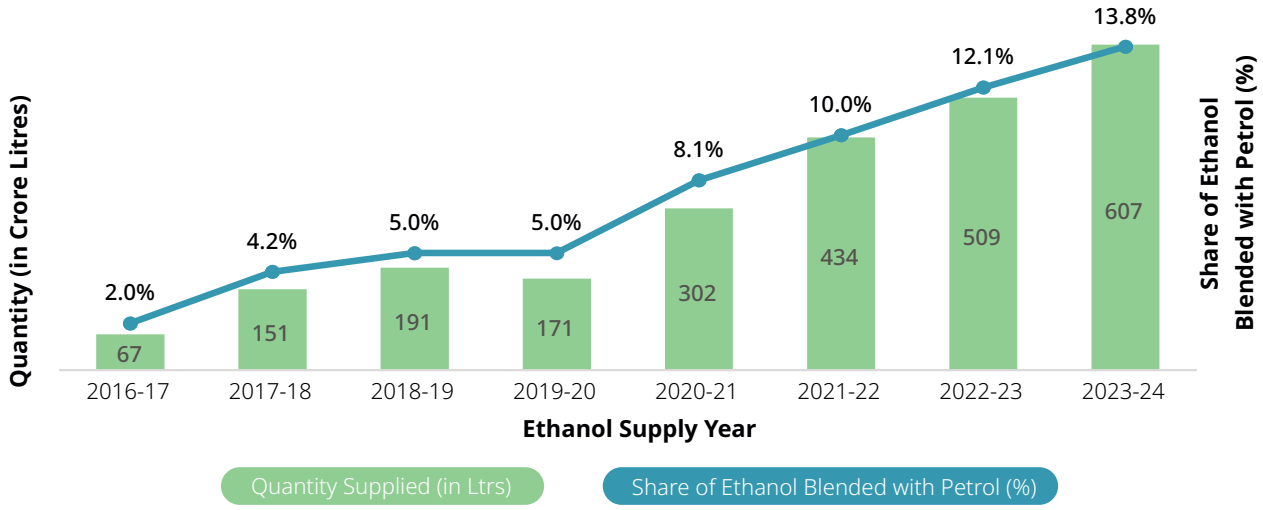


Figure 26: *Ethanol Supply and Blending in India*

* Ethanol Supply Year: Ethanol supply year for 2022-23 taken for Dec'22-Oct'23 & thereafter changed to ethanol supplies between 1st November of current year to 31st October of the following year. 2023-24 (Nov'23 to Sep'24)

Source: (MoPNG, 2024)

Historically, ethanol production in India has relied heavily on 'C-heavy' molasses. C-heavy molasses isa by-product of the sugar refining process characterised by a lower sugar content compared to other molasses variants. Consequently, ethanol yield per volume from C-heavy molasses has been relatively lower (Singh, 2021). However, the amendment of the National Biofuel Policy (NBP) in 2022 permitted the utilisation of additional molasses and alternative feedstocks for biofuel production.

This policy revision facilitated the diversion of other feedstocks such as B-heavy molasses, sugar, sugar syrup, maize and damaged food grains towards ethanol production. In 2023-24, maize alone accounted for the largest share in the total feedstock at 39.56 percent, followed by B heavy molasses at 23.39

2 Target to achieve 10 percent blending of ethanol in petrol in the country under Ethanol-Blending Programme by November 2022

percent, damaged food grains at 17.41 percent while sugar syrup and C heavy molasses accounted for 19.64 percent.

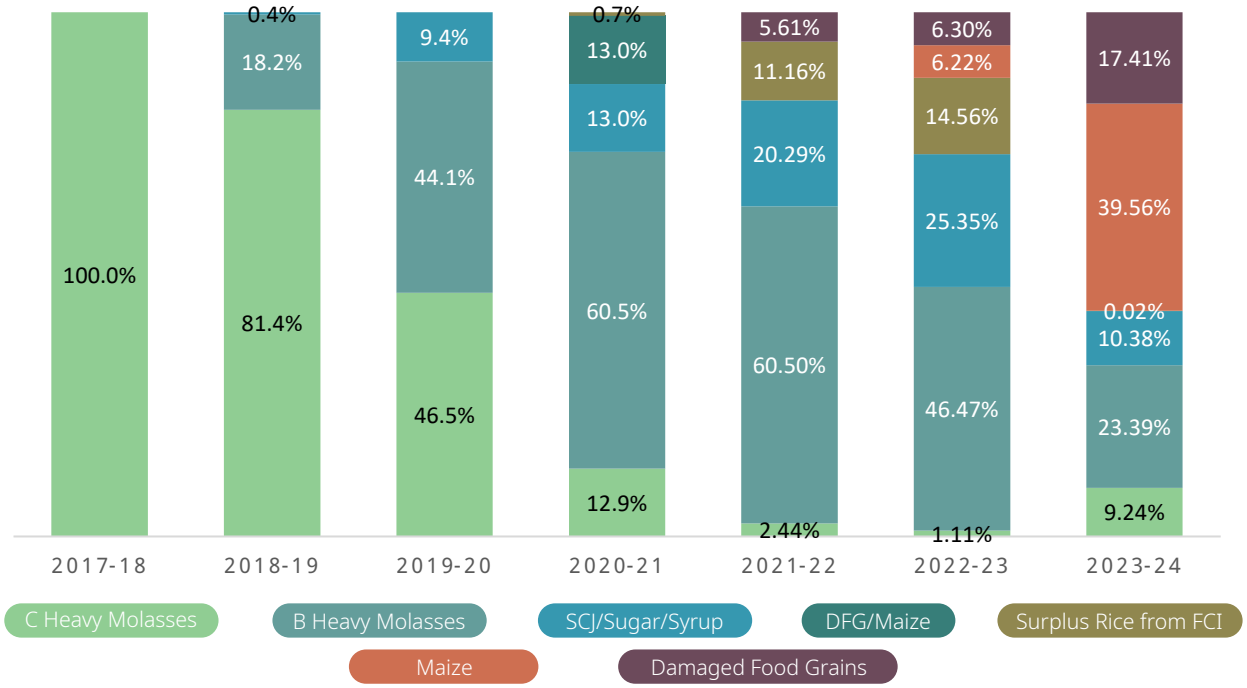


Figure 27: *Percentage Contribution from Different Feedstocks in Ethanol*

Source: (MoPNG, 2024)

Methanol

Methanol is another efficient alternative fuel which emits less NO_x and particulate matter (PM) than gasoline. As methanol does not contain any sulphur, it does not produce any SO_x. It can be blended with both gasoline/diesel for use in the transport sector and with LPG for cleaner cooking. Further, methanol can be converted to Dimethyl Ether (DME) which is a clean diesel alternative.

India's methanol production and usage are still in the early stages, but the country has significant potential attributed to methanol's diverse applications. It can be produced through natural gas, coal, biomass etc.

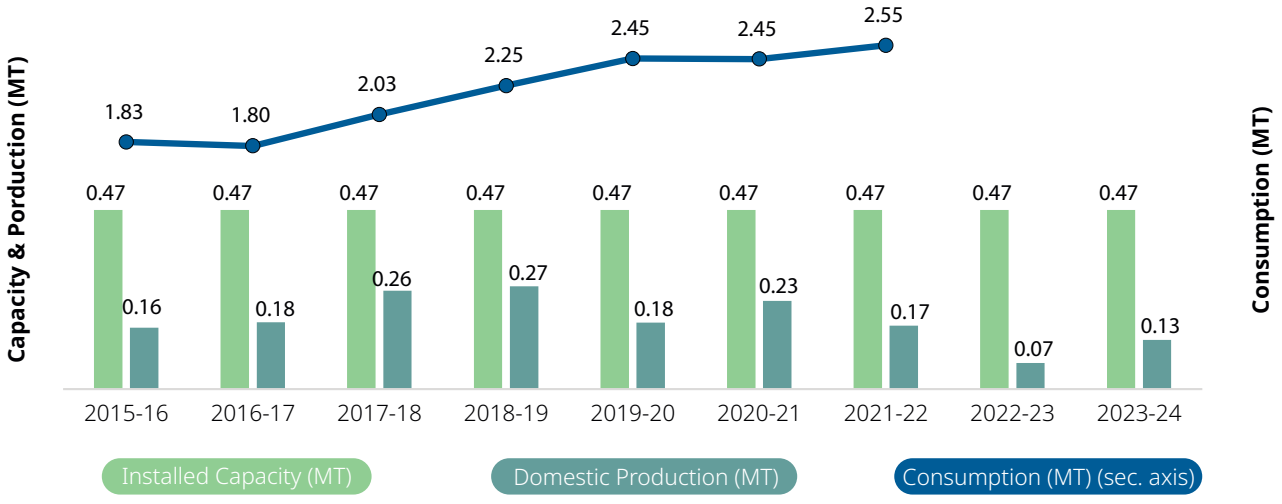


Figure 28: *Year-wise Performance overview of Methanol*

* Methanol consumption data is not available for 2022-23 and 2023-24.

Source: (DCPC, 2023)

In 2023-24, India's installed methanol capacity was 0.47 MT, while domestic production reached 0.13 MT. Methanol consumption in India grew by 6 percent from 1.83 MT in 2015-16 to 2.55 MT in 2021-22. Based on the significant shortfall between domestic production and consumption (as shown in Figure 28), it is clear that India has been dependent on imports to fulfil its methanol demand. Table 4 indicates a consistent rise in methanol imports in India. Over 60 percent of methanol is imported from countries like Saudi Arabia and Qatar.

Additionally, India exports methanol to other countries namely Sri Lanka, South Africa, and Nepal. Exports decreased by 13 percent CAGR over the last six years, dropping from 0.044 MT in 2015-16 to 0.019 MT in 2021-22 (Table 4).

Table 4: Import, Export & Net Imports of Methanol (in MT)

Years	Import (MT)	Export (MT)	Net Imports (MT)
2015-16	1.71	0.04	1.67
2016-17	1.64	0.01	1.62
2017-18	1.78	0.01	1.77
2018-19	1.99	0.01	1.98
2019-20	2.29	0.01	2.27
2020-21	2.22	0.01	2.21
2021-22	2.40	0.02	2.38

Source: (DCPC, 2023)

Since the methanol economy is considered as one of the viable future economies, methanol and dimethyl ether will replace fossil fuels for energy storage and ground transportation fuels. NITI Aayog has launched the 'Methanol Economy Programme' to further enhance domestic methanol production. This initiative aims to increase the use of methanol in India, positioning it as a key chemical feedstock to reduce the country's dependence on imported crude oil. Additionally, it can lower greenhouse gas emissions such as particulate matter, NO_x and SO_x, thereby improving urban air quality (NITI Aayog, 2021). Other initiatives such as the Methanol Economy Research Programme (MERP) launched by the Department of Science and Technology in 2015 and the Methanol Cooking Fuel Programme (MCFP) launched by Assam Petrochemicals in 2018 are also taken to boost methanol production.

Other Government Initiatives

The biofuel sector holds substantial potential to enhance the country's energy security, lower its carbon footprint and generate employment. The Government of India has been vigorously promoting biofuels as part of its broader strategy to boost the share of renewable energy, particularly in the transportation sector. The Government has announced various measures to boost the domestic production of biofuels (see Figure 29).

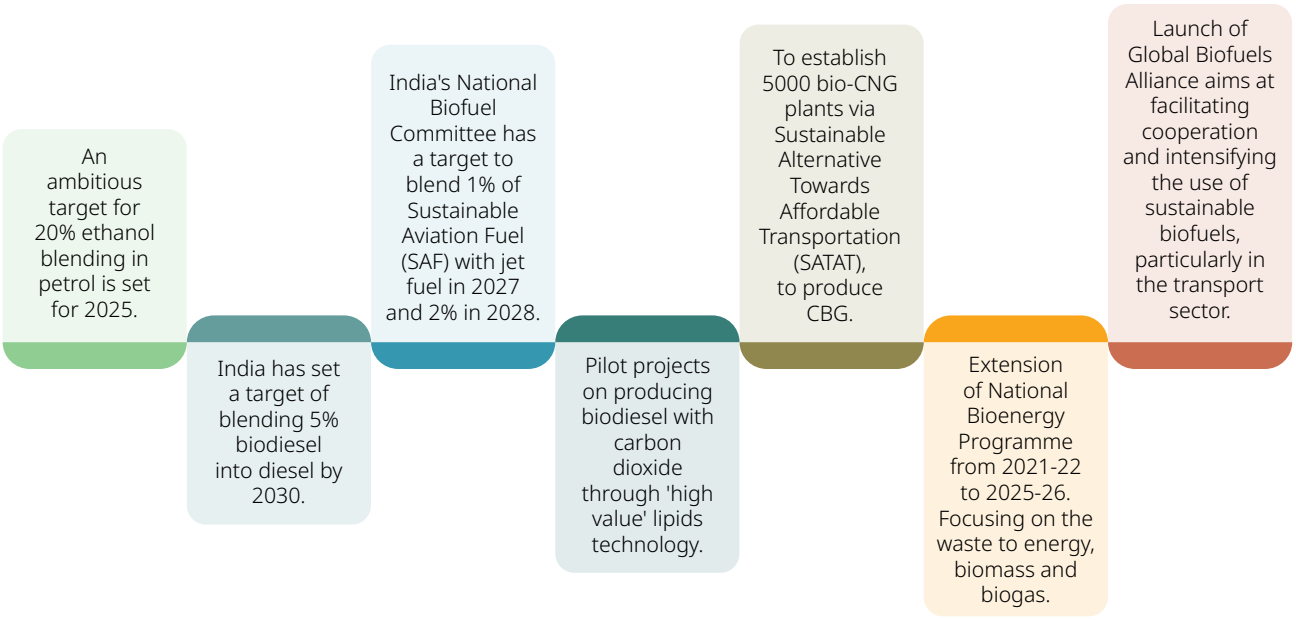


Figure 29: *Government Initiatives related to Biofuels*

2.4.3 Green Hydrogen

India aims to achieve energy independence by 2047 and reach net-zero emissions by 2070, with green hydrogen playing a crucial role in these objectives. Leveraging its vast renewable energy resources, India launched the National Green Hydrogen Mission (NGHM) in January 2023, with a budget of ₹19,744 crores. This includes ₹17,490 crores for the Strategic Interventions for Green Hydrogen Transition (SIGHT) program, ₹1,466 crores for pilot projects, ₹400 crores for R&D, and ₹388 crores for other components. The Mission aims to establish India as a global hub for green hydrogen production, usage, and export, targeting an annual production of 5 MMT by 2030.

India's electrolyser manufacturing landscape is currently in its early stages, with around six alkaline electrolyser manufacturers currently operating, according to the Ministry of New and Renewable Energy. Independent reports indicate that the country's existing manufacturing capacity for electrolysers is approximately 300 MW. Projections suggest that India's domestic electrolyser market could reach $31 billion by 2050, driven by a demand for 226 GW. In the near term, a demand of 20 GW is expected by 2030, highlighting the nation's potential for substantial growth in the hydrogen ecosystem (Vasudha Foundation, 2024).

Green hydrogen is particularly effective for industries that are difficult to decarbonize, such as steelmaking, where direct electrification is not feasible. By substituting fossil fuels with green hydrogen as a feedstock, these industries can significantly reduce their carbon footprint. Key industrial applications include:

- **Steel Making:** Substituting coal with green hydrogen.
- **Cement Production:** Using green hydrogen in kilns.
- **Fertiliser Production:** Utilizing green hydrogen to produce ammonia
- **Chemical Manufacturing:** Employing green hydrogen as a feedstock for chemicals like ammonia.
- **Refining:** Integrating green hydrogen to decarbonise fuel production.

Some of recent developments/announcements on green hydrogen are:

- MNRE has released the Guidelines for Implementation of Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme Component-II of the National Green Hydrogen Mission:
  - Incentive for Procurement of Green Ammonia Production (under Mode-2A): The incentive will be Rs. 8.82/kg of Green Ammonia in the first year of production and supply, Rs. 7.06/kg during the second year of production and supply, and Rs. 5.30/kg during the third year of production and supply.
  - Incentive for Procurement of Green Hydrogen Production (under Mode-2B): The incentive will be Rs. 50/kg of Green Hydrogen in the first year of production and supply, Rs. 40/kg during the second year of production and supply and Rs. 30/kg during the third year of production and supply.
- The Ministry of New and Renewable Energy (MNRE) has released the scheme guidelines for the implementation of pilot projects for the use of Green Hydrogen in the shipping, steel, and transport sectors under the National Green Hydrogen Mission (NGHM).
- SECI has released the request for selection of electrolyser manufacturers for setting up manufacturing capacities for electrolysers and green hydrogen producers for setting up production facilities for green hydrogen in India under Strategic Interventions for Green Hydrogen Transition (SIGHT) Scheme (Tranche-I)
- The Ministry of New and Renewable Energy (MNRE) has released the scheme guidelines for the implementation of the strategic interventions for green hydrogen transition programme- Component I: incentive scheme for electrolyser manufacturing tranche II, research and development, and skilling, up-skilling and re-skilling under the National Green Hydrogen Mission.
- The Ministry of New and Renewable Energy has released the scheme guidelines for setting up Hydrogen Hubs in India under the National Green Hydrogen Mission. Its target is to establish at least two green hydrogen hubs by 2025-26 with a budgetary outlay of Rs 200 crores.
- Jindal Stainless Ltd., in collaboration with Hygenco commissioned India's 1st green hydrogen plant in the stainless steel sector at Hisar, Haryana, which aims to reduce CO_2 emission by 2,700 metric tonnes per annum.
- MNRE has released the Green Hydrogen Certification Scheme of India. The scheme aims to establish a comprehensive framework for measuring, monitoring, and certifying green hydrogen production. It outlines governance structures, certificates, procedures and guidelines for calculating greenhouse gas (GHG) emission intensity.
- SECI has released the tender for production and supply of Green Ammonia in India under SIGHT Scheme (Mode-2A-Tranche-I). The selection of developers for the total available green ammonia capacity of 5,39,000 metric tonnes per annum will be carried out through e-bidding followed by e-reverse auction process.
- The Ministry of New and Renewable Energy has increased the annual allocation of Green Ammonia in the fertilizer sector from 5.50 lakh tonnes to 7.50 lakh tonnes, under the SIGHT Programme of the National Green Hydrogen Mission.
- MNRE has unveiled the guidelines for funding of testing facilities, infrastructure, and institutional support for development of Standards and Regulatory framework under the National Green Hydrogen Mission. The Scheme will support creation of new testing facilities and upgradation of existing Testing Facilities to ensure safe and secure operations with a total budgetary outlay of Rs. 200 Crores during the period 2024-26.
- On 3rd July 2024, MNRE has issued a scheme guidelines for implementation of "Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme – Component II: Incentive Scheme for Green Hydrogen Production (under Mode 1)- Tranche-II" of the National Gree Hydrogen Mission with an outlay of Rs 13050 crores during 2025-26 to 2029-30. The capacity of Tranche-II will be 450,000 TPA

of Green Hydrogen, with 40,000 TPA capacity reserved for biomass-based pathways (bucket-II) and the rest for technology agnostic pathways (bucket-I).

- The Indian Railways' "Hydrogen for Heritage" project, which plans to deploy 35 hydrogen trains on heritage and hill routes, with an estimated cost of ₹80 crores per train and ₹70 crores per route for infrastructure.

Secondary Energy Supply

2.5 Electricity

Electricity serves as a fundamental component in fuelling nation's infrastructure and economy. This sector is crucial in bolstering industrial expansion, providing energy for households, propelling economic development and welfare. India's electricity grid has undergone significant transformations in recent years such as becoming power-surplus, creating a unified national grid, strengthening the distribution network, achieving universal household electrification, reducing the aggregate technical and commercial losses, advancing energy conservation initiatives, and implementing efficiency improvement programmes reflecting its ambitious journey toward sustainable and efficient demand growth.

India's power generation sources are incredibly varied. The electricity generation basket for India's ranges from conventional sources such as coal, lignite, diesel, natural gas, hydro and nuclear to alternative sources like wind, solar, biomass and waste-to-energy. With the rapid increase in demand for electricity, there has been a substantial surge in capacity expansion to meet the country's needs.

2.5.1 Utility

Electricity Capacity

India is the third largest electricity producer worldwide, with an impressive installed capacity of 454 GW as of October 2024. Coal-based power plants contribute the largest share, accounting for 48 percent of the total installed capacity. This is a significant decline from 59 percent in 2016-17, reflects a concerted effort to shift away from fossil fuels and to triple the global renewable energy capacity by 2030.

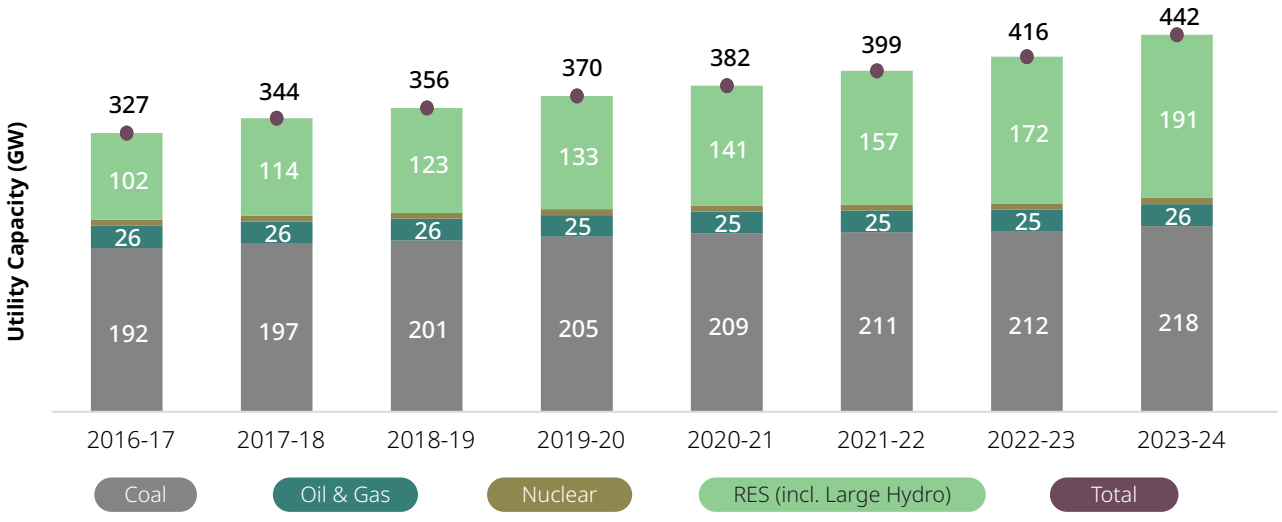


Figure 30: *India's Electricity Installed Capacity (Utility)*

Source: (CEA b, 2024)

From 2016-17, India's installed capacity of non-fossil fuel energy sources (including nuclear, hydro, and renewables) is growing at an annual rate of 9 percent, reaching 211 GW as of October 2024. This significant growth highlights India's dedication to its updated Nationally Determined Contributions (NDC) target of achieving 50 percent non-fossil fuel capacity by 2030. As of October 2024, non-fossil fuel-based capacity accounts for 46.5 percent of the total installed capacity.

Renewable Energy

Renewable energy (RE) encompasses a diverse range of sources such as hydro, solar, wind, biopower and waste to energy. India has emerged as a prominent player in the global RE sector, ranking fourth globally in installed RE capacity (Manohar, 2024). The total RE installed capacity stood at 203 GW as of October 2024, representing 45 percent of the country's total electricity installed capacity of 454 GW.

As of October 2024, solar power holds the largest share of the total renewable energy capacity at 45 percent, showing an impressive annual growth of 36 percent from 2016-17 to 2023-24. Hydro and wind power follow, each contributing 23 percent to the total RE capacity. Biopower and small hydro fill in the remaining capacity with 6 percent and 3 percent respectively.

Over the last seven years, the solar power capacity has grown seven times, reaching 82 GW by March 2024. This capacity includes 64 GW of ground-mounted solar (79 percent), 12 GW of rooftop solar (15 percent) and 3 GW (3 percent) each from hybrid and off-grid solar components. In addition to this, 87 GW of solar projects are in the pipeline to be commissioned soon.

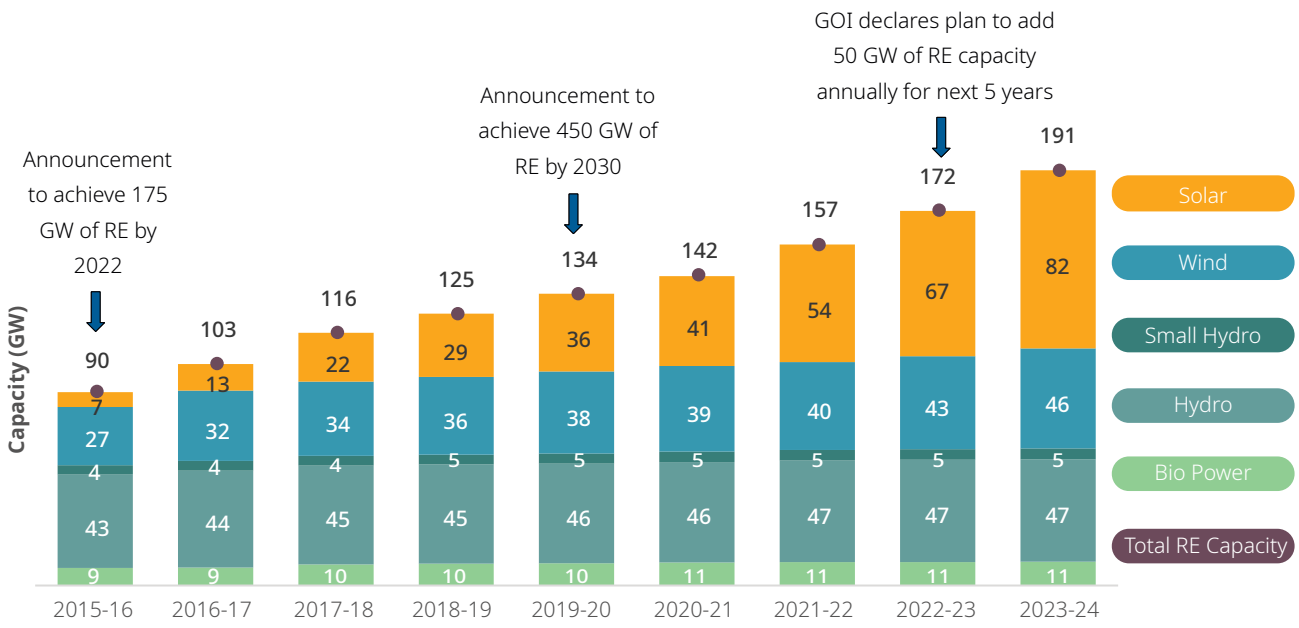


Figure 31: *Renewable Energy Installed Capacity (Utility)*

Source: (MNRE, a, 2024)

The country began solar rooftop installations in 2017-18 with merely 1 GW, and by 2024-25 (as of October 2024), this capacity increased to 14.45 GW, reflecting a yearly growth rate of 46 percent. The Government launched PM Surya Ghar Muft Bijli Yojana in February 2024 to accelerate RTS installations in the residential category. This scheme aims to install RTS capacity for one crore households, with a total financial outlay of Rs. 75,021 crores (MNRE, 2024).

This impressive growth in solar energy capacity both in utility scale and rooftop systems is driven by various Central and State Government initiatives that aim at promoting sustainable development and

self-reliance. One such initiative is the Production-Linked Incentive (PLI) scheme, designed to make India a global leader in the solar industry. This strategic move will strengthen the domestic solar panel manufacturing sector and reduce the country's dependence on imports, particularly from China. This initiative aligns with the vision of Atma Nirbhar Bharat.

Similarly, India stood as the fourth largest country in terms of cumulative wind capacity in the world with the installed capacity of 47.72 GW as of October 2024. Wind power contributes 23 percent to the total renewable energy capacity (203 GW) and represents 10 percent of the total electricity capacity in the country. The wind capacity installation has grown by 5 percent yearly, over the last seven years. In the past few years, wind capacity growth has been sluggish due to increased tariffs, supply chain obstacles, reduced investments, declining off-taker interest, challenges in land acquisition, unpredictable wind patterns, and the need for expanded grid infrastructure.

The Government of India has a plan to bid for 50 GW of renewable energy capacity annually from 2023–2028, including at least 10 GW of wind power capacity each year. This plan is part of the government's effort to achieve 500 GW of non-fossil fuel electricity capacity by 2030 (PIB, Apr, 2023). The country's significant growth factors include the cost competitiveness of wind energy, compliance with the wind Renewable Purchase Obligation (RPO) targets set by the State and Central Government, dedicated grid infrastructure for the integration of wind, acceleration in commercial and industrial sector demand, etc. The Government also plans to tender 4 GW of offshore wind energy blocks in Tamil Nadu and Gujarat, and then 5 GW per year for the next five years.

Electricity Generation

India's electricity generation has experienced a consistent annual growth of 5 percent over the past seven years. In 2023-24, the country generated 1734 TWh of electricity. Coal-based electricity holds the largest share in generating electricity. It contributes to 74.7 percent, followed by the low carbon sources like renewable energy (incl. large hydro) at 20.8 percent, nuclear at 2.8 percent and the remaining 1.8 percent share is produced by oil & gas. Electricity generation from renewable energy sources annually experienced a tremendous 8 percent annual growth rate from 204 TWh in 2016-17 to 360 TWh in 2023-24.

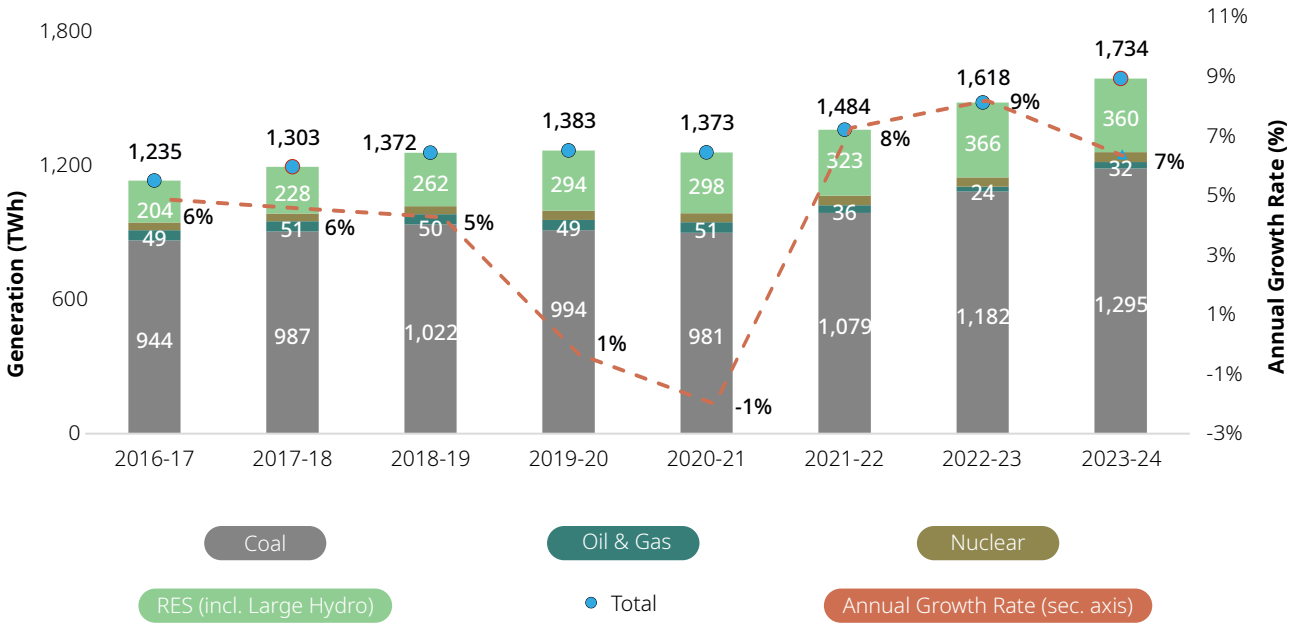


Figure 32: *Source-wise Electricity Generation*

Source: (NPP, 2024) and (CEA c, 2024)

In addition to the remarkable growth in capacity addition of Renewable Energy (RE), India witnessed a substantial increase in generating renewable energy. The graph below shows the RE generation across all sources for utilities from the span of 2016-17 to 2023-24. In 2023-24, RE generation accounted for 360 TWh, demonstrating an 8 percent annual increase over the seven years. Although hydro generation retained the largest share at 37 percent of the total generation, but there was a marginal decline in its output attributed to unfavourable monsoon conditions during 2023-24. Solar power generation accounted for 32 percent share in the total RE generation, exhibiting a remarkable annual growth of 36 percent over the past seven years. Wind power generation has contributed to 20 to 24 percent in the same period.

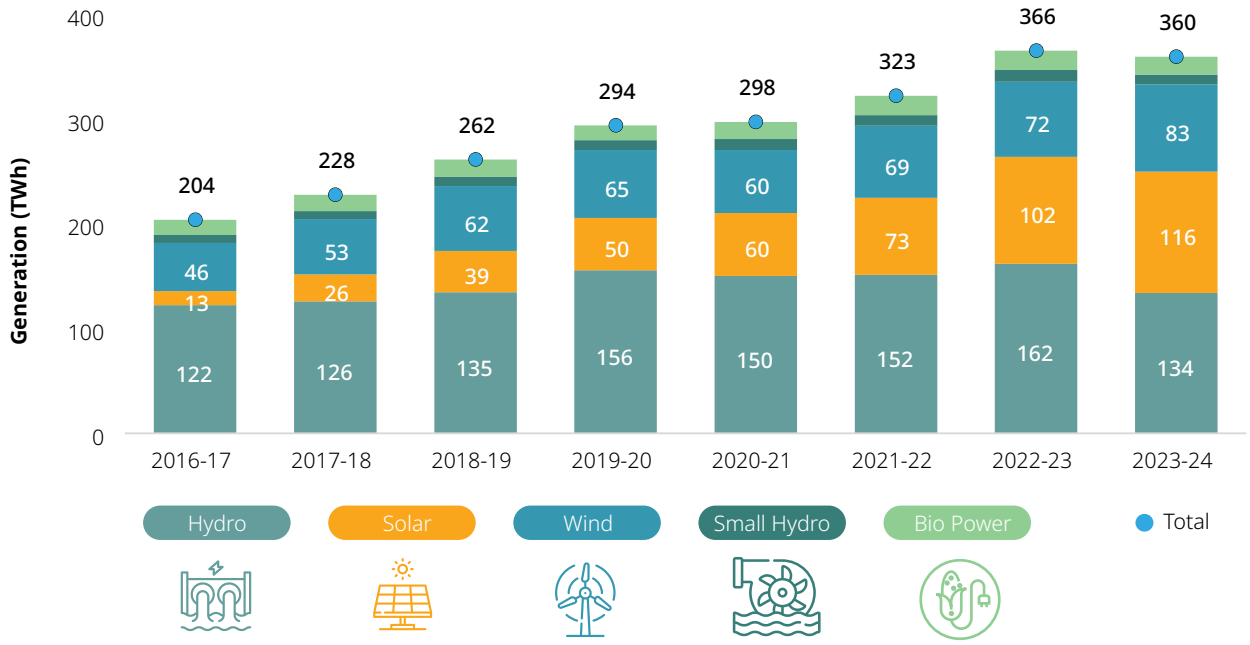


Figure 33: *Source-wise Renewable Electricity Generation*

Source: (CEA c, 2024)

2.5.2 Non-Utility Plants: Capacity and Generation

Non-utility or captive plants are mostly established by power intensive industries such as aluminium, cement, chemicals, fertilisers, iron & steel, paper and sugar etc. They are set up either to supplement the electricity purchased from the Utilities or for emergency use to protect against unreliable grid power.

The non-utility generating capacity stood at 79 GW as of 2023-24, marking 6.4 percent annual growth from the year 2016-17. In total capacity, 59.1 percent is contributed by coal, marking the largest share, followed by 23.1 percent by diesel, 9.6 percent by renewables, 8.2 percent by gas and 0.2 percent by hydro. Further, these plants generated 215 BU in 2023-24, marking 3.2 percent of annual growth from 2016-17. The gross generation dipped by 6 percent in 2020-21 as compared to the 2019-20, due to the COVID restrictions. The generation also dipped in 2021-22 by 7 percent mainly due to the conversion of some non-utility plants to utility plants.

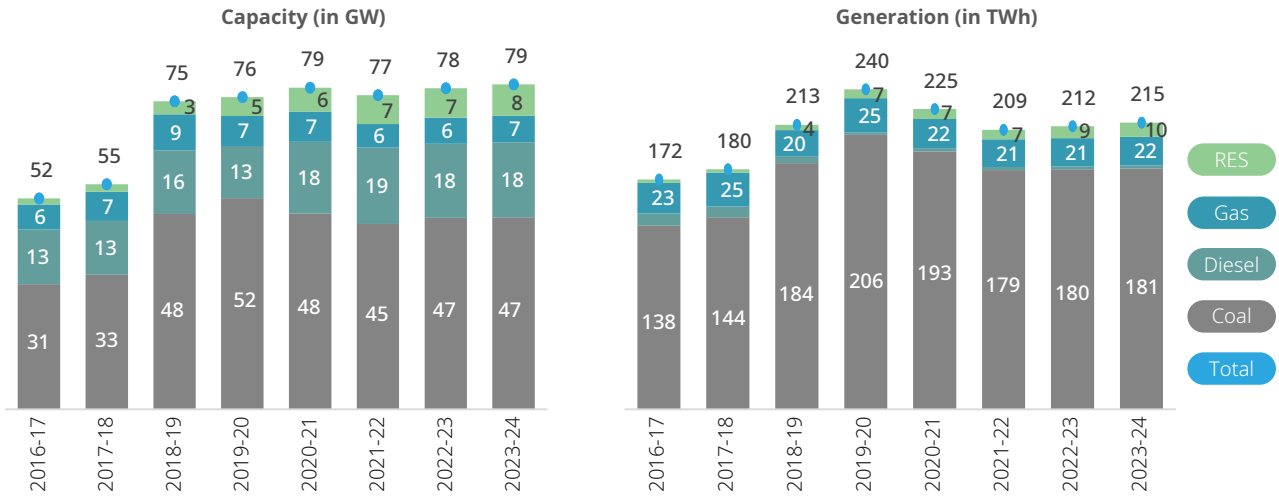


Figure 34: *Source-wise Installed Capacity and Generation of Non-Utility Plants*

Source: (CEA d, 2024)

According to the Central Electricity Authority (CEA), 8,408 industrial units with a demand of 0.5 MW and above have their own captive power plants in India. Figure 35 shows the industry-wise breakup of captive installed capacity. Among the various types of industries, the iron and steel sector hold the largest share of captive power plants, accounting for 20 percent (15 GW) of the total capacity. This is followed by the aluminium industry with a 13 percent share. Other significant contributors include the cement and sugar industries each holding a 9 percent share of the overall captive power plant capacity.

Figure 35: *Industry-wise Captive Installed Capacity as of 2022-23 (in GW)*[3]

Source: (CEA d, 2024)

State's Insights on Electricity Supply

Table 5 provides a comprehensive summary of the capacity of electricity. It also gives a glance on the electricity generation in the top 10 states, that are selected based on their highest contributions to National GDP (constant) in the year 2023-24 (full list in annexure). Among these states, West Bengal, Uttar Pradesh, and Madhya Pradesh rely heavily on fossil fuels, with over 70 percent of their electricity installed capacity coming from these sources and more than 90 percent of their total electricity production dependent on them..

3 Miscellaneous includes Mining and Quarrying, Rubber, Plastics, Colleries, Jute, and others.

Table 5: Overview of Electricity Supply (Utility) in key states in the year 2023-24

States	Total Installed Capacity (GW)	Share in Total Capacity (%)			Total Generation (BU)	Share in Total Generation (%)		
		Fossil	Non-Fossil	Renewable Energy		Fossil	Non-Fossil	Renewable Energy
Maharashtra	46	59%	41%	38%	169	81%	19%	14%
Gujarat	53	45%	55%	52%	135	63%	37%	32%
Tamil Nadu	40	38%	62%	56%	123	61%	39%	27%
Uttar Pradesh	33	81%	19%	17%	165	93%	7%	5%
Karnataka	32	30%	70%	67%	91	49%	51%	43%
West Bengal	16	87%	13%	13%	94	95%	5%	5%
Rajasthan	40	29%	71%	68%	117	53%	47%	41%
Andhra Pradesh	29	62%	38%	38%	90	79%	21%	21%
Telangana	17	55%	45%	45%	66	87%	13%	13%
Madhya Pradesh	31	70%	30%	30%	165	90%	10%	10%

Source: (NPP, 2024), (MNRE, a, 2024), and (CEA c, 2024)

In contrast, Rajasthan, Karnataka, Tamil Nadu, and Gujarat have more than 50 percent of their electric power capacity from non-fossil fuel-based energy resources. Notably, Gujarat, Rajasthan, and Tamil Nadu lead the nation with the highest renewable energy capacity installation.

In terms of total installation of solar capacity in the country, Rajasthan, Gujarat, Karnataka, Tamil Nadu and Maharashtra are the leading states, collectively contributing 71 percent of the total solar capacity (82 GW) as of March 2024.

For wind energy, Gujarat, Tamil Nadu, Karnataka, Maharashtra, and Rajasthan stand out as the top five states with wind installed capacity, collectively accounting for 85 percent of the total wind installed capacity (46 GW) as of March 2024. Their significant contributions to wind energy demonstrate their dedication to harnessing wind power as a vital renewable resource, further diversifying the country's energy mix.

3. Demand side - Trends and Analysis

The rapid population growth, rising per capita income and emerging consumer demands are contributing to a significant surge in energy consumption in India. The industry and residential sector consume major portion of India's total final energy consumption, followed by transport and the agriculture sector. India's rapid electrification is driven by increased appliance usage in the building sector and the swift adoption of electric vehicles to reduce carbon emissions in transportation. This surge in electrification is accompanied by a significant uptick in energy demand.

India has taken proactive measures to meet the increasing energy demands of its population while staying committed to achieving sustainable development goals, considering the nation's growing energy needs. Simultaneously, it is transitioning towards clean and renewable energy and focussing on enhancing energy efficiency. While, on the supply side, the Government shifts towards renewable energy and green hydrogen, efforts are also being made on the demand side for efficient use of energy. The Government aims to make a positive impact through various initiatives and policy measures like the implementation of building codes, promotion of Light-Emitting Diode (LED) lighting technology and scaling up the renewable energy in buildings and agriculture sector.

Over the past few years, the emphasis on data access has predominantly been on the supply side. However, there is an imperative to extend similar attention on the demand side ensuring both energy security and energy access for all in India. Energy demand data provides a comprehensive view of the country's energy use and providing valuable insights into how much energy is consumed in different sectors. This data plays an important role in shaping future energy strategies and decision-making processes. By ensuring the availability of reliable and consistent data, policymakers can evaluate the impact of the Government initiatives, track progress towards fulfilling the country's environmental commitments and craft well-informed policies backed by data.

Electricity Demand

India has witnessed a substantial rise in the electricity consumption across all sectors over the years. The total electricity consumption reached 1,543 TWh in 2023-24, with a 7 percent increase from the last year. Further, India's per capita electricity consumption has risen to 1,395 kWh (one-third of the global average) as of 2023-24, nearly doubled over the past decade (CEA f. 2024). The increase in electricity consumption is driven by the burgeoning demand from residential, commercial, and industrial sectors. The industrial sector, which accounts for 42 percent of the total electricity consumption, plays a vital role in powering the nation's manufacturing and production activities.

The residential sector is the second largest electricity consumer, accounts for 24 percent of total electricity usage, with an annual growth rate of 6 percent. This growth is propelled by the widespread adoption of electrical appliances especially for space cooling and improved access to electricity in rural and urban poor areas, supported by the Government initiatives such as the Sahaj Bijli Har Ghar Yojana (Saubhagya Scheme).

The agriculture sector holds 17 percent of the total electricity consumed. This sector becomes the third largest consumer of electricity with a consistent rise in its consumption. This growth is propelled by improved access to electricity, leading to an increased reliance on electric pumps for groundwater irrigation. The boost in electricity use can be attribute to the Government's initiative to phase out diesel pumps across the country.

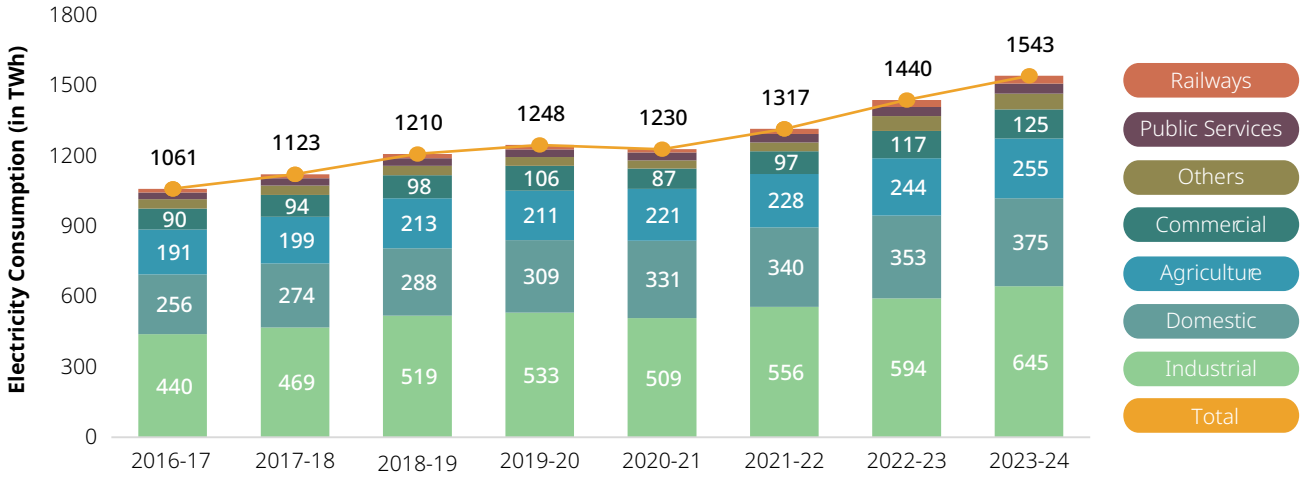


Figure 36: *Sector-wise Electricity Consumption*

Source: (CEA f, 2024)

Electricity Peak Demand

India's electricity demand surged to a record high of 250 GW in May 2024. In 2023-24, the electricity peak demand stood at 243 GW, reflecting a remarkable 13 percent rise from 2022-23, which is the highest annual growth in thirty years. This surge in demand is driven by increased industrial and commercial activities, economic growth, rising space cooling needs due to higher ambient temperatures, and demand from new sectors such as electric vehicles.

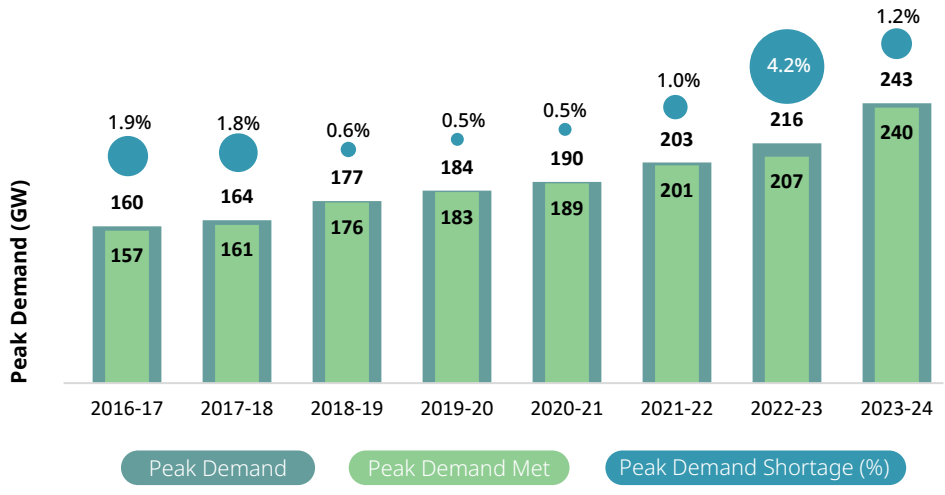
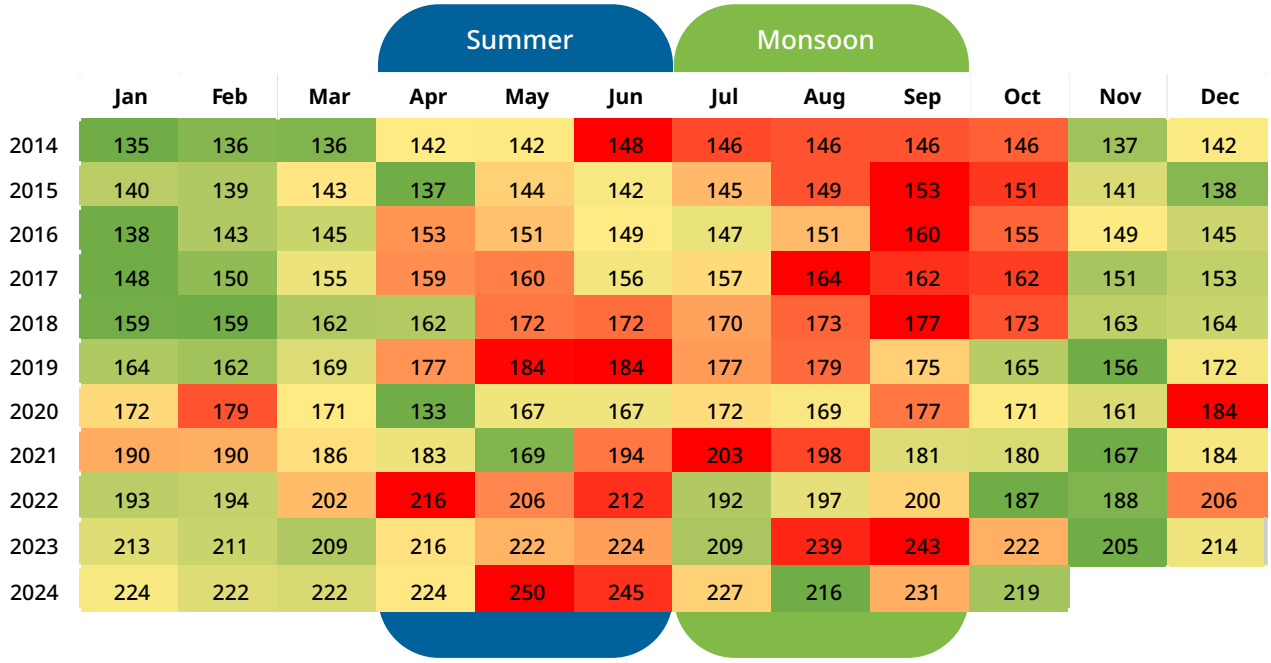


Figure 37: *India's Peak Electricity Demand Trends*

Source: (CEA a, 2024)

In the last decade, India's peak electricity demand has grown at an average of 5.4 percent rising from 148 GW in 2014 to 250 GW in 2024. Before COVID-19 pandemic, India's electricity peak demand typically occurred in August and September, coinciding with the monsoon season. This is primarily driven by higher domestic and commercial usage, especially for lighting and space cooling in humid conditions. However, in the year 2022, the annual peak demand has occurred in the summer season (April–July). Space cooling demand due to rise in temperatures and severe heat waves is the main factor behind the surge in electricity demand, particularly in April 2022.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	135	136	136	142	142	148	146	146	146	146	137	142
2015	140	139	143	137	144	142	145	149	153	151	141	138
2016	138	143	145	153	151	149	147	151	160	155	149	145
2017	148	150	155	159	160	156	157	164	162	162	151	153
2018	159	159	162	162	172	172	170	173	177	173	163	164
2019	164	162	169	177	184	184	177	179	175	165	156	172
2020	172	179	171	133	167	167	172	169	177	171	161	184
2021	190	190	186	183	169	194	203	198	181	180	167	184
2022	193	194	202	216	206	212	192	197	200	187	188	206
2023	213	211	209	216	222	224	209	239	243	222	205	214
2024	224	222	222	224	250	245	227	216	231	219		

Figure 38: *Monthly Peak Demand Variations (in GW)*

Green to Red Colours Signify the Increasing Intensity of Peak Demand
Source: (CEA a, 2024)

State's Insights on Electricity Demand:

Maharashtra, Gujarat, Uttar Pradesh and Tamin Nadu are among the top 10 states (based on the contribution to the country's GDP), that demand electricity exceeding 100 TWh In Maharashtra, Gujarat, and Tamil Nadu, the industrial sector accounts for a majority share of the state's electricity consumption. In Uttar Pradesh, the residential sector drives the total electricity needs in the state.

In most of the states, peak electricity demand growth rates are higher than the electricity demand growth rates, especially in Gujarat, Uttar Pradesh, Rajasthan, West Bengal and Tamil Nadu (refer Table 6). The possible reasons for the higher peak demand growth rate could be the space cooling requirements during the intensive summer days. Furthermore, the analysis reveals that many of these states have a higher proportion of industrial consumers, implying that the industrial sector impacts the overall electricity demand significantly.

Table 6: Overview of Electricity Consumption and Peak Demand in Key States

State	Peak Demand in 2023-24		Peak Demand Season	Peak Demand Growth Rate (%)	Electricity Consumption (BU) (in 2022-23)	Electricity Consumption Growth Rate (%)	Sector Contributing Most to Total Electricity Use	Share of the dominating Sector in Total Electricity Use (%)	Per-capita Electricity Consumption (kWh) (in 2022-23)
	GW	Month		2016-17 to 2023-24		2016-17 to 2022-23			
Maharashtra	31	Aug	Apr-Sep	5%	168	5%	Industry	42%	1676
Gujarat	25	Sep	Jun-Oct	8%	145	4%	Industry	65%	2393
Tamil Nadu	19	Apr	Feb-Jun	4%	111	3%	Industry	42%	1763
Karnataka	17	Mar	Jan-Apr	8%	78	1%	Industry	34%	1425
Uttar Pradesh	29	Jul	May-Sep	8%	127	6%	Domestic	41%	723
West Bengal	12	Jun	Apr-Sep	6%	62	5%	Industry	41%	819
Rajasthan	18	Jan	Nov-Jan	8%	87	6%	Agriculture	35%	1501
Andhra Pradesh	13	Mar	Feb-Jun	8%	72	6%	Industry	43%	1634
Telangana	16	Mar	Dec-Apr	8%	72	7%	Agriculture	31%	2349
Madhya Pradesh	18	Jan	Oct-Feb	7%	75	7%	Agriculture	37%	1230

Source: (CEA a, 2024) and (CEA d, 2024)

Further, the occurrence of the peak electricity demand varies across the states. In most states, peak demand occurs during the summer or post-monsoon season. However, states like Madhya Pradesh, Rajasthan, and Telangana experience peak demand in the winter season, which can be attributed to the irrigation needs for the sowing of the Rabi crop.

3.1 Industry

Industries in India are categorised into energy-intensive and non-energy-intensive sectors both playing a vital role in the nation's economic landscape. Energy-intensive industries like aluminium, cement, chlor-alkali, fertiliser, iron and steel, petrochemicals, pulp and paper, and textiles require substantial energy to operate. Non-energy-intensive sectors, such as automotive, food processing, pharmaceuticals, and IT, include a diverse array of micro, small, and medium enterprises, typically consume less energy per unit of output.

India's industrial sector is a strong pillar of the nation's economy, contributing significantly to its GDP and providing employment to millions of people. In 2023-24, the industry sector, including manufacturing,

mining, electricity, and construction, accounted for 31 percent of the gross value added (at constant prices) (Ministry of Finance, 2023), playing a key role in India's economic growth.

Industrial energy consumption data indicates that large quantum of energy usage is linked to unspecified industries, with no further segmentation or detailed insights available for these sectors. The publicly accessible data on industrial fuel consumption is inadequate, with notable gaps, particularly regarding sector-specific fuel usage and its applications, such as power generation or industrial processes. This data is essential for analysing fuel consumption patterns and formulating effective decarbonisation strategies or sectoral net-zero initiatives.

Further, under the PAT scheme, BEE identified eight energy-intensive industries. Their energy-consuming plants consuming energy beyond certain threshold limits, known as Designated Consumers (DCs), are mandated to report fuel usage and related data. This report dives into the fuel consumption data from DCs to gain insights into fuel distribution across sectors. Section 4.1.1 using data from ministry reports and DCs under the PAT scheme, provides insights into the dynamics of energy consumption within these industries.

Policy Initiatives in the Industry Sector

As India aims to become a $30-35 trillion economy by 2047 under the 'Viksit Bharat@2047' vision (Parliament LARRDIS, Dec, 2023), the industrial sector stands as a crucial pillar supporting this ambitious vision. To bolster the manufacturing sector and attract investments, the Government of India has implemented various initiatives alongside the ongoing schemes and policies. 'Make in India' initiative is one notable initiative, launched in September 2014. This aims to facilitate investment, foster innovation, enhance skill development, protect intellectual property & build best in class manufacturing infrastructure. Since its launch, the initiative has achieved significant progress across various sectors. The Foreign Direct Investment (FDI) inflows have doubled inflows from USD 45.15 billion in 2014-15 to USD 83.6 billion in 2021-22. It was a major accomplishment by its eighth year of implementation in 2021-22 (PIB, Sep, 2022).

To further develop manufacturing and support the 'Atmanirbhar Bharat' vision, the Government announced a Production Linked Incentive (PLI) Scheme for 14 key sectors. The Government released a sum of ₹1.97 lakh crore to enhance manufacturing capabilities and exports (PIB, Aug, 2023). An investment of ₹1.07 lakh crore released across these sectors by December 2023 (Digital Sansad, Feb, 2024). The Skill India Mission, launched in 2015, aims to equip youth with industry-relevant skills. The programmes like Pradhan Mantri Kaushal Vikas Yojana (PMKVY), Jan Shikshan Sansthan (JSS), National Apprenticeship Promotion Scheme (NAPS) and Craftsman Training Scheme (CTS) through Industrial Training Institutes (ITIs) are some initiatives. Since their launch, these programmes have trained around 2.55 crore of candidates (Digital Sansad a, Feb, 2024).

Efforts to improve the Ease of Doing Business are also underway through procedural simplification and legal rationalisation. The Department for Promotion of Industry and Internal Trade (DPIIT) coordinates these initiatives, involving various Ministries, Departments and States/UTs to simplify, digitise, decriminalise business processes and reduce compliance burdens. The Business Reform Action Plan (BRAP) assesses States/UTs on reforms such as investment enablers, transparency and online single-window systems. As a result, India improved its rank from 142nd in 2014 to 63rd in 2019 in the Doing Business Report, 2020 by World Bank taking a leap of 79 places in five years (PIB, Feb, 2024).

The PM Gati Shakti National Master Plan, launched in October 2021, aims to streamline multimodal infrastructure planning via a Geographic Information System (GIS) based platform, reducing logistics costs and enhancing efficiency. Till now, over 1463 GIS data layers pertaining to infrastructure assets

have been mapped, identifying 100 connectivity gaps for key sectors such as Food, Fertiliser, Steel, Coal etc. The Union Budget for FY 2023-24 includes a provision of ₹75,000 crores for rail and road projects to address these gaps (Digital Sansad, Dec, 2023). These proactive initiatives and reforms are essential for creating a conducive environment for industrial growth, propelling India towards its economic goals.

As the industrial sector continues to grow, managing its energy demand becomes increasingly important. The industry sector is energy intensive, accounting for around 49.5 percent of the total energy consumption in the country. This substantial energy utilisation underscores the sector's importance in the economy. It also highlights the need for implementing advanced energy-efficient practices and technologies to sustain growth while mitigating environmental impacts.

A: Final Energy Consumption

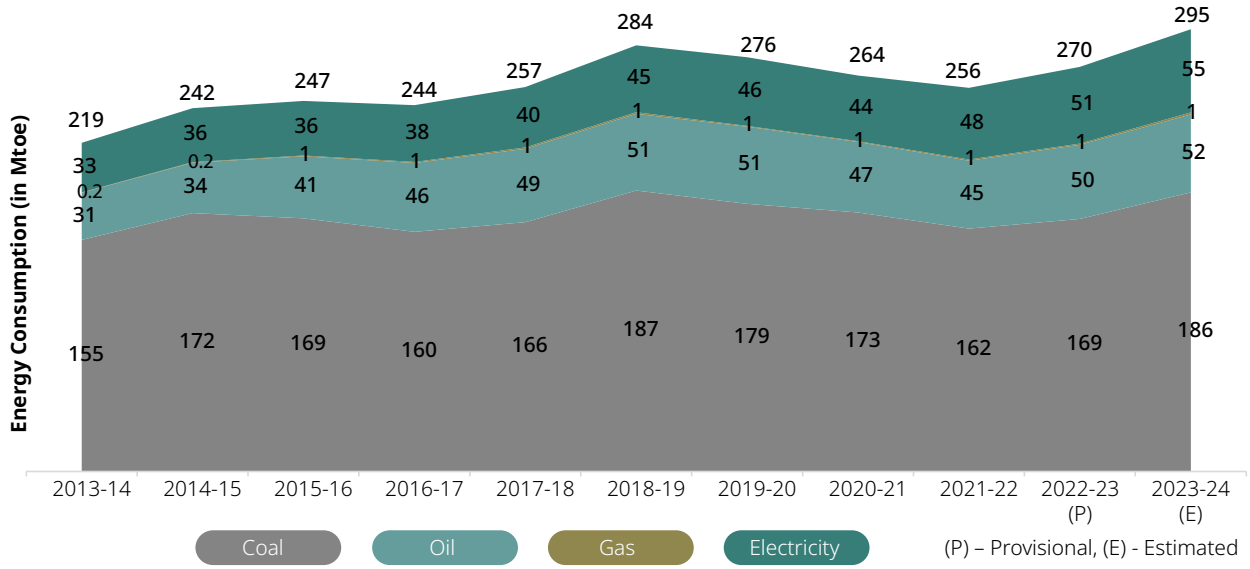


Figure 39: *Final Energy Consumption in the Industry Sector*

Source: (MoSPI) and for 2023-24, calculated based on actual data from various ministries

- The industry sector witnessed a shift towards cleaner fuels with the coal consumption share declining from 70 percent in 2013-14 to 63 percent in 2023-24 in total industrial energy consumption.
- The share of oil products in total energy consumption has increased slightly from 14 percent to 17 percent, with oil products consumption increasing from 31 Mtoe in 2013-14 to 52 Mtoe in 2023-24.
- Electricity consumption increased from 33 Mtoe to 55 Mtoe over the decade, with its share rising from 15 percent to 19 percent during the same period. This increase can be attributed to the expansion of production capacity, electrification of other industrial processes, and technological advancements in the sector.

B: Source wise Energy Consumption

Table 7: Consumption of various Energy Products in the Industry Sector (in MT)

	Unit	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Coal	MT	302.2	313.0	346.7	329.8	325.1	318.0	330.1	365.70
Lignite	MT	4.3	7.5	8.1	6.0	5.6	10.3	7.9	6.90
Diesel	MT	2.32	2.56	2.93	3.04	3.31	3.14	1.74	2.81
FO	MT	2.56	2.41	2.63	2.23	1.97	2.22	2.06	1.23
LSHS	MT	0.05	0.05	0.18	0.20	0.20	0.19	0.25	0.22
LPG	MT	0.22	0.20	0.20	0.15	0.21	0.18	0.23	0.38
Naphtha	MT	10.76	10.78	11.42	11.90	12.29	12.70	11.15	11.46
Natural Gas (incl. energy and non- energy use)	MMSCM	21278	20977	20583	20952	22055	22906	23184	26348
Electricity	TWh	440	469	519	533	509	556	594	645

Source: (MoSPI, 2024), (CEA f, 2024), and (MoPNG, 2024)

- The Iron and Steel Sector is a primary consumer of coal amongst other industries. Coal consumption in the industry sector increased from 302 MT in 2016-17 to 366 MT in 2023-24, exhibiting a CAGR of 3 percent.
- Within the industry sector, naphtha is the most consumed petroleum product, followed by Furnace Oil (FO) and diesel. Naphtha serves as a crucial feedstock in the petrochemical industry and is used as a solvent in the chemical industry. Notably, 75 percent of total naphtha consumption was dedicated to the petrochemical industry in 2023-24.
- Natural gas consumption within the industrial sector experienced a 28 percent increase from 2018-19 to 2023-24. This surge is primarily attributed to heightened gas consumption in the fertiliser sector. In 2022-23, the fertiliser industry accounted for 31 percent of the nation's total natural gas consumption, primarily used in the production of urea.
- Industry sector accounted for the largest share of 42 percent of the total electricity consumption in 2023-24. Electricity consumption in the industrial sector increased from 440 TWh in 2016-17 to 645 TWh in 2023-24.
- Despite a slight dip in electricity consumption to 509 TWh in 2020-21, likely due to COVID-19 pandemic-related disruptions, the sector quickly rebounded, with electricity use climbing to 556 TWh in 2021-22 and further to 645 TWh in 2023-24.

C: State-wise Industrial Electricity Consumption

The Figure 40 illustrates the top 10 states with the highest electricity consumption in the industrial sector. It also shows the percentage share of industrial consumption in each state's total electricity usage for 2022-23.

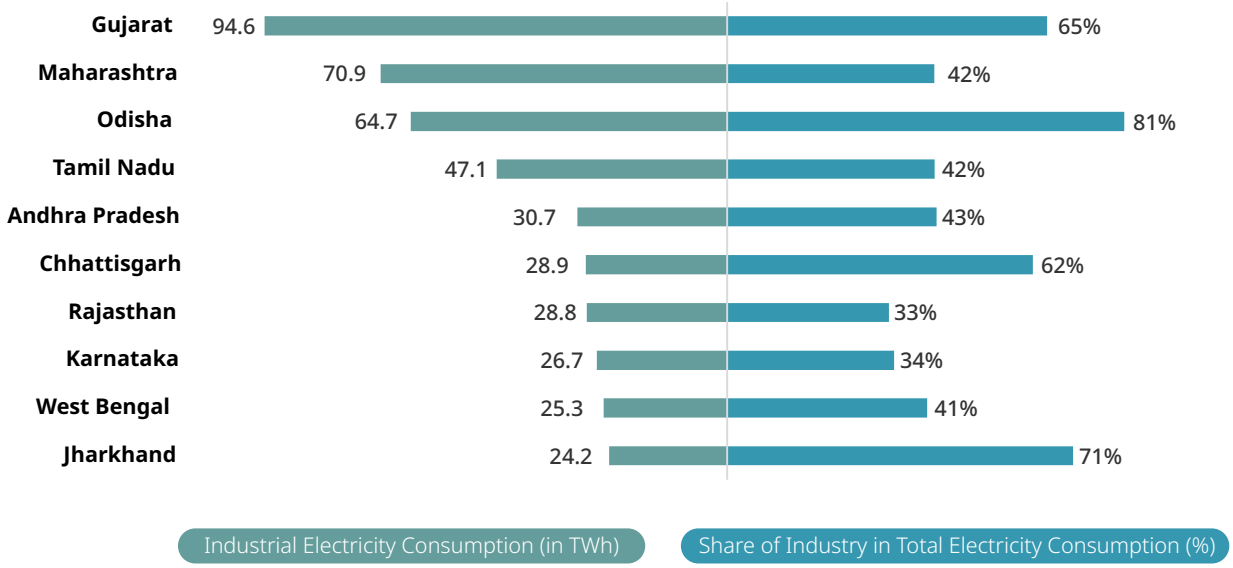


Figure 40: *Top 10 States with Highest Industrial Electricity Consumption in 2022-23*

Source: (CEA d, 2024)

- Collectively, these top 10 states accounted for 74 percent of India's industrial electricity consumption in 2022-23
- Gujarat leads, with the highest electricity consumption, accounting for 16 percent of India's total industrial electricity consumption. This is followed by Maharashtra and Odisha, contributing 12 percent and 11 percent to the overall consumption respectively
- Gujarat, Odisha, Chhattisgarh and Jharkhand show a strong dominance in industrial electricity consumption, while other states have significant consumption in other sectors.

Energy Consumption in Industries – As per the PAT Scheme

BEE launched the PAT scheme in March 2012 to enhance the energy efficiency in the energy intensive sectors in the country. It operates on a three-year rolling cycle, setting Specific Energy Consumption (SEC) reduction targets for eligible units based on their energy consumption thresholds. This systematic approach is designed to progressively enhance the energy efficiency in each unit, with targets varying according to their current efficiency levels.

Since its inception, BEE has rolled out eight PAT cycles. It covers a total of 1,333 industries referred as 'Designated Consumers' (DCs) across 13 sectors. These include Energy Intensive Industries, Thermal Power Plants, Refineries, Railways, Distribution Companies (DISCOMs) and Buildings. A total of 820 DCs were specifically notified under the energy intensive industries covering eight major sectors - Iron and Steel, Cement, Fertiliser, Aluminium, Pulp and Paper, Textile, Petrochemical and Chlor-Alkali. Since the focus is on industrial consumption sectors, Thermal Power Plants, Refineries, Railways, DISCOMs, and Buildings are excluded from consideration in this section.

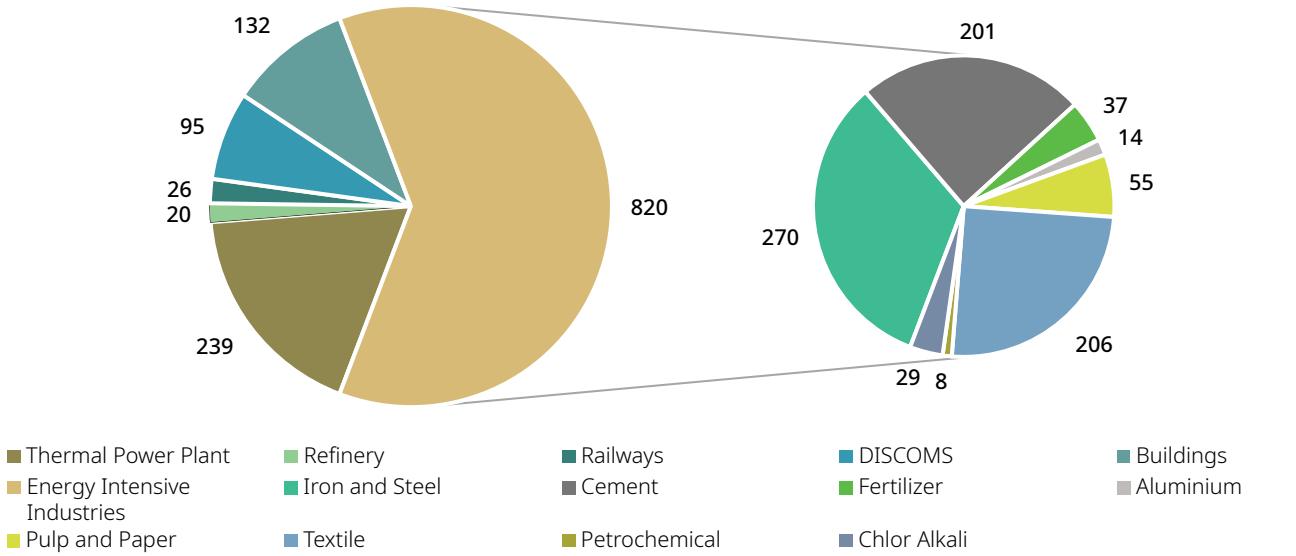


Figure 41: *DCs Notified Under the PAT Scheme*

The PAT scheme is instrumental in enhancing energy use and efficiency related data across industries. It mandates DCs to submit detailed annual data on industrial production, fuel and electricity consumption, specific energy consumption, and more.

Data Collection Process in PAT

BEE conducts a detailed feasibility study to identify DCs and determine energy consumption thresholds (Annexure – Table VIII & IX). A robust baseline study is designed for each DC to collect data and information on existing industry practices and consumption and further setting energy efficiency targets. Every financial year, each DC submits data according to Form 1 (Annexure – Table XI) or sector specific proforma. BEE conducts a thorough monitoring and verification procedure and mandatory energy audits to ensure the accuracy of data submitted by the DCs. This ensures that the data collected from all the DCs is reliable, accurate and continuous and hence, can further provide inferences on India's industrial energy consumption.

BEE plans to expand the PAT scheme by adding ten new energy-intensive sectors in upcoming cycles to broaden its impact and achieve industrial energy efficiency goals. These new sectors include Automobile, Ceramic, Chemical, Copper, Dairy, Glass, Port Trusts, Tyre Manufacturing, Zinc and Mining. Furthermore, BEE has initiated programmes that aim at enhancing sustainability and competitiveness within the Micro, Small and Medium Enterprises (MSME) Sector. This involves comprehensive energy consumption mapping of selected energy-intensive MSME sub-sectors.

The industrial sector consumed a total of 295 Mtoe in the fiscal year 2023-24. Out of this, BEE has mapped 178.8 Mtoe of energy consumption across different segments of the Industry Sector (as presented in the Figure 42 and Table 8). This includes 159.6 Mtoe from eight energy-intensive sectors, 8.1 Mtoe from new sectors, and 11 Mtoe from MSMEs.

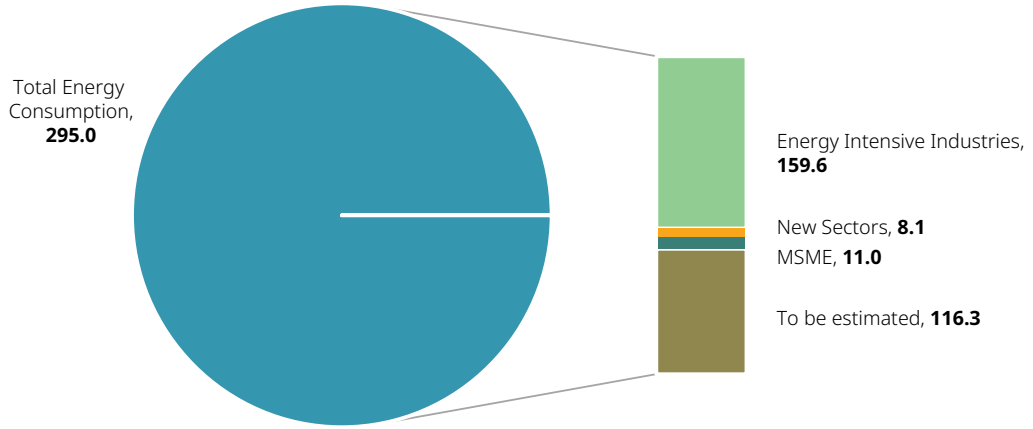


Figure 42: *Estimated Industrial Energy Consumption (in Mtoe)*

Figure 43 illustrates the estimated coverage of various energy-intensive industries under the PAT scheme. It indicates that the aluminium sector is completely covered with 96 percent and 94 percent of the chlor-alkali and cement sectors respectively, included in the PAT scheme.

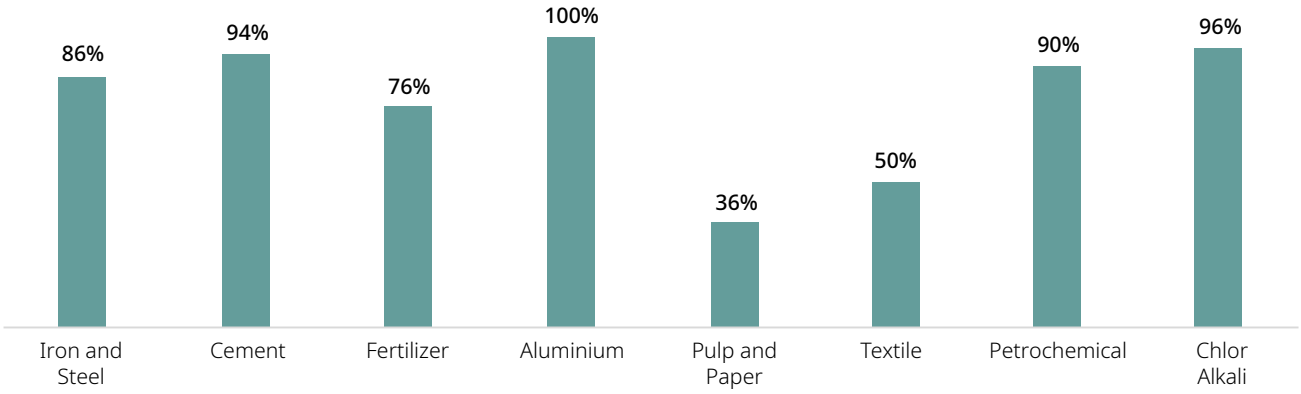


Figure 43: *Energy Intensive Industries covered under PAT Scheme (estimated)*

BEE is further gearing up and putting additional processes to unpack the remaining industrial energy consumption in the near future.

Table 8 provides the details on Sectoral Energy Consumption in different sectors along with the PAT coverage.

Table 8: Estimated Industry Energy Consumption Across Different Sectors (varied years from 2019-20 to 2023-24)

Sector	Sectoral estimated annual Energy Consumption (Million Toe)	DCs under PAT
Energy Intensive Industries		
Iron and Steel	79.90	253
Cement	29.04	191
Fertilizer	19.63	34
Aluminium	17.45	14

Sector	Sectoral estimated annual Energy Consumption (Million Toe)	DCs under PAT
Petrochemical	5.25	10
Chlor Alkali	3.02	29
Textile	2.84	173
Pulp and Paper	2.52	40
Sub Total	**159.65**	**744**
New Sectors		
Automobile Assembly Units	0.90	147
Ceramic	0.70	35
Chemical	1.36	37
Copper	0.25	3
Dairy	0.77	50
Glass	1.90	25
Port Trust	0.23	27
Tyre Manufacturer	0.76	66
Zinc	0.45	3
Mining	0.83	422
Sub Total	**8.14**	**815**
MSME		
Bricks	0.18	-
Chemical	0.29	-
Food processing	0.15	-
Forging	0.23	-
Foundry	0.28	-
Glass & Refractory	0.34	-
Leather	0.03	-
Paper	1.71	-
Pharma	1.13	-
Steel re-rolling	0.95	-
Textile	5.72	-
Sub Total	**11.01**	**-**
Grand Total	**178.79**	**-**

3.1.1 Iron and Steel

The Iron and Steel Sector holds significant importance in India's economic growth, contributing about 2 percent to the GDP and employs around 6 lakh people directly and 20 lakh people indirectly (Ministry of Steel, 2017). Positioned strategically with an extensive coastline, India leverages its geographical advantages for robust participation in the global steel market. It ranks as the world's second-largest producer of crude steel, with 138.8 million tonnes of finished steel produced in the fiscal year 2024. India's per capita finished steel consumption was 97.7 Kg in 2023-24, compared to the global average of 219.3 Kg (Ministry of Steel, 2024).

In 2017, the Government of India introduced the National Steel Policy to foster a technologically advanced and globally competitive steel industry. The policy aligns with the objectives of the 'Make in India' initiative. This policy anticipates substantial investments across sectors such as Construction, Infrastructure, Automobile, Power and Defence, thereby stimulating the demand for steel. The Government has introduced initiatives like 100 percent FDI through automatic route, PLI scheme and PM Gati Shakti National Master Plan. These are to enhance the production capacity and investments in the steel sector. Through the PLI scheme, the steel sector is expected to attract an investment of Rs. 29,530 Crore with a downstream capacity of additional 25 million tonnes and employment generation potential of 70000 (Ministry of Steel, 2023).

Despite its growth prospects, the iron and steel sector face significant environmental challenges being the highest energy consumer and emitter of CO_2 emissions among other industries. In 2019, the sector accounted for about 39 percent of the nation's GHG emissions from manufacturing, industries and construction. Recognising the sector's importance for economic development and its impact on carbon emissions, the Government has initiated measures to decarbonise the industry and committed to achieve Net-Zero target by 2070. These initiatives include the Steel Scrap Recycling Policy of 2019, aimed at increasing domestic scrap availability and reducing coal consumption in steel production. It is also adopting the Best Available Technologies (BAT) available globally in modernisation & expansions projects. As a result, the carbon emission intensity of the iron and steel industry decreased from 3.1 tonnes per tonne of crude steel (T/tcs) in 2005 to around 2.6 T/tcs by 2020 (PIB, Feb., 2022).

Furthermore, under the PAT scheme, the iron and steel industry has been identified as an energy intensive sector, with 204 DCs notified up to PAT Cycle VII (from 2021-22 to 2024-25). Through PAT cycles from 2012-13 to 2019-20, significant energy savings of 5.5 Mtoe and emissions reduction of 20 $MTCO_2e$ were achieved. Additionally, the steel sector plays an important role in the National Green Hydrogen Energy Mission, which aims to deploy green hydrogen in iron and steel making processes. Acknowledging global concerns about green steel taxonomy, India has formed a Task Force on the Development of Taxonomy for Green Steel. It engages industry, academia and other stakeholders to advance discussions and recommendations. Moreover, the Ministry of Steel supports research and development activities aim to enhance energy efficiency and reduce carbon footprints in the steel sector, providing financial assistance for technology-driven projects.

The following graph illustrates the year-on-year production of Iron and Steel in India.

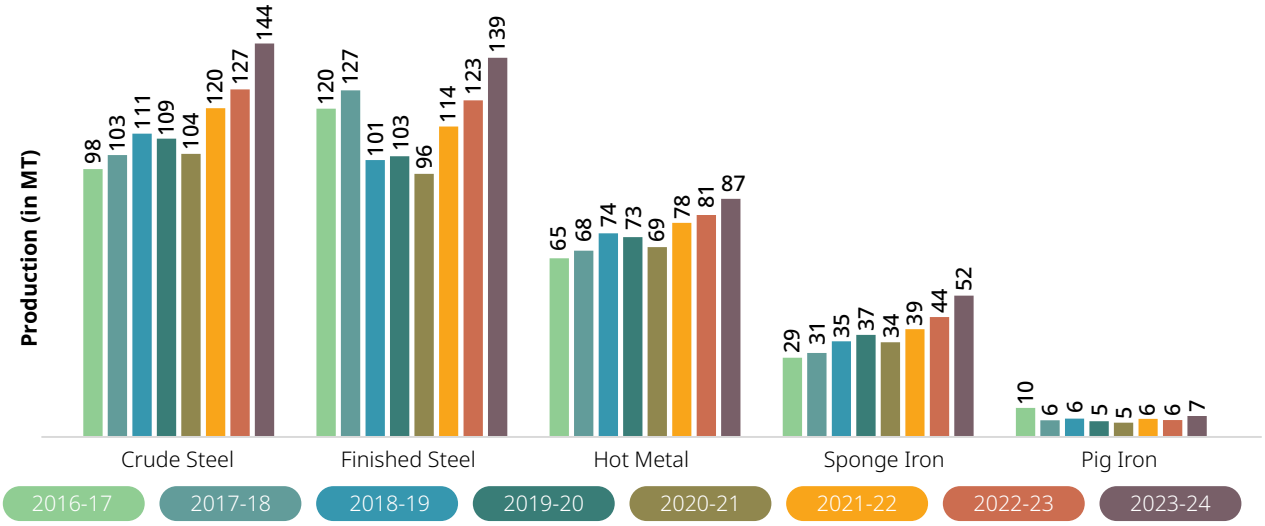


Figure 44: *Iron and Steel Production Trends*

Source: (Ministry of Steel, 2024)

- India's crude steel production capacity reached 179.5 MT in 2023-24. Crude steel production increased from 98 MT in 2016-17 to 144 MT in 2023-24, with a capacity utilisation of 80 percent. According to the National Steel Policy, crude steel production is expected to double by 2030-31, reaching 255 MT.
- Finished steel production declined by 20 percent from 2017-18 to 2018-19 due to low demand in various sectors. However, it rebounded after the COVID-19 pandemic, reaching 139 MT in 2023-24. Further, the demand for finished steel is projected to reach 230 MT by 2030-31.
- Hot metal production increased from 65 MT in 2016-17 to 87 MT in 2023-24, with a CAGR of 4 percent.
- Sponge iron production increased from 29 MT in 2016-17 to 52 MT in 2023-24. In contrast, pig iron production declined from 10 MT in 2016-17 to 6 MT in 2017-18 and remained at the same level.

Fuel Consumption in the Iron and Steel sector

The major energy sources in the Iron and Steel Sector are coal, lignite, and oil. Coking coal is used to produce coke for blast furnaces, reducing iron ore to pig iron while non-coking coal is used in captive power plants to produce electricity. Furnace oil fuels is used to oil-fired furnaces, particularly for reheating and heat treatment, while diesel is used in furnaces where sulphur presence is undesirable. Table 9 provides the consumption of various fuels in the Iron and Steel Sector.

Table 9: Consumption of various Energy Products in Iron and Steel Sector (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Coal	57.54	66.98	76.74	74.27	69.74	75.30	78.90	78.14
Lignite	0.04	0.12	0.09	0.02	0.02	0.26	0.12	0.09
FO	0.98	0.93	0.89	0.78	0.67	0.76	0.68	0.39
Diesel	0.18	0.21	0.22	0.20	0.20	0.23	0.16	0.18
LSHS	0.05	0.04	0.13	0.17	0.16	0.16	0.19	0.17
LPG	0.14	0.13	0.09	0.06	0.11	0.08	0.06	0.07

Source: (MoSPI, 2024) and (MoPNG, 2024)

- Coal consumption in the iron and steel sector increased from 57.5 MT in 2016-17 to 78.14 MT in 2023-24, with a slight dip in 2020-21 likely due to the COVID-19 pandemic.
- Conversely, furnace oil consumption declined from 0.98 MT in 2016-17 to 0.39 MT in 2023-24, while diesel consumption fluctuated over the years.
- Consumption of Low Sulphur Heavy Stock (LSHS) and LPG has varied over the years.

Analysis as per PAT scheme

The steel manufacturing process requires substantial energy and materials. Coal serves as a crucial reducing agent and energy source across various processes. Predominantly, coal is the primary fuel used, followed by gas and oil. The graph illustrates the fuel consumption trends within the Iron and Steel sector across 119 DCs. Overall, there was a decreasing trend in fuel consumption from 2021-22 to 2022-23. In the fiscal year 2021-22, solid fuels accounted for 75 percent of total thermal energy consumption, which decreased to 58 percent in 2022-23.

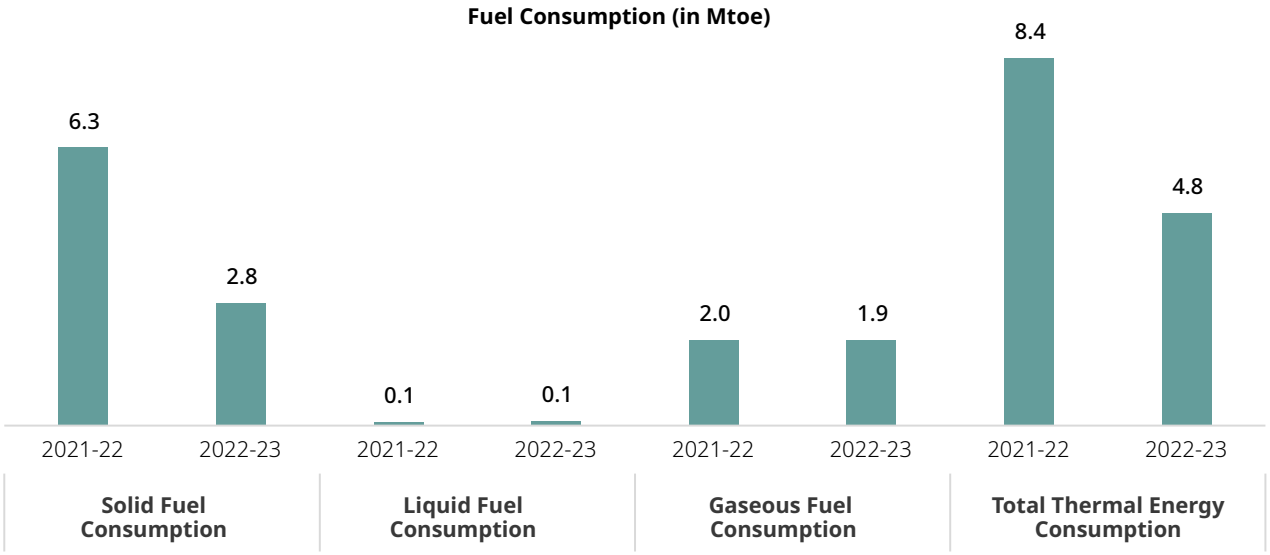


Figure 45: *Fuel Consumption within Iron and Steel Sector (by 119 DCs)*

The blast furnace, serves as the main process where iron ore undergoes reduction to produce iron, which is then processed into value-added products. It is also a major energy consumer energy within the plant. The primary energy consumption occurs by using pet coke and coal. The graph below illustrates the allocation of different fuels across various stages within the plant. The majority fuels are utilised in various processes, with the remaining portion allocated to captive power generation and DG sets.

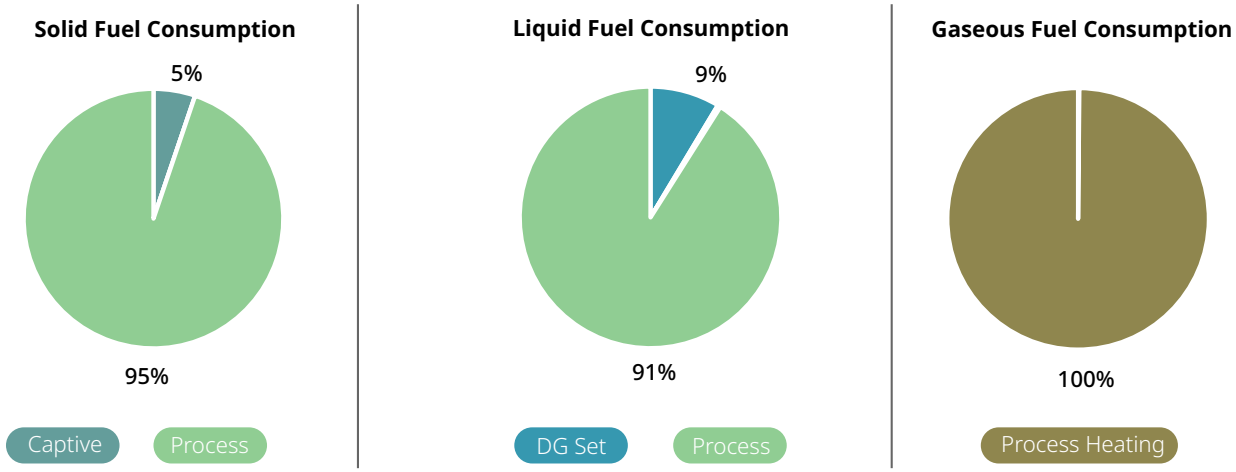


Figure 46: *Distribution of Fuel used in Iron and Steel Sector (in 2022-23)*

3.1.2 Aluminium

India's aluminium industry is a cornerstone of the national economy, experiencing significant growth and development over the years. With abundant bauxite reserves, favourable policies and rising demand for aluminium products, India has become a major player in the global aluminium market. India contributes 3 percent to the world's aluminium capacity, with the production capacity of 41 lakh tonnes. Aluminium stands as the second-largest metal market globally, following iron and steel.

As India progresses toward its economic goals, aluminium will be increasingly crucial, especially in power, transportation, construction and packaging. The demand for aluminium in India is expected to double by 2033, driven by the Government's push for infrastructure and initiatives such as Make in India, Housing for All, Smart Cities, the National Infrastructure Pipeline, Renewable energy capacity expansion, and the FAME scheme for electric vehicles. Given its extensive use in renewable energy, especially solar power, aluminium demand is set to rise, aiming to achieve 450 GW of renewable energy by 2030.

The aluminium industry is highly energy-intensive, producing metal in three stages: mining of bauxite, refining of alumina and smelting of alumina into aluminium. The process of refining and smelting is highly energy intensive and demands a large amount of electrical energy. In India, aluminium smelting requires about 14,361 kWh of electricity to produce 1 tonne of aluminium, compared to the global average of 14,145 kWh (BEE a, 2018).

Since aluminium sector consumes a substantial amount of energy, the Government has classified the it as energy-intensive under the Perform, Achieve, and Trade (PAT) scheme. Under this scheme, the BEE has notified 14 DCs from the aluminium sector up to PAT Cycle VII (from 2021-22 to 2024-25). In PAT Cycle I (from 2012-13 to 2014-15), the sector achieved a reduction of 0.73 Mtoe against a target of 0.456 Mtoe, while in PAT Cycle II (from 2015-16 to 2018-19), it achieved energy savings of 1.226 Mtoe against the target of 0.46 Mtoe, demonstrating 167 percent of the energy savings target achievement (BEE, Dec, 2023). Further to reduce energy consumption and increase energy efficiency, BEE has listed several energy-efficient technologies for various sectors including aluminium. In addition to this, the Ministry of Mines has provided the Sustainable Development Framework, encouraging sustainable and energy-efficient practices in the mining and metals sectors.

The aluminium production increased from 2.9 million tonnes in 2016-17 to 4.16 million tonnes in 2023-24, surged by 44 percent. This growth is supported by India's abundant bauxite reserves. Four major producers namely National Aluminium Co. Ltd (NALCO), Hindalco Industries Ltd (HINDALCO), Bharat Aluminium Co. Ltd (BALCO) and Vedanta Aluminium Ltd (VAL) are at the forefront in aluminium production. The following graph shows year-on-year production of Aluminium in India.

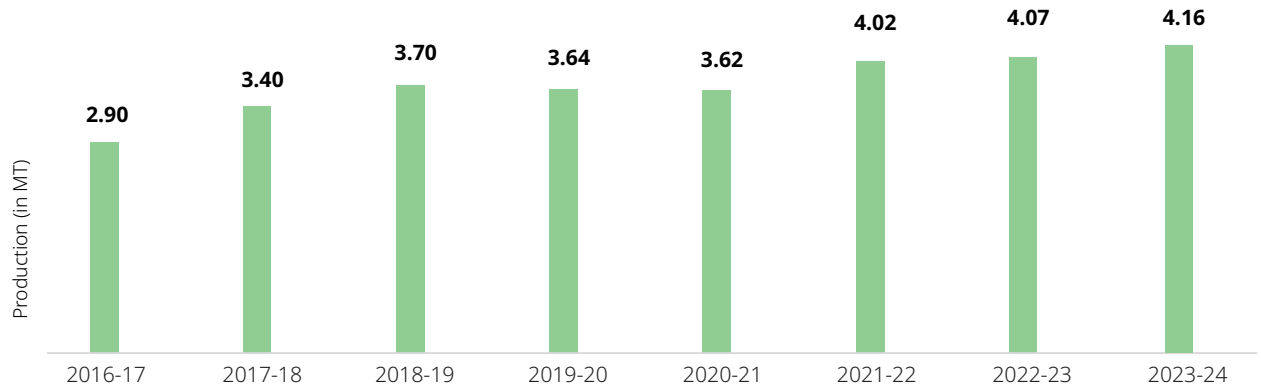


Figure 47: *Aluminium Production Trends*

Source: (Indian Bureau of Mines, 2023)

Fuel Consumption in the Aluminium Sector

In the aluminium industry, power is a crucial input due to the energy-intensive nature of the electrolytic reduction process which produces aluminium from alumina. This process requires significant amounts of electricity. Additionally, the production of aluminium involves the anode baking process, which requires additional thermal energy. This thermal energy is predominantly met by furnace oil. From 2016-17 to 2022-23, the consumption of furnace oil increased by 49 percent, reflecting its growing importance in meeting the thermal energy demands of anode baking. However, the FO consumption has declined in 2023-24. Diesel usage in the industry saw a slight decline over the same period.

Table 10: Consumption of Furnace Oil and Diesel in Aluminium Sector (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Diesel	0.03	0.05	0.04	0.02	0.02	0.03	0.02	0.02
FO	0.26	0.24	0.39	0.34	0.35	0.39	0.38	0.23

Source: (MoPNG, 2024)

The aluminium industry consumes a significant amount of coal to operate the captive power plants within the industry. As per CEA, the installed capacity of coal captive power plants in the aluminium industry was 9.58 GW as of 31.03.2023. However, a specific data on coal consumption for these captive power plants by industry is not publicly available. Instead, the data is aggregated under the total coal consumption for all captive power plants in India, without categorising it by industry sector.

Analysis as per PAT scheme

The graph below illustrates the fuel consumption across 14 DCs. There was a 21 percent reduction in thermal energy consumption between 2021-22 and 2022-23, driven mainly by decreased solid fuel usage, particularly coal. Furthermore, electricity consumption experienced a significant 28 percent decline. A majority of electricity is sourced from captive power plants within the industry, as shown in the Figure 48.

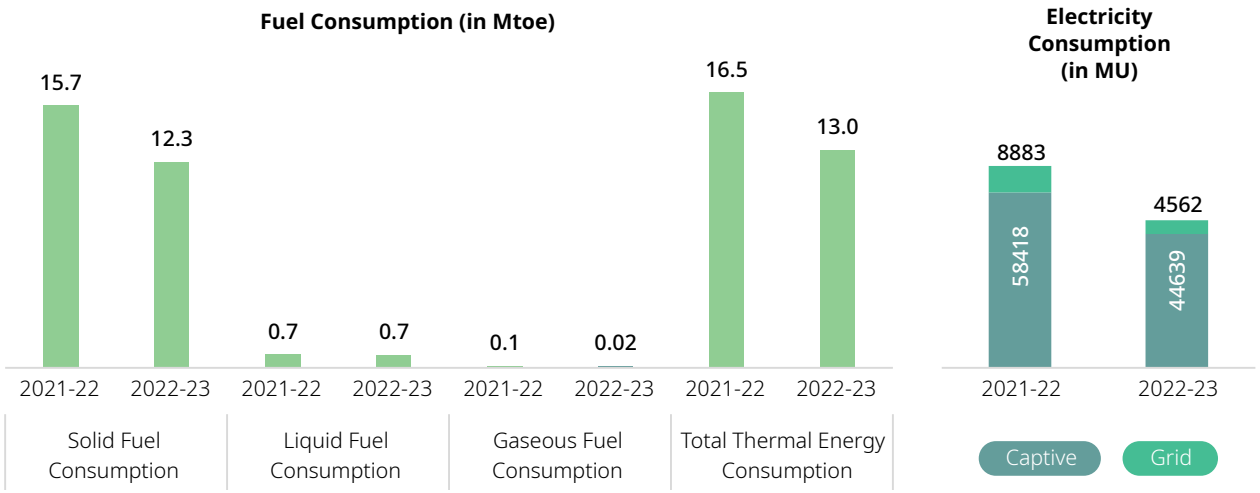


Figure 48: *Fuel and Electricity Consumption within the Aluminium Industry (by 14 DCs)*

Solid fuel includes Domestic Coal, Lignite, Imported Coal, pet coke, Biomass, Solid Waste and other solid fuels.
Liquid fuels include FO, LSHS, HSD, LDO and Liquid Waste.
Gaseous fuels include natural gas and LPG.

The data from the 14 DCs also provide a breakdown of fuel consumption by process. It reveals that 93 percent of solid fuel is used for power generation in the industry's captive power plants. In contrast, liquid and gaseous fuels are primarily used for various processes, with a portion of liquid fuel also being utilised in the captive power plants.

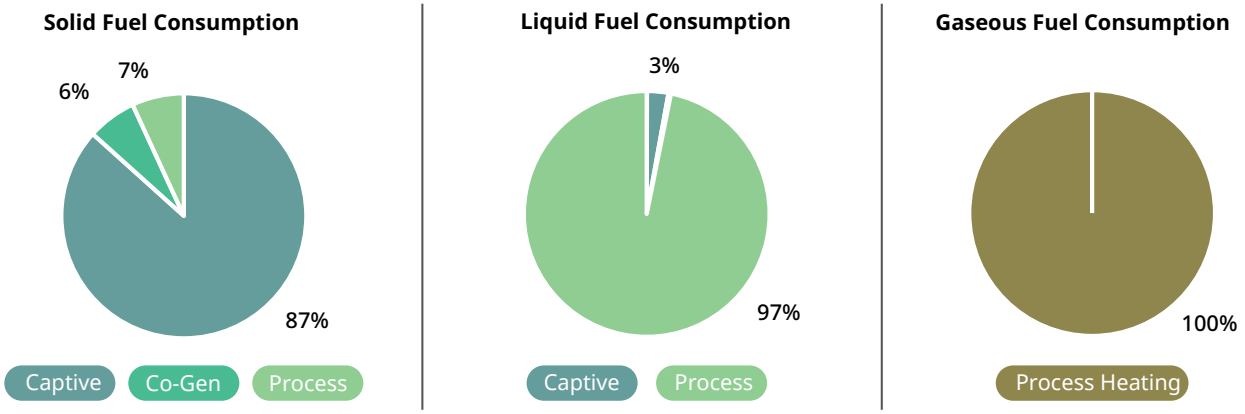


Figure 49: *Distribution of Fuel used in Aluminium Industry (in 2022-23)*

3.1.3 Cement

The Cement Industry in India is crucial to the nation's economic growth and development. As the world's second-largest producer of cement after China, India had an annual production capacity of 600 million tonnes in 2022-23. Despite being the second largest producer, India's per capita cement consumption is below the global average. However, the sector is poised for substantial growth due to Government initiatives focused on housing, infrastructure, and smart cities. Programmes like Pradhan Mantri Awas Yojana (PMAY), Smart City Mission, Bharatmala Pariyojna, PM Gati Shakti-National Master Plan (NMP) and Sagarmala Programme are expected to drive future demand.

However, this growth comes with environmental challenges, as the sector is highly energy and emission-intensive. In 2019, the cement sector accounted for about 13 percent of India's manufacturing and construction emissions, the second highest after the Iron and Steel sector. Emissions from cement production arise from electricity and thermal energy use, as well as industrial processes. Clinker, a crucial component that provides strength when mixed with water, is particularly carbon-intensive. More clinker production means more limestone use and higher emissions.

Advancing growth while tackling environmental challenges, India's cement sector is highly efficient, surpassing the global average. The cement industry is one of the eight energy-intensive sectors under the PAT scheme, which has improved the sector's energy efficiency. Under the PAT scheme, the BEE has notified 175 DCs from the cement sector up to PAT Cycle VII. In PAT Cycles I and II, the cement sector exceeded energy-saving targets by 81.6 percent and 48 percent, respectively.

To further mitigate emissions, India is developing low-carbon alternatives like Limestone Calcined Clay Cement (LC3) and geopolymer cement, which can reduce carbon emissions by 30 percent and 80 percent, respectively. Additionally, India aims to become a global hub for green hydrogen through the 'National Green Hydrogen Mission'. Incorporating green hydrogen in cement sector can reduce emissions by repurposing waste heat and replacing natural gas in cement kilns. This can help in eliminating all stationary combustion CO_2 emissions.

India contributes around 9 percent of global cement capacity, with a production capacity of 600 million tonnes per annum. In 2022-23, India's cement production reached 391 million tonnes, showing a capacity utilisation of 65 percent. The following graph illustrates the year-on-year production of cement in India.

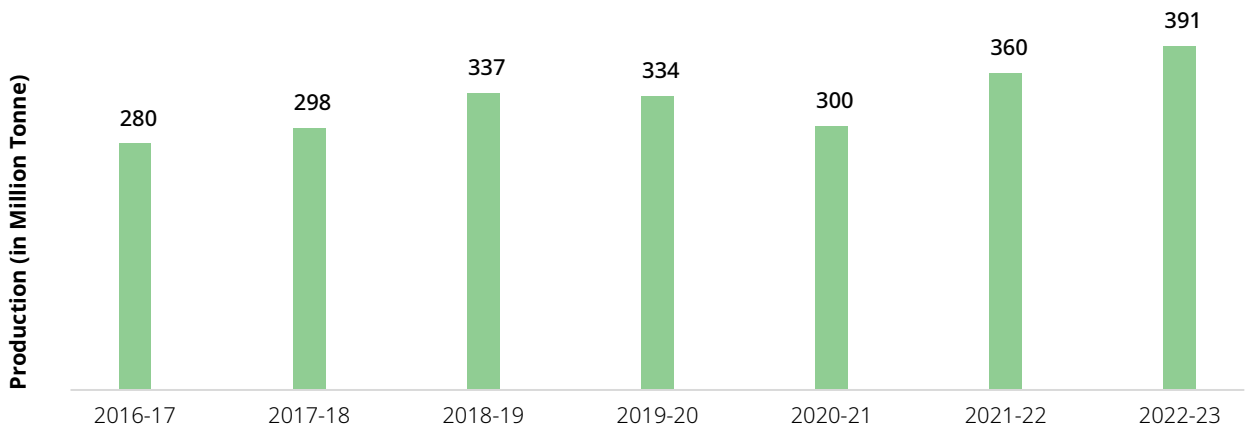


Figure 50: *Cement Production Trends*

Source: (Indian Bureau of Mines, 2023)

Fuel Consumption in the Cement Sector

The cement industries primarily depend on solid fuels like coal, lignite and pet coke with minimal use of liquid fuel. Cement production involves a kiln, a large furnace where raw materials are heated at high temperatures. Coal, along with pet coke or alternative fuels, is burned in the kiln to provide thermal energy.

Table 11: Consumption of various Energy Products in the Cement Sector (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Coal	6.37	7.71	8.82	8.57	6.75	7.31	8.12	9.16
Lignite	0.29	1.09	1.8	1	0.81	1.55	0.84	0.13
Diesel	0.16	0.04	0.03	0.03	0.03	0.04	0.02	0.53
FO	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.01

Source: (MoC, 2024) and (MoPNG, 2024)

- Coal and lignite are the most used energy sources in this sector, with varying consumption patterns over the years
- Diesel consumption showed a notable decline from 2016-17 to 2018-19, followed by stable levels in subsequent years up to 2022-23. In 2023-24, diesel consumption surged, registering a 27-fold increase compared to 2022-23.

Analysis as per PAT scheme

The graph below illustrates the fuel consumption data from 20 DCs. In the cement industry, coal, pet coke and lignite are used primarily as kiln fuels for producing clinker. The utilisation of these solid fuels saw a slight rise from 2.7 Mtoe in 2021-22 to 2.9 Mtoe in 2022-23. Additionally, electricity consumption increased by 16 percent during the same period with the majority sourced from captive power plants.

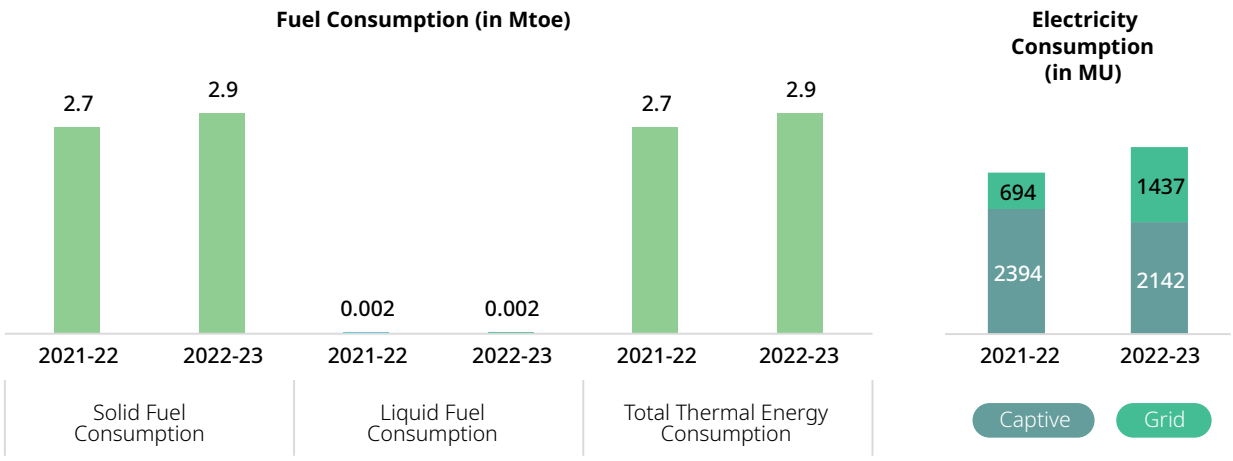


Figure 51: *Fuel and Electricity Consumption within Cement Industry (by 20 DCs)*

The graph below indicates that within the cement industry, 87 percent of solid fuels are allocated to processes, with the remaining 13 percent utilised in captive power plants. In terms of liquid fuels, 81 percent are designated for processes, 11 percent for DG sets, and 8 percent for captive power plants. These liquid fuels primarily consist of furnace oil and diesel.

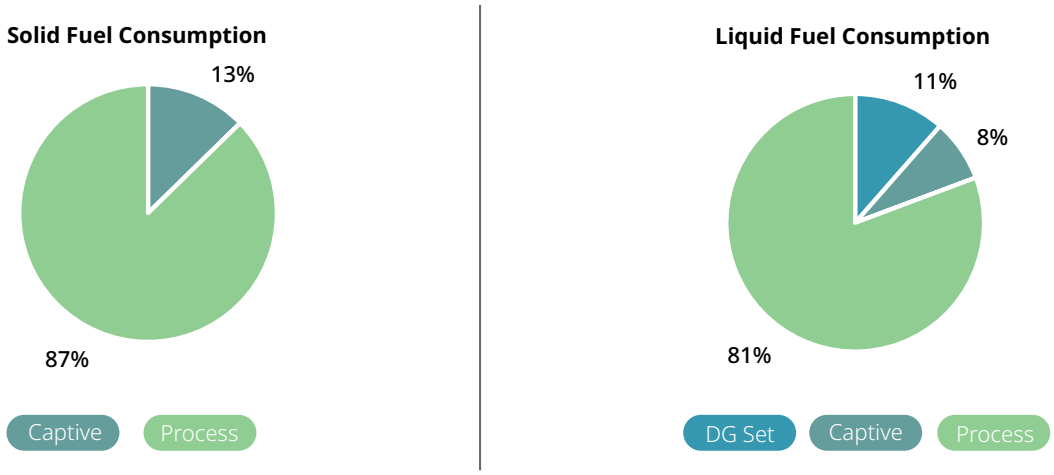


Figure 52: *Distribution of Fuel used in Cement Industry (in 2022-23)*

3.1.4 Chlor-Alkali

The chlor-alkali sector is one of oldest industrial sectors in India. It produces key chemicals such as chlorine, caustic soda and soda ash. Caustic soda is the primary product of this industry, with chlorine and hydrogen as byproducts. In 2022-23, India's annual caustic soda capacity stood at 5.6 million tonnes, representing 5.5 percent of global capacity. The industry is poised for growth due to its critical role in various sectors such as textiles, pulp and paper, and pharmaceuticals.

The production of chlor-alkali products, especially caustic soda, is highly energy-intensive. Recognising the substantial energy demands, the sector has consistently pursued cleaner and more efficient technologies, resulting in significant advancements. Caustic soda is produced through the electrolysis process, using diaphragm cell, mercury cell or membrane cell technologies. Amongst these, the mercury cell process is the most energy-intensive, while the membrane cell process is the most energy-efficient. Due to its high energy consumption and associated environmental pollution, mercury cell technology has been almost entirely phased out in India. The mercury cell process consumes approximately 3200 kWh per metric ton of caustic soda and transitioning to membrane cell technology has reduced energy demands

by at least 35 percent to around 2100 kWh per MT of chlor-alkali (BEE b, 2018). Such improvements are crucial as the chlor-alkali industry is recognised as an energy-intensive sector under the PAT scheme. Up to PAT Cycle VIII (from 2022-23 to 2025-26), the BEE has notified 28 DCs in this sector. These have achieved substantial energy targets and reductions in CO_2 emissions under various cycles, showcasing the sector's commitment to energy efficiency.

Despite these advancements, a substantial amount of hydrogen is still released as a co-product in chlor-alkali plants, which often gets wasted. This hydrogen can be utilised as a clean energy source. Additionally, chlor-alkali plants can use hydrogen fuel cells to convert hydrogen into electricity, thereby reducing greenhouse gas emissions and further minimising the environmental impact of chlor-alkali production.

The following graph illustrates the growth in production of various chemicals in India.

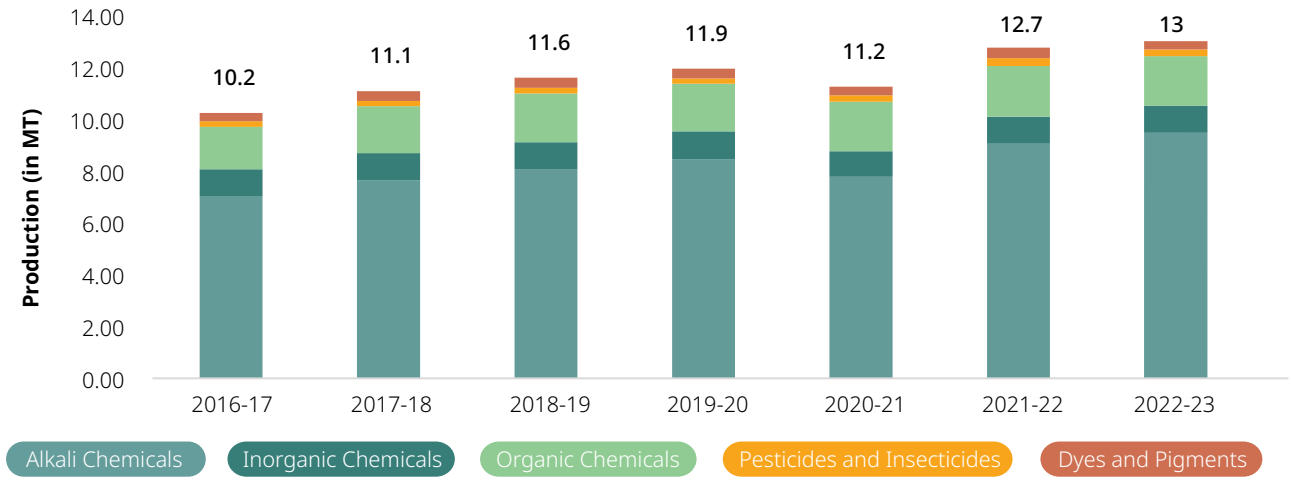


Figure 53: *Major Chemicals Production Trends*

Source: (DCPC a, 2023)

- Alkali chemicals account for around 70 percent of the total major chemicals production. The alkali chemicals include caustic soda, soda ash and liquid chlorine
- The production of alkali chemicals shows a steady increase over the years. This can be attributed to rising industrial demand in sectors like PVC production, water treatment, textile and pharmaceuticals, driven by economic growth
- Inorganic chemicals are essential in industries like glass and ceramics, organic chemicals are crucial to produce plastics and synthetic fibres, pesticides and insecticides support agriculture. It also produces dyes and pigments that are essential for the textile and printing industries. These diverse applications drive a steady demand and production growth.

Fuel consumption in the chlor-alkali industry (As per PAT scheme)

In the chlor-alkali industry, solid fuels, primarily coal and lignite, are crucial, accounts for approximately 95 percent of total thermal energy consumption. Coal is predominantly used for both electricity generation and steam or heat within the chlor-alkali industry. Fuel consumption remained stable from 2021-22 to 2022-23, with a slight increase noticed in electricity consumption during the same period.

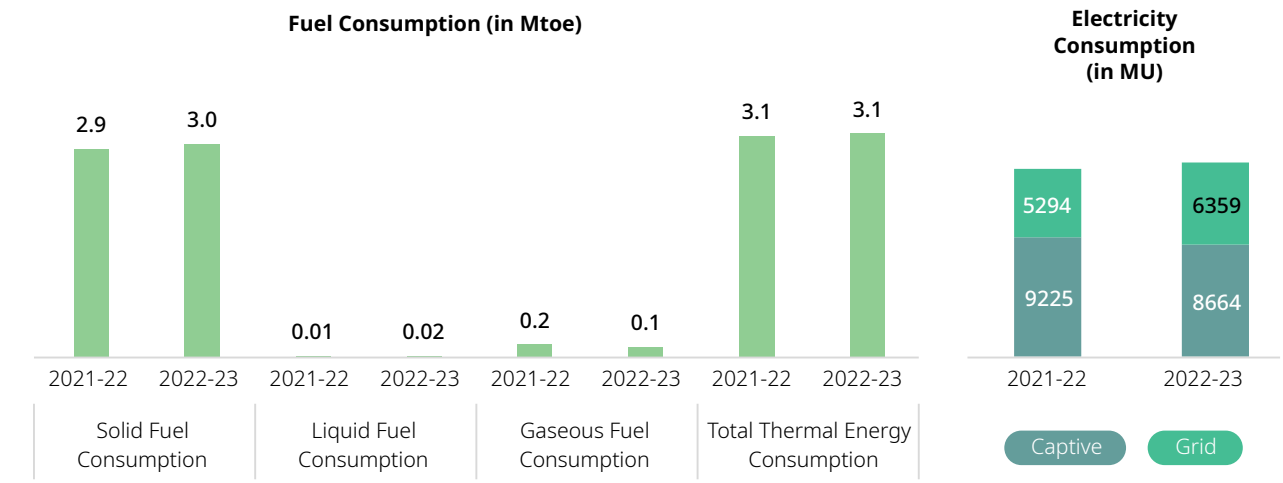


Figure 54: *Fuel and Electricity Consumption within the Chlor-alkali Sector (by 29 DCs)*

In the Chlor-Alkali industry, 99 percent of solid fuels are used in captive power generation and co-generation, ensuring a steady supply of electricity and heat necessary for production. 73 percent of liquid fuels are used in industrial processes, providing the essential energy for chemical reactions and operations. Meanwhile, 20 percent of liquid fuels support cogeneration, 5 percent are used in DG sets and 2 percent are utilised in captive power plants. Regarding gaseous fuels, 76 percent are consumed by gas turbines, while the remaining 24 percent of gaseous fuels are used for process heating.

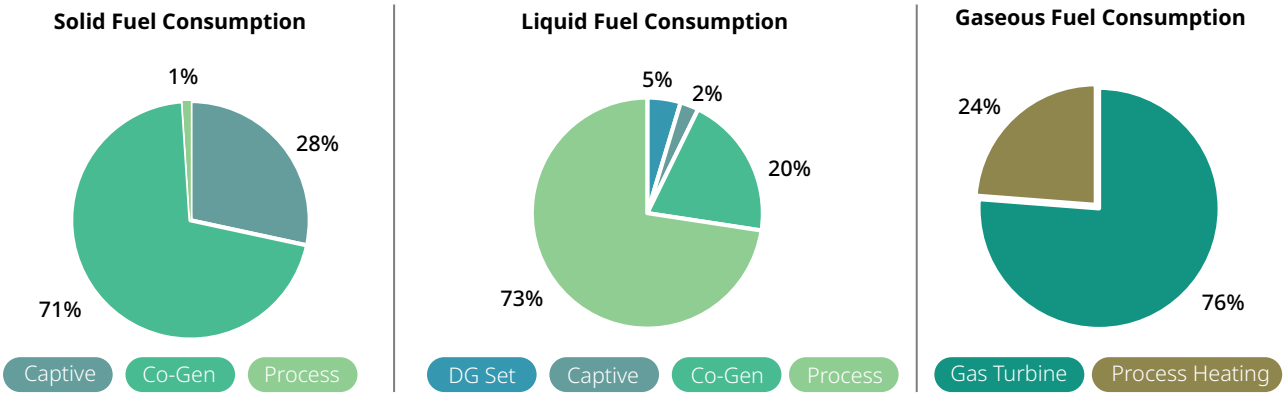


Figure 55: *Distribution of Fuel used in Chlor-Alkali Sector (in 2022-23)*

3.1.5 Fertiliser

Globally, India ranks as the second-largest consumer and third-largest manufacturer of fertilisers. With an impressive total production of around 52 million tonnes (MT) in 2022-23, India's fertiliser industry contributes roughly 20 percent to the global output. The major fertilisers produced in India include Urea, Di-Ammonium Phosphate (DAP) and other complex fertilisers. The fertiliser industry in India plays a significant role in enhancing agricultural output.

The fertiliser industry relies heavily on urea, which constituted 55 percent of total fertiliser production in 2022-23. Urea production is the highest contributor to the emissions from the sector, followed by DAP and other complex fertiliser. The majority of these emissions stem from the use of natural gas in fertiliser production. The fertiliser industry accounts for a substantial 84 percent of natural gas consumption in the industry sector in India, where natural gas serves both as a feedstock and a fuel for urea production. Traditionally, urea production relied on fuel oil and naphtha as primary fuels. However, fertiliser manufacturers are gradually transitioning to a cleaner alternatives.

This transition supports the Government's efforts to reduce energy consumption and lower emissions in the fertiliser industry. Consequently, the fertiliser sector falls under the PAT scheme, with urea plants being the majority of DCs under the PAT scheme. During PAT Cycle-1, the fertiliser industry has surpassed its energy-saving target of 0.478 Mtoe, achieving an impressive total energy saving of 0.78 Mtoe. It marked a remarkable 63 percent achievement over the energy savings targets. Similarly, the New Urea Policy 2015 aims at promoting energy efficiency within urea manufacturing units. This policy establishes specific energy consumption norms for both existing and new urea units, offering rewards to those exceeding prescribed energy efficiency levels.

Additionally, the Government of India has launched the 'National Green Hydrogen Mission' with a budget of Rs. 19744 crores (PIB, Mar, 2023). This mission aims at making India a global hub for green hydrogen production, usage and export. This initiative can facilitate the transition to green hydrogen for ammonia production, a key input for the fertiliser industry, thereby reducing dependence on fossil fuels and lowering emissions from the sector. The adoption of green hydrogen in India's fertiliser industry can ensure food and strengthen agricultural value chains.

The following graph shows the year-on-year production of various fertilisers in India.

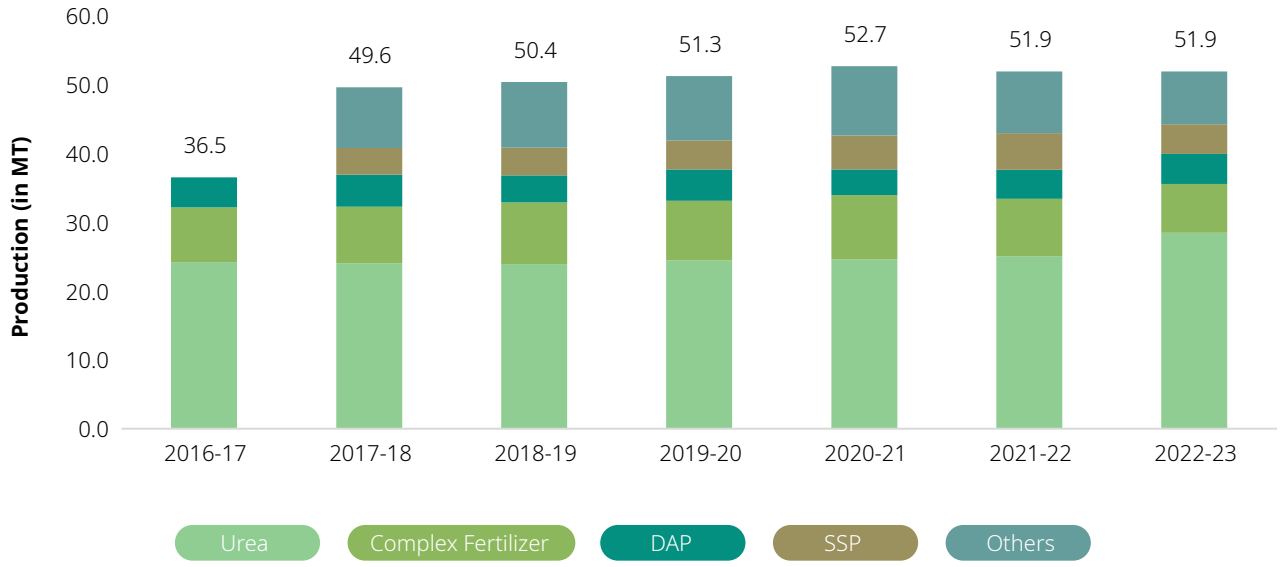


Figure 56: *Fertiliser Production Trends*

Source: (Ministry of Chemicals & Fertilisers, 2023)

- Despite fluctuations in the production of the different type of fertilisers, total fertiliser production has shown an overall upward trend. Production has risen from 36.5 MT in 2016-17 to 52 MT in 2022-23, reflecting a compound annual growth rate of 6 percent
- Urea remains dominant in the fertiliser production landscape due to its crucial role in the industry. From 2016-17 to 2020-21, urea production showed a steady trend, but it increased significantly in 2022-23, rising to 28.5 MT from 25 MT in 2021-22.

Fuel Consumption in the Fertiliser Sector

The production of ammonia is heavily dependent on fossil fuels. Natural gas-based steam reforming and coal gasification form the primary modes of ammonia production. The main feedstocks used for manufacturing urea include natural gas, naphtha and FO. However, the use of naphtha and FO has declined as industries are increasingly shifting towards natural gas-based plants.

Table 12: Consumption of various Energy Products in the Fertiliser Sector (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Coal	2.13	1.88	1.79	1.77	1.53	1.11	0.67	0.80
FO	0.49	0.52	0.46	0.39	0.29	0.34	0.32	0.28
Naphtha	0.35	0.37	0.35	0.15	0.07	0.00	0.00	0.00
HSD	0.01	0.01	0.01	0.01	0.01	0.005	0.004	0.005
LSHS	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.006

Source: (MoC, 2024) and (MoPNG, 2024)

- Overall, there is a clear trend towards reduced consumption of most energy products in the fertiliser sector
- There has been a significant decline in the use of coal in fertiliser industry, from 2.13 MT in 2016-17 to 0.80 MT in 2023-24. Coal based units have been closed due to their lack of economic viability, high specific energy consumption and the deterioration in the quality of coal.

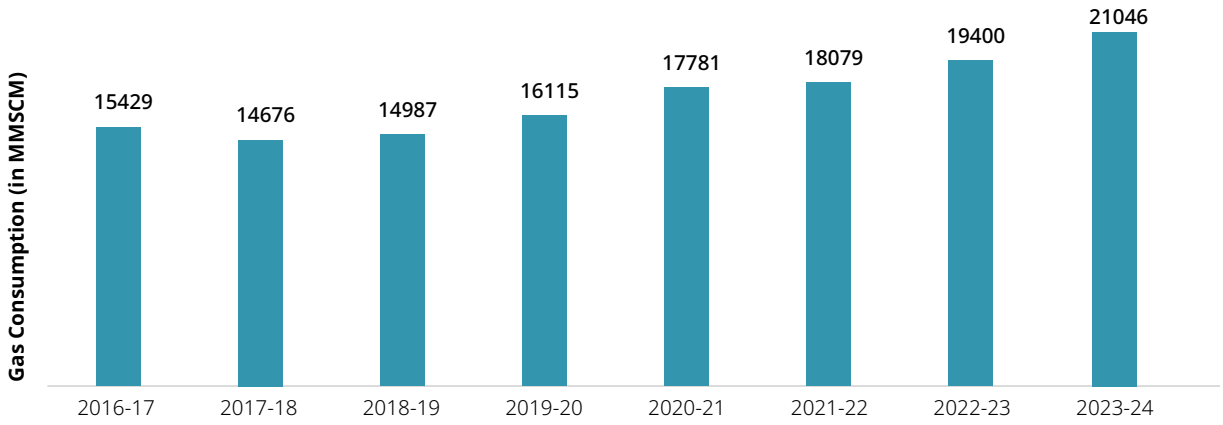


Figure 57: *Natural Gas Consumption in the Fertiliser Sector*

Source: (MoSPI, 2024)

- Natural gas is the most preferred feedstock and fuel for production of fertilisers because it has the highest hydrogen to carbon ratio and provides fertiliser at the least cost
- The consumption of natural gas in the fertiliser sector has shown an upward trend from 2016-17 to 2022-23, increasing from 15429 Million Standard Cubic Metres (MMSCM) to 19400 MMSCM, primarily driven by urea manufacturers transitioning to natural gas for urea production.

Analysis as per PAT scheme

As mentioned above, the fertiliser industry heavily relies on natural gas, utilising it both as a feedstock and fuel. Data gathered from 38 DCs indicates a rise in total thermal energy consumption, increasing from 6.4 Mtoe in 2021-22 to 6.9 Mtoe in 2022-23. Around 90 percent of this consumption constitutes gaseous fuels, predominantly natural gas and LPG.

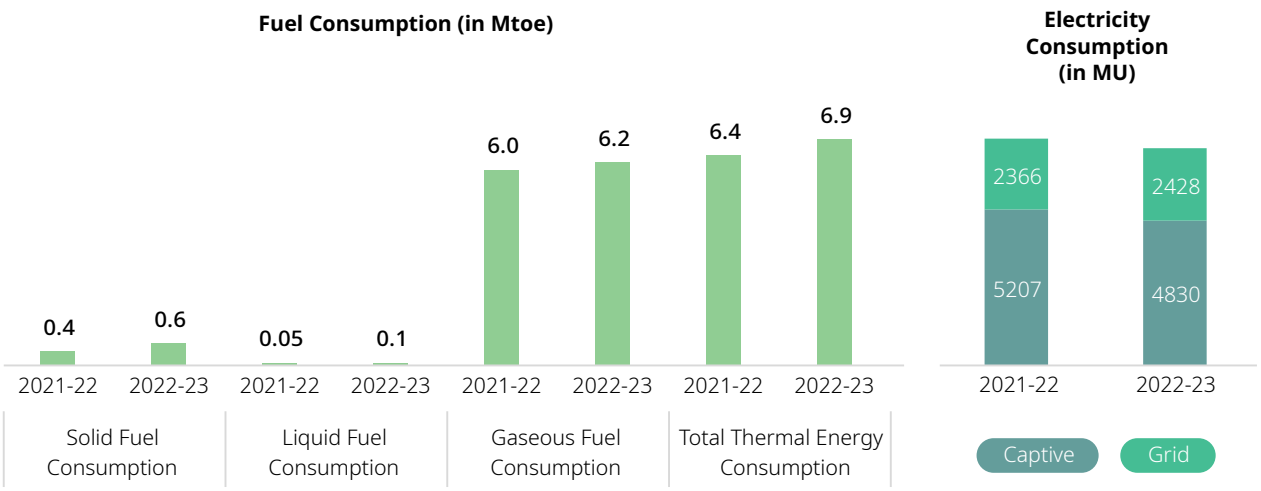


Figure 58: *Fuel and Electricity Consumption within Fertiliser Sector (by 38 DCs)*

The following graph delineates the utilisation of various fuels across different stages within the industry. It indicates that a majority of fuel is used for industrial processes within the fertiliser sector. Specifically, 80 percent of solid fuels, 90 percent of liquid fuels and 73 percent of gaseous fuels are allocated to industrial processes, with the remaining portion of solid and liquid fuels utilised for co-generation and gaseous fuel for gas turbines.

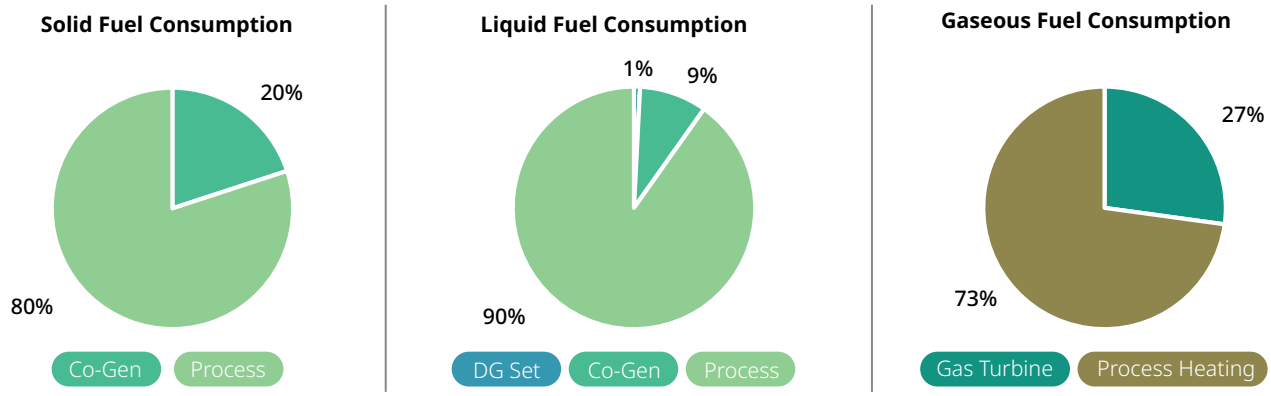


Figure 59: *Distribution of Fuel used in Fertiliser Sector (in 2022-23)*

3.1.6 Petrochemical

India's chemical and petrochemical industry stands as a linchpin of the nation's economic advancement. It has maintained its position as the sixth largest producer of chemicals in the world and the fourth largest in Asia. In the dynamic landscape of global trade, the industry's contribution to India's export and import sectors reached remarkable heights, accounting for approximately 10.5 percent and 11.2 percent respectively in the FY 2022-23 (Ministry of Chemicals & Fertilizers, 2024).

India's chemical and petrochemical industry, valued at 178 billion USD in FY 2020, is expected to grow to 300 billion USD by 2025 (Ministry of Chemicals & Fertilizers, 2022). This growth is driven by the rapidly increasing population and significant technological advancements in the country. The sector is gaining momentum with the support of Government initiatives like 'Make in India' and 'Atmanirbhar Bharat', which provide essential technical support and significant investments to strengthen the industry further. Moreover, strategic policies like the National Petrochemical Policy of 2007, the Hydrocarbon Vision 2030 launched in 2016, and initiatives such as Skill India, 100 percent Foreign Direct Investment

(FDI) in petrochemical industry and the Production Linked Incentive (PLI) Scheme 2021 have collectively ushered in an era of unprecedented growth. This has solidified India's position as a global player in the petrochemical arena.

However, the petrochemical industries are significant energy consumers and major contributors to greenhouse gas emissions. As these industries grow, emissions are expected to rise. In 2019, the chemical sector accounts for 0.5 percent of manufacturing industries and construction sector emissions. The petrochemical sector relies significantly on imported crude oil because the production of most products requires naphtha, making it energy intensive. Ammonia production, an energy-intensive process primarily used in the fertiliser industry, also finds applications in refrigerants and pharmaceuticals. Ethylene and propylene production, crucial for plastics, are also major energy consumers, second only to ammonia production. Improving energy efficiency is essential for reducing greenhouse gas emissions in these industries. The petrochemical sector has been included in PAT Cycle IV (from 2017-18 to 2021-22), mandating emission reductions under the PAT scheme.

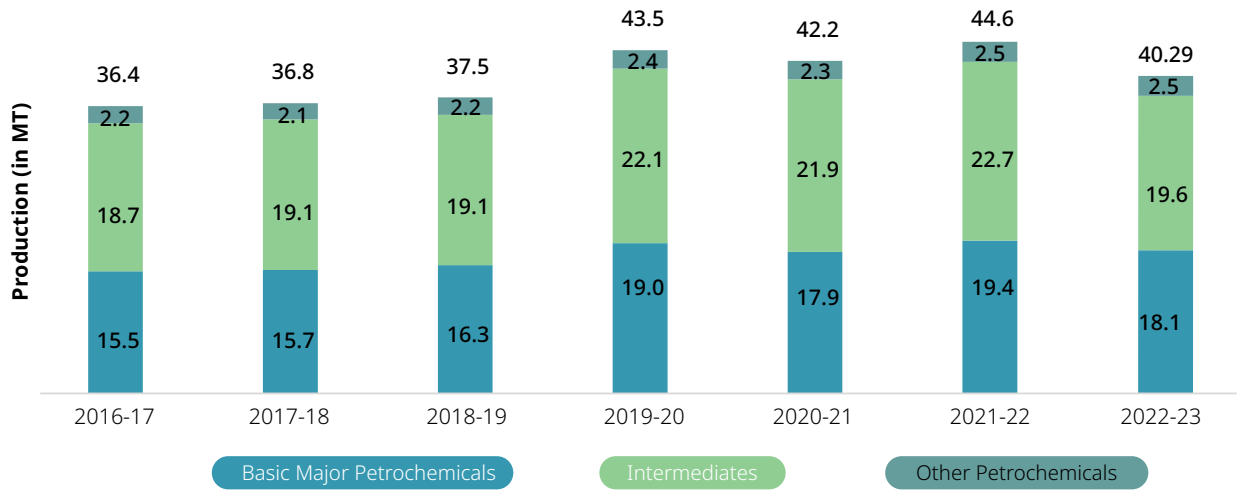


Figure 60: *Production of Different Petrochemicals*

Source: (DCPC a, 2023)

- Petrochemical production showed an upward trend, increasing from 36.4 MT in 2016-17 to 44.6 MT in 2021-22, with a slight dip in 2020-21 due to the COVID-19 pandemic.
- The major petrochemicals include, synthetic fibres, polymers, synthetic rubber, synthetic detergent intermediates and performance plastics. The intermediates comprise fibre intermediate and building blocks.
- Approximately 49 percent of petrochemical production consists of intermediates, including fibre intermediates, olefins, and aromatics, while the remaining 51 percent comprises synthetic fibres, polymers, synthetic rubber, and other petrochemicals.

Fuel Consumption in the Petrochemical Sector

Naphtha is the leading petroleum product consumed in the petrochemical sector. It serves as a crucial feedstock and solvent in the chemical industry, essential for the production of various chemicals, plastics and synthetic fibres. Table 13 illustrates the consumption of various energy products in the petrochemical industry.

Table 13: Consumption of Coal and Petroleum Products in the Petrochemical Sector (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Naphtha	10.21	10.01	10.60	10.87	11.34	11.90	10.43	10.42
Diesel	0.12	0.13	0.14	0.14	0.16	0.13	0.08	0.10
FO	0.24	0.24	0.30	0.24	0.23	0.23	0.20	0.11
LSHS	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01
LPG	0.01	0.01	0.02	0.02	0.04	0.04	0.06	0.17
Coal	0.31	0.27	0.25	0.21	0.16	0.20	0.20	0.20
Lignite	0.20	0.22	0.33	0.30	0.37	0.37	0.99	0.14

Source: (MoC, 2024) and (MoPNG, 2024)

- Diesel consumption, although relatively small, shows an increasing trend before peaking in 2020-21 and then declining sharply in 2022-23.
- LPG usage showed minimal growth over the years; however, it has increased threefold from 2022-23 to 2023-24. LPG is often used as a fuel for heating and energy in chemical processes and sometimes as a feedstock for producing other chemicals.
- Coal consumption in the petrochemical sector is declining, decreasing from 0.31 MT in 2016-17 to 0.20 MT in 2023-24. Meanwhile, lignite consumption increased significantly particularly in 2022-23. Coal and lignite are used for heating and power generation in the petrochemical industry.

Analysis as per PAT scheme

Data from 8 DCs shows a slight increase in fuel consumption from 2016-17 to 2022-23. Gaseous fuel consumption rose from 100.8 GJ in 2016-17 to 105 GJ in 2022-23, while liquid fuel consumption remained steady. Similarly, electricity consumption increased from 25.9 GJ in 2016-17 to 32.7 GJ in 2022-23.

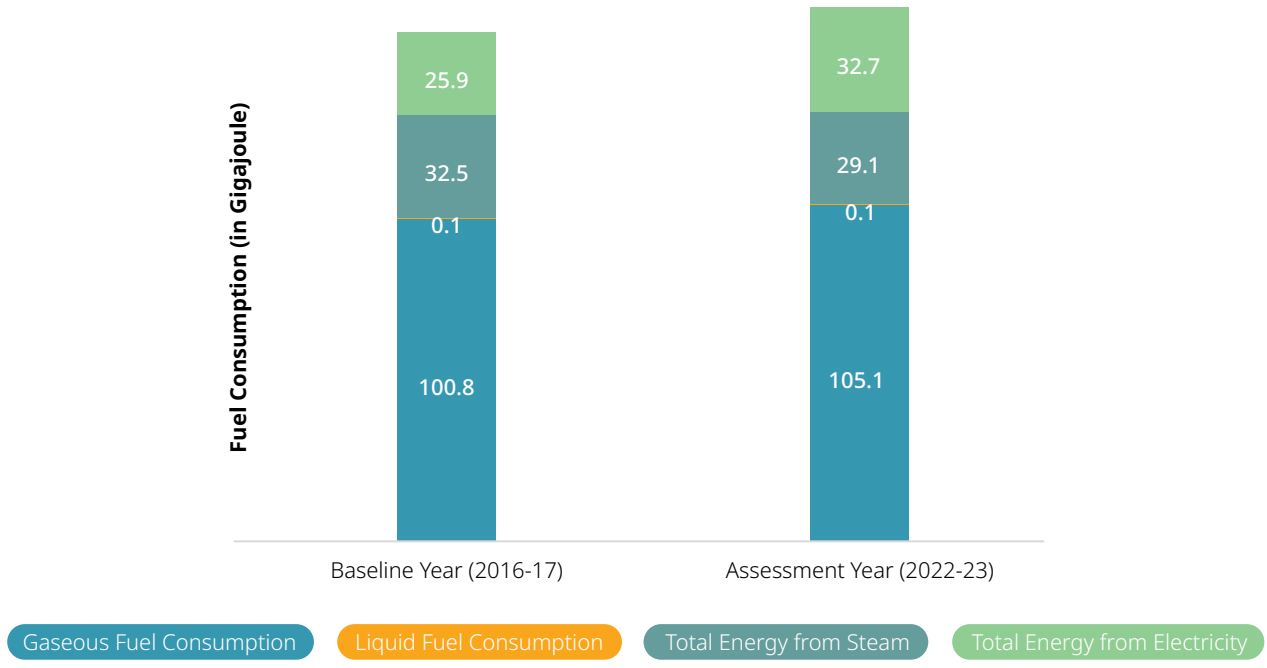


Figure 61: *Fuel Consumption in Petrochemical Industry (by 8 DCs)*

3.1.7 Pulp and Paper

India's paper industry, is an important contributor in the global paper production, constituting to about 3.7 percent to the total output. In the fiscal year 2021-22, the industry produced 22.4 million tonnes of pulp and paper, with approximately 7-8 percent of this production exported. India has over 850 paper mills nationwide, producing a wide variety of paper products. The industry employs more than 0.5 million people directly and 1.5 million people indirectly (BEE c, 2028).

The Minister of Finance and Corporate Affairs announced during the Union Budget 2023-24 that the Government will allocate funds to facilitate the implementation of policies promoting agro- and commercial forestry. This initiative, introduced by the Government of India in the Union Budget 2022-23 to encourage agro-forestry, is expected to boost the paper industry by ensuring stability in its raw material supply and contributing to the expansion of green cover nationwide.

The paper industry in India is classified based on raw materials into wood-based, agro-based and waste paper categories, with waste paper being the largest contributor to total production, followed by wood-based and agro-based. Additionally, the industry is categorised by paper grades, including Writing & Printing, Industrial Packaging, and Newsprint & Paperboard.

The pulp and paper industry is one of the most energy intensive and polluting sectors. The average emission intensity for the Indian pulp and paper industry is 1.58 $MTCO_2e$ per metric ton of paper. Wood and agro-based mills are major consumers of coal for steam and power generation. In contrast, medium-scale agro-based mills rely on locally available biomass fuels such as bagasse, firewood chips, wood dust and husk for steam generation.

The modernisation of paper mills is crucial for improving the quality of paper production. It is also significant in reducing environmental impact through the adoption of energy-efficient technologies. The BEE has identified a range of energy-efficient technologies with the potential to save energy, including those applicable to the paper and pulp industry. Under the PAT scheme, a total of 48 DCs have been notified till PAT Cycle VII (from 2021-22 to 2024-25).

The graph illustrates the trends in production of paper, paperboard and newsprint from 2016-17 to 2021-22. During this period, production rose steadily from 16.9 million tons to 22.4 million tons, indicating a consistent upward trajectory over the years.

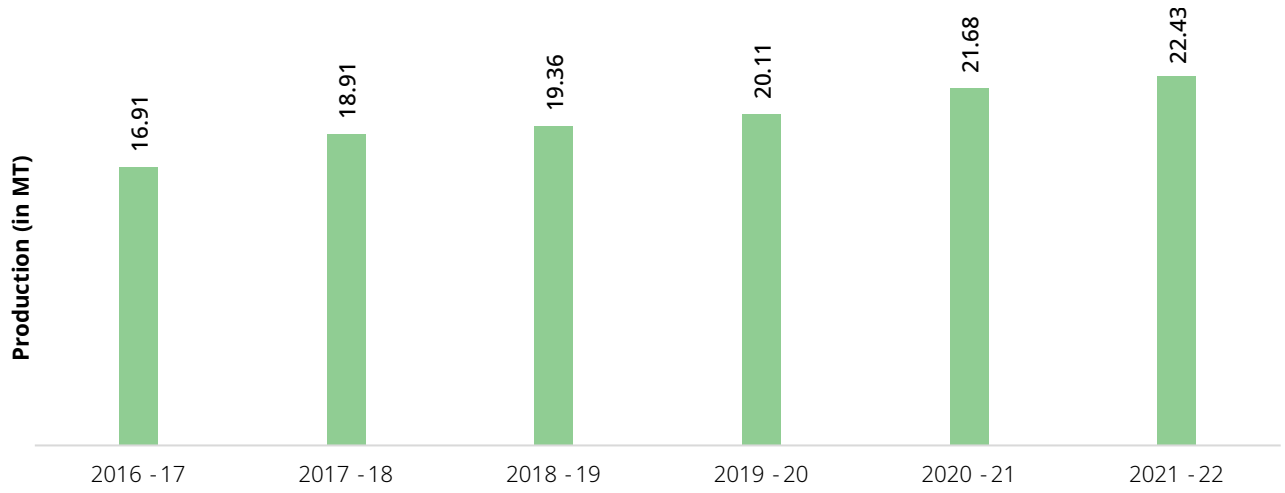


Figure 62: *Trends of Production in Paper, Paperboard and Newsprint*

Source: (CPPRI, 2022)

Fuel Consumption in the Pulp and Paper Sector

The graph below illustrates the trends in consumption of coal and lignite in the pulp and paper industry. This industry primarily relies on coal and lignite for steam and power generation. The consumption of coal increased steadily until 2018-19, followed by a decline in 2019-20 and 2020-21, likely due to the impact of COVID-19, before showing an upward trend again. Overall, the consumption of lignite shows a fluctuating pattern, with a significant surge observed in 2021-22.

Table 14: Coal and Lignite Consumption in the Pulp and Paper Industry (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Coal	1.18	1.51	1.64	1.33	1.05	1.24	1.20	1.03
Lignite	0.53	0.76	0.60	0.55	0.57	2.11	0.92	1.04

Source: (MoPNG, 2024) and for 2023-24 (MoC, 2024)

Analysis as per PAT scheme

Within the pulp and paper industry, large wood and agro-based mills are one of the major consumers of coal for steam and power generation. The medium-scale agro-based mills rely on locally available biomass for steam generation. The graph below clearly shows that the pulp and paper industry is heavily reliant on solid fuels, with minimal use of liquid and gaseous fuels. The consumption of solid fuels in these 16 DCs increased from 0.8 Mtoe in 2021-22 to 1.3 Mtoe in 2022-23, while the minimal consumption of liquid fuels remained constant. The electricity consumption in these DCs has increased from 2792 MU in 2021-22 to 4403 MU in 2022-23, with most of the electricity coming from captive power plants.

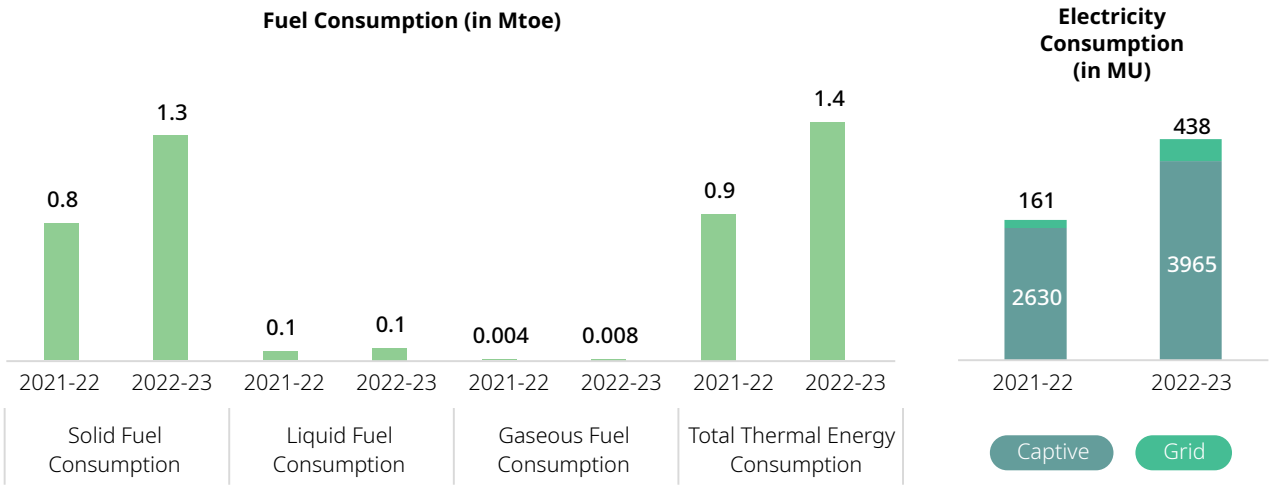


Figure 63: *Fuel and Electricity Consumption within the Pulp and Paper Sector (by 16 DCs)*

In the pulp and paper industry, 91 percent of solid fuels are used for cogeneration, providing both steam and power, while 9 percent are utilised for industrial processes. Among liquid fuels, 97 percent are used in processes, with the remaining portion being utilised in DG sets and Co-generation. Gaseous fuels are exclusively used for process heating, with 100 percent dedication to this purpose.

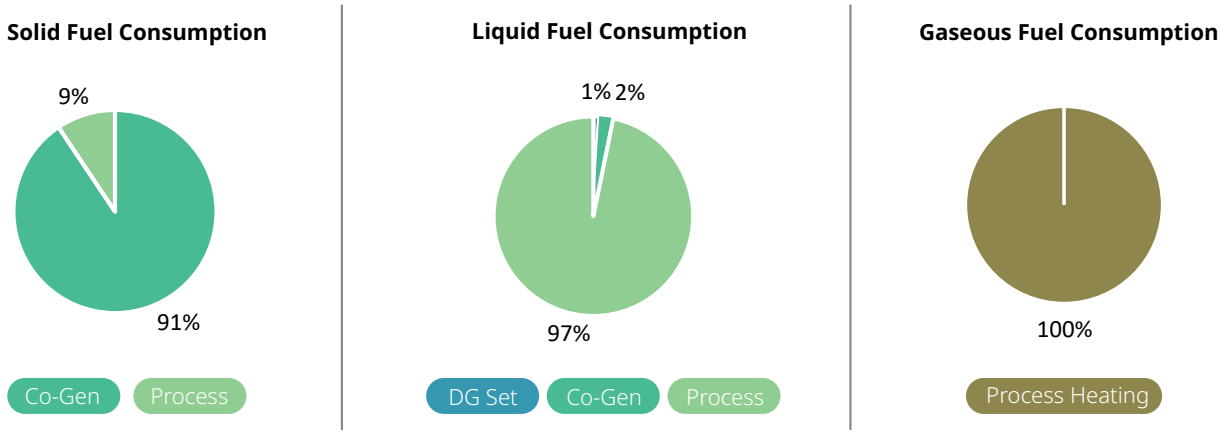


Figure 64: *Distribution of Fuel Used in the Pulp and Paper Sector (in 2022-23)*

3.1.8 Textile

India's significance in the global textile landscape is undeniable. The textiles and apparel industry contributes 2.3 percent to the country's GDP, 13 percent to industrial production and 12 percent to exports. India is the third largest exporter of textile and apparel in the world with a 4.6 percent share in global trade. This is expected to grow by a compound 10 percent annually from $165 billion in 2022 to reach $350 billion by 2030 (Rathee, 2024). The textile sector employs approx. 45 million people directly and another 60 million through allied sectors (Department of Textiles, 2023), making it one of the largest sources of employment in the country.

The Ministry of Textile, Government of India, has consistently introduced and endorsed various programmes and schemes to revamp and modernise the textile industry, playing a key role in shaping its trajectory. These efforts drive sustainable growth, foster technological advancements, and mitigate environmental impact. Initiatives like the Technology Upgradation Fund Scheme (TUFS) incentivise technological modernisation and adoption of energy-efficient machinery, significantly reducing carbon emissions. The scheme disbursed Rs 15,909 crore from 1999-2000 to 2012-13 and Rs 8714.45 crore under Amended TUFS (ATUFS) from 2015-16 to 2022-23, incentivising 1117 energy-saving machines (Parliament LARRDIS, 2014). Additionally, initiatives like the Sustainable and Accelerated Adoption of efficient Textile Technologies to Help Small Industries (SAATHI), promote energy-efficient technologies, replacing old electric motors with IE3 motors, saving 10-15 percent in energy costs (PIB, Aug, 2018). Further, under the PAT scheme, BEE has notified a total of 168 DCs till PAT Cycle VII (from 2021-22 to 2024-25) and has achieved substantial energy savings targets. Furthermore, the BEE-GEF-UNIDO Programme focuses on promoting energy-efficient and renewable energy technologies in MSME clusters, including those in the textile sector, contributing to environmental sustainability. The project has been able to implement around 33 EE/ RE projects with energy savings of 213 toe and reduced CO_2 emissions of 1390 tonnes and achieved co-financing investment from MSME's INR 8.73 crores (BEE, Dec, 2023). Additional schemes like the Production Linked Incentive (PLI), Textile Cluster Development Scheme (TCDS), and Integrated Processing Development Scheme (IPDS) incentivise production and eco-friendly practices, further bolstering India's textile sector.

In terms of textile production, India boasts a strong manufacturing base for cotton, manmade fibres, and blended yarns. The country ranks at the second largest producer of cotton, silk, and manmade fibres globally. In the fiscal year 2022-23, India's textile output included 5.7 million tonnes of cotton, 2.2 million tonnes of manmade fibre and 1.6 million tonnes of jute. India's cotton production is forecasted to reach 7.2 million tonnes (approximately 43 million bales of 170 kg each) by 2030, driven by increasing consumer demand. The following graph illustrates India's textile production trends over the years.

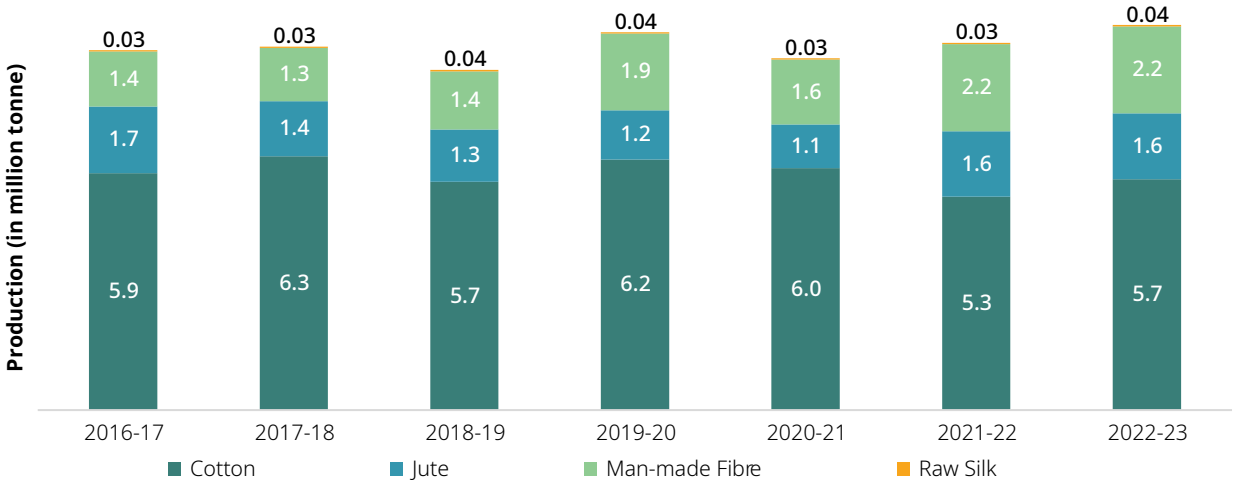


Figure 65: *India's Textile Production Trends*

Source: (Ministry of Textile, 2024)

- Cotton is India's most produced textile product, followed by man-made fibre and jute. Man-made fibre surpassed jute production from 2018-19 onwards
- The production of cotton, jute, and raw silk remains stable overall with slight increases or decreases over the years
- However, the production of manmade fibre has steadily increased over the years. Its share in total fibre production rose from 15 percent in 2016-17 to 23 percent in 2022-23 and is expected to continue increasing to meet rising demand.

Fuel Consumption in the Textile Sector

The textile industry depends significantly on fossil fuels for its energy needs. Coal is primarily used to power boilers and to support essential processes like dyeing and printing. In addition to this, diesel is predominantly used to operate generators within the industry.

Table 15: Consumption of Coal and Petroleum Products in the Textile Sector (in MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
Coal	0.24	0.24	0.20	0.10	0.08	0.08	0.09	0.17
Lignite	1.29	2.46	2.61	0.16	0.29	2.08	2.62	0.99
Diesel	0.04	0.19	0.26	0.27	0.27	0.24	0.13	0.01
FO	0.07	0.05	0.05	0.04	0.04	0.03	0.01	0.01
LPG	0.002	0.002	0.002	0.003	0.002	0.002	0.001	0.002
LSHS			0.003	0.003	0.004	0.007	0.010	0.010

Source: (MoC, 2024) and (MoPNG, 2024)

- The textile sector primarily relies on coal and lignite as major fuels, with coal consumption shows a declining trend in recent years
- Lignite is the most extensively used fuel in the textile industry. Its consumption declined during 2019-20 and 2020-21, possibly due to the impact of COVID-19, but returned to previous levels from 2021-22 onwards

- Overall, petroleum product consumption in the textile industry has been decreasing. Diesel, however, reached its peak during the periods of 2019–20 and 2020-21.

Analysis as per PAT scheme

The graph below illustrates the fuel consumption trends in the textile sector across 68 DCs. It shows a significant 52 percent reduction in solid fuel consumption, declining from 0.7 Mtoe in 2021-22 to 0.34 Mtoe in 2022-23. In contrast, electricity consumption increased by 32 percent over the same period, driven largely by its use in spinning and processing within the textile sector. Liquid fuel usage remained minimal and declined, while gaseous fuel consumption increased.

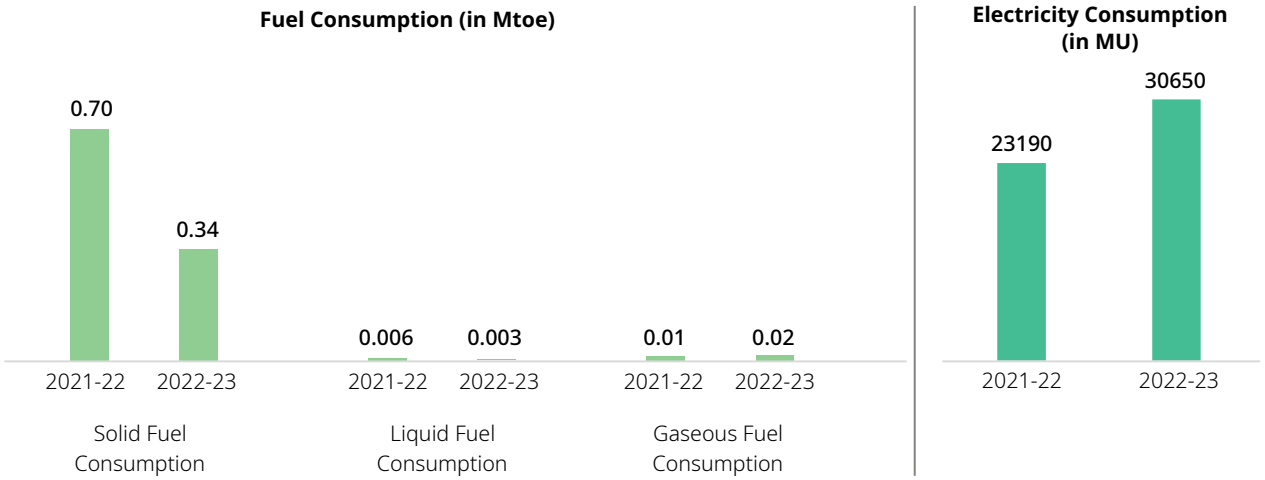


Figure 66: *Fuel and Electricity Consumption within the Textile Sector (by 68 DCs)*

Data from 68 DCs shows that 62 percent of solid fuel, primarily coal, is utilised in processes such as printing and dyeing, while the remaining 38 percent serves co-generation purposes. For liquid fuel, mainly diesel, 61 percent is allocated to DG sets, with an additional 39 percent dedicated to industrial processes. All gaseous fuels are exclusively directed towards process heating in the textile sector.

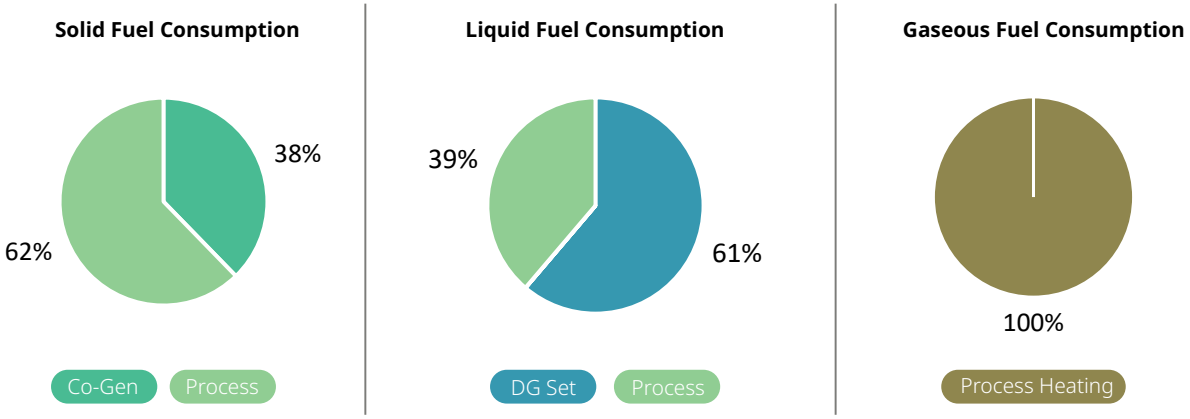


Figure 67: *Distribution of Fuel used in the Textile Sector (in 2022-23)*

3.2 Buildings

The World Population Review database suggested that India surpassed China in March 2023 to become the highest populated country in the world. India's burgeoning population and rapid urbanisation necessitate a balance between housing, infrastructure development and climate goals. Hence, the building sector, a significant contributor to emissions, emerges as a critical area for intervention. The evolving demographic landscape of India can be seen from the rising urban population and the decrease in rural population over the years. From 31 percent in 2011 (Census India, 2011) to an estimated 35 percent in 2023, the upward trajectory of India's urban population is evident. Projections suggest that this trend will continue, with the urban population expected to reach 38 percent by 2036 (MoH&FW, 2020). As a result of increasing population, economic growth and rapid urbanisation, the demand for buildings—both residential and commercial—is increasing across the country. It significantly contributes to the nation's high energy demand.

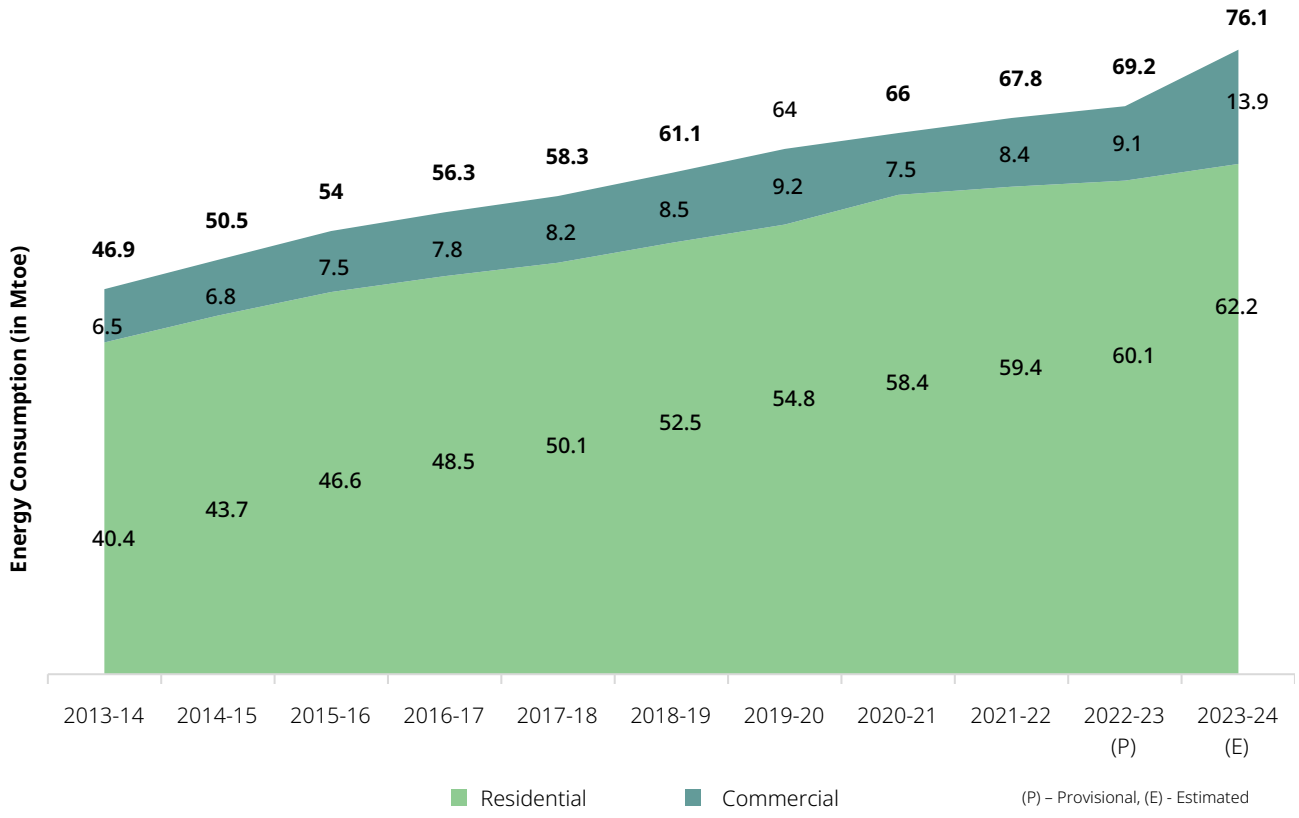


Figure 68: *Final Energy Consumption in the Buildings*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

Further, the expansion of urban areas and peri-urban areas and the construction of pucca houses in rural India is also contributing towards the rising household energy needs. The average floor area of residential buildings in 2020-21 for rural areas was 50.5 square metres while for urban areas it was 64.5 square metres, with an all-India average standing at 54.2 square metres.(MoSPI, Mar, 2023)

On the other hand, the total floor area of all commercial buildings in 2017 was estimated to be 1.1 billion square metres with projections to reach an estimated 1.78 billion square metres by 2027 (Kumar et al., 2018,). The building sector accounts for 13 percent of total energy consumption in 2023-24, with a steady growth at 5 percent each year.

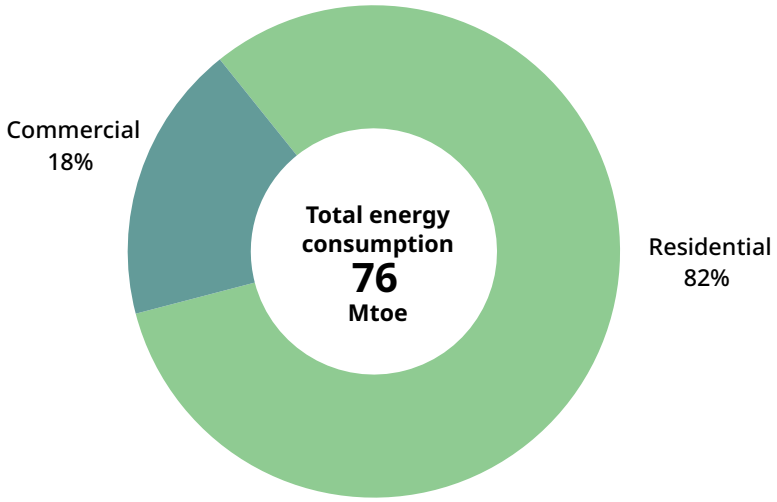


Figure 69: *Total Energy Consumption in Buildings in 2023-24 (Estimated)*

Source: The figures are calculated based on actual data from various ministries

Residential energy consumption accounted for 82 percent of the total, while commercial energy consumption comprised 18 percent (refer to Figure 69). The building sector's energy demand primarily comes from electricity used for lighting, cooling, heating, and cooking. By 2032, electricity demand in residential and commercial buildings is projected to increase fivefold and threefold, respectively (Puducherry Climate Change Cell, 2022). A significant portion of this rising demand will stem from the growing need for space cooling.

Key Policy Interventions in Building Sector

Passive policy measures:

- **Energy Conservation and Sustainable Building Code (ECSBC):** India has taken a major step in 2024 toward a greener future with the introduction of two new building codes: the Energy Conservation and Sustainable Building Code (ECSBC) for commercial buildings and the Eco Niwas Samhita (ENS) for residential buildings. The revised codes apply to large commercial buildings and multi-storied residential complexes with a connected electricity load of 100 kW or more, which means the codes will impact big offices, shopping malls, and apartment buildings and will help in reduction of 18 percent electricity consumption. Additionally, it incorporates sustainability features related to natural cooling, ventilation, water, and wastewater disposal. States may adopt these building codes.
- To widen the scope of the Building Labelling Programme based on Energy Consumption, BEE introduced a Labeling programme for Net Zero Energy Buildings (NZEB) and Net Positive Energy Buildings (NPEB). The programme is named as "Shunya" Labelling Programme. Shunya is the Hindi meaning of Zero (0) thus making it suitable to label the NZEB and NPEB buildings as Shunya.

Active policy measures:

- To reduce electricity demand through use of energy efficient appliances, BEE launched the Standards and Labelling (S&L) program in 2006 under the Energy Conservation (EC) Act, 2001 aims to enhance energy efficiency in residential, commercial, and industrial appliances, particularly in cooling and refrigeration equipment. The S&L program mandates affixing of star label on appliances in accordance with the provisions of EC Act. BEE revises energy performance standards periodically to keep pace with technological advancements and market trends. Consequently, product label information is updated, and star ratings, ranging from 1 to 5, are assigned based on energy efficiency. The star rating plan is reviewed every two years or before the label's validity period expires, whichever comes first. As on

November 2024, the program covers 39 appliances, with 16 appliances under mandatory regime of labelling and 23 appliances under voluntary regime of labelling. Through S&L program, electricity savings of 89.84 billion units (BU) were achieved during FY 2023-24.

- To evaluate the impact of the S&L programme, it is essential to capture production data for the registered appliances. Under the programme, manufacturers are required to submit production data for each product to BEE either quarterly or annually, with penalties for non-compliance. As of November 2024, BEE has registered a total of 3553 brands and 28,320 models across various appliance categories. The total production for all appliances under the programme was 549 million units for 2023-24, compared to 567 million units for 2022-23.
- Indian Initiatives like **SAUBHAGYA and Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)** aims at providing electricity to all homes. 99 percent of households have been electrified under SAUBHAGYA (Ministry of Power, 2024). The **UJALA (Unnat Jyoti by Affordable LEDs for All)** scheme promotes affordable energy-efficient appliances like light-emitting diode bulbs, tube lights and fans. The program achieved remarkable success, saving 47.8 billion units of energy and reducing carbon dioxide emissions by 38.78 $MTCO_2$ each year.
- As the number of buildings continue to rise, energy consumption is expected to rise significantly. This rise in the building sector is influenced by the various national missions, such as the **Pradhan Mantri Awas Yojana (PMAY), which aims to provide 'housing for all'. As of 8th July 2024, under PMAY, 8.4 million houses have been completed in urban areas** (Ministry of House & Urban Affairs, 2024), **while 5.7 million houses were completed in 2022-23, in the rural area** (Ministry of Rural Development, 2024). Furthermore, the Government recently announced plans to construct an additional 30 million houses in both rural and urban areas under the PMAY (PIB, Jun, 2024). Initiated in 2015, the **Smart Cities Mission** aims to develop 100 cities with advanced infrastructure and governance, including expanding housing opportunities for all.

Building Sector: Residential and Commercial Buildings

The section is divided into two sub-sections: residential and commercial buildings. Each sub-section analyses energy consumption trends, considering both fuel and electricity usage in these building categories.

The combined residential and commercial building sector in India accounts for 32 percent of the total electricity consumption. Projections suggest a substantial increase in electricity demand, expected to increase from 421 terawatt-hours (TWh) in 2022 to 2,421 TWh by 2047 (IESS, 2023). It is anticipated that buildings will contribute to 55 percent of the total electricity demand in the country by that year.

Details of the national electricity consumption including the share of commercial and domestic buildings sectors are presented in the Figure 70. Out of the total consumption of electricity in 2023-24 (P), industry sector accounted for the largest share (42 percent), followed by domestic (24 percent), agriculture (17 percent) and commercial sectors (8 percent).

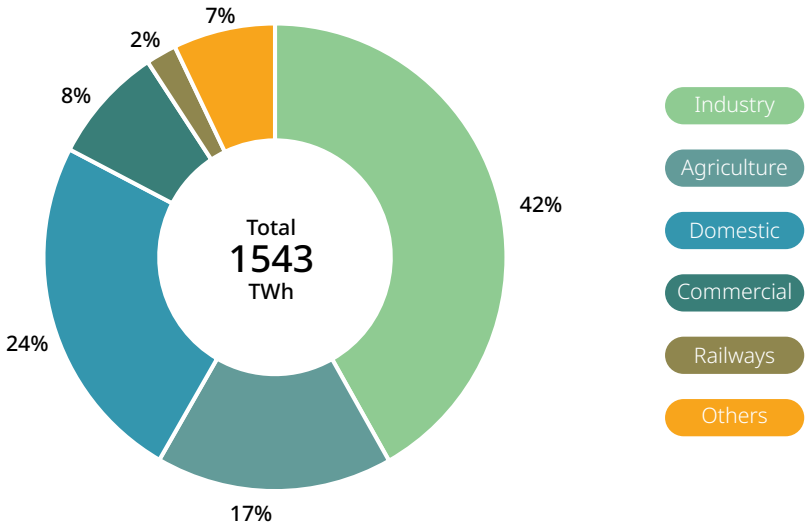


Figure 70: *Sector-wise Electricity Consumption in 2023-24*

Source: CEA f. (2024)

Residential Buildings

The residential building sector of India is one of the fastest growing sectors. The energy consumption from residential buildings is predicted to rise by more than eight times by 2050 under the business-as-usual scenario. The surge in energy consumption can be attributed to population growth and urbanization, leading to a significant disparity between the escalating demand and the constrained supply of electricity. The increasing demand for electricity is primarily driven by shifts in living standards and a heightened reliance on achieving thermal comfort affordably.

Commercial Buildings

In general, approximately 8-9 percent of the total electricity consumption is attributed to commercial buildings, encompassing offices, hospitals, hotels, retail outlets, educational buildings, Government offices, and more. The collective built-up area of commercial buildings is projected to reach 1.9 billion square meters by 2030. With one of the highest growth rates in the sector, it becomes imperative to regulate and optimize energy consumption in commercial buildings to ensure sustainable development.

3.2.1 Residential Buildings

In the household sector, energy is primarily consumed for lighting, cooking, space cooling and powering electrical appliances. The most common energy sources include electricity, LPG, solid biomass, biogas and kerosene. Electricity and LPG remain the main sources of energy for households in India.

Fuel Usage in Residential Buildings In India, many households continue to rely on solid fuels such as firewood, dung cakes, coal and agricultural residues for cooking. As of 2020-21, around 34 percent of households are still dependent on firewood, chips and crop residue as their primary cooking energy source (MoSPI, Mar, 2023). This reliance varied significantly between rural and urban areas: around 47 percent of rural households used firewood for cooking, compared to only 6.5 percent of urban households (MoSPI, Mar, 2023). In rural India, firewood and chips were the primary cooking energy sources for over 76.3 percent of households in 2009-10 (MoSPI, Sept, 2012). It significantly reduced to 47 percent in 2020-21.

Recognising the severe health impacts associated with burning of traditional fuels, India has actively worked in transitioning to clean cooking fuels and has made notable progress over the years. The **Pradhan**

Mantri Ujjwala Yojana (PMUY) (2016): The scheme set a target of releasing 80 million LPG connections by 2020 (Achieved in March 2020). In 2021, Ujjwala 2.0 was introduced to provide 10 million deposit-free LPG connections for the remaining families (Achieved in Dec 2022). By 1st Sep 2024, the total number of connections under PMUY had reached 103.3 million. Moreover, the Government raised fuel subsidies to ₹300 per 14.2 kg cylinder for 12 refills annually for affordability (w.e.f. 4th Oct 2023). This initiative increased the number of active domestic LPG consumers from 145.2 million in April 2014 to 327.7 million as on 1st Sept 2024, significantly boosting the use of clean cooking fuel nationwide.

By 2020-21, approximately 49.8 percent of rural households and about 92 percent of urban households used clean fuels for cooking. Clean fuels include LPG, PNG, gobar gas, biogas, electricity (including solar or wind-generated) and solar cookers. Overall, 62 percent of households across India used LPG as their primary cooking fuel. In urban areas, LPG was the primary cooking fuel for 89 percent of households, while in rural areas, around 49 percent of households relied on LPG. In 2020-21, Chhattisgarh recorded the lowest usage of LPG as the primary cooking fuel among all states in India, with only 30.6 percent of households adopting it. Conversely, Chandigarh, Telangana and Puducherry reported some of the highest percentages of households using LPG for cooking (MoSPI, Mar, 2023).

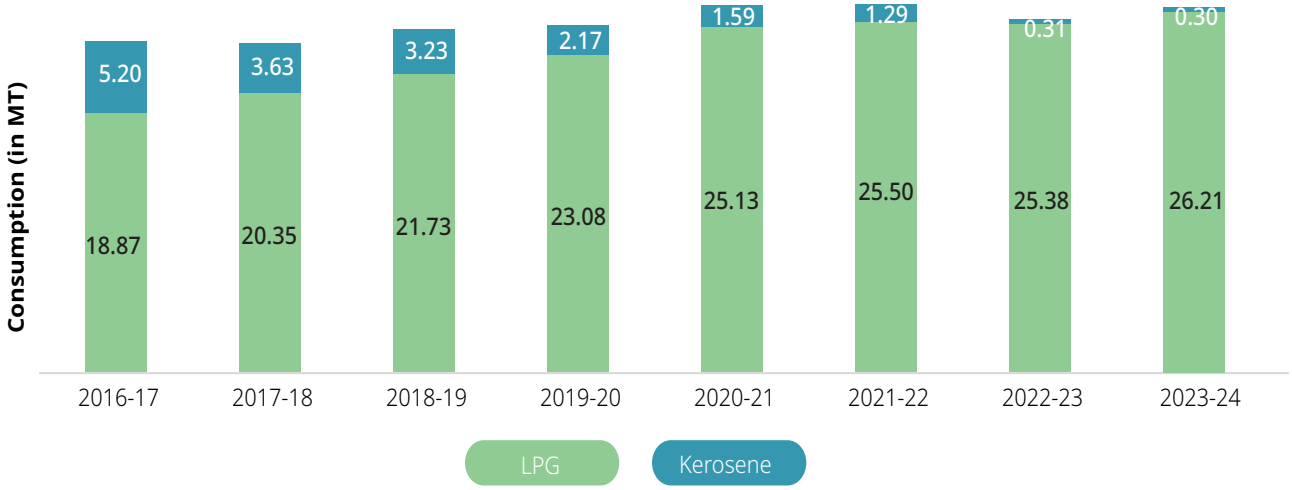


Figure 71: *LPG and Kerosene Consumption in Residential Sector*

Source: (MoPNG, 2024)

Figure 71 shows that LPG consumption has been on an increasing trend since 2016-17, whereas the consumption of kerosene has declined during the same period. The LPG consumption in the households increased by 39 percent between 2016-17 to 2023-24. The decrease in kerosene usage can be attributed to its gradual replacement by LPG and electricity, driven by the schemes like PMUY and Saubhagya, along with 'Go Electric' Campaign and the National Efficient Cooking Programme. These schemes promoted electric cooking appliances like induction cooktops and electric pressure cookers.

Electricity consumption in residential buildings

Residential buildings are one of the major consumers of electricity in India. In 2023-24, the residential buildings accounted for 24 percent (375 TWh) of total electricity consumption, (refer to Figure 72). With India's initiatives to provide electricity to all homes, 99 percent of households have been electrified (Ministry of Power, 2024).

Households rely on electricity for cooking, heating, cooling, lighting and powering electrical appliances. The increasing ownership of appliances in Indian households has further boosted electricity demand, as people turn to electrical appliances for work, education and comfort.

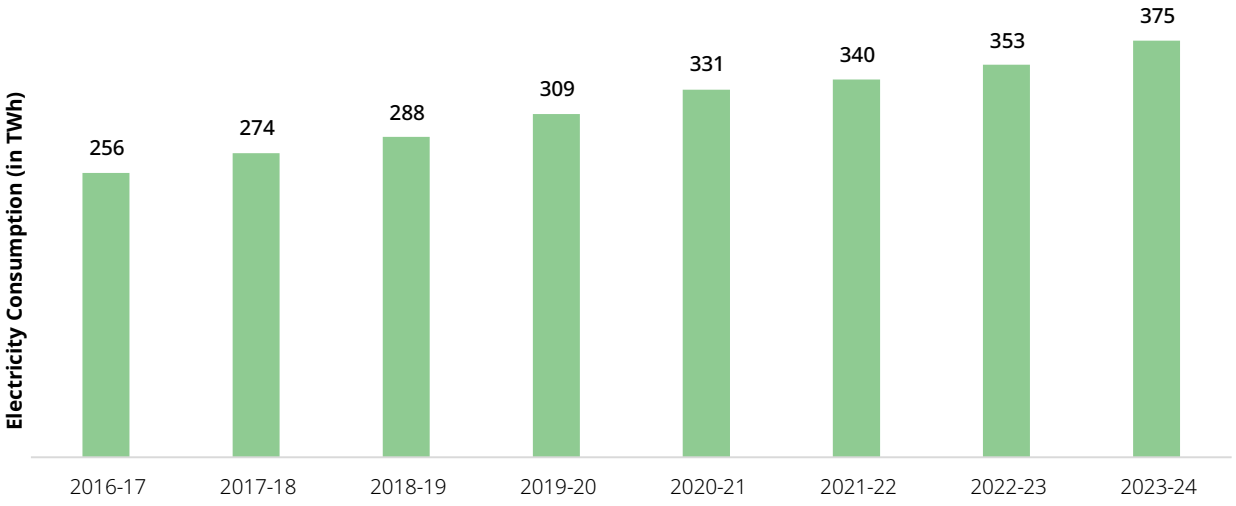


Figure 72: *Electricity Consumption in the Residential Sector*

Source: CEA f. (2024)

- The overall electricity consumption in the household sector has risen by 46.5 percent from the FY 2016-17 to FY 2023-24.
- An increase in energy consumption during 2020-21 can be attributed to the pandemic, which led to a rise in appliance usage while 'working from home', including air conditioners, lights, laptops, and other electronic devices.

State Insights on Residential Electricity Consumption

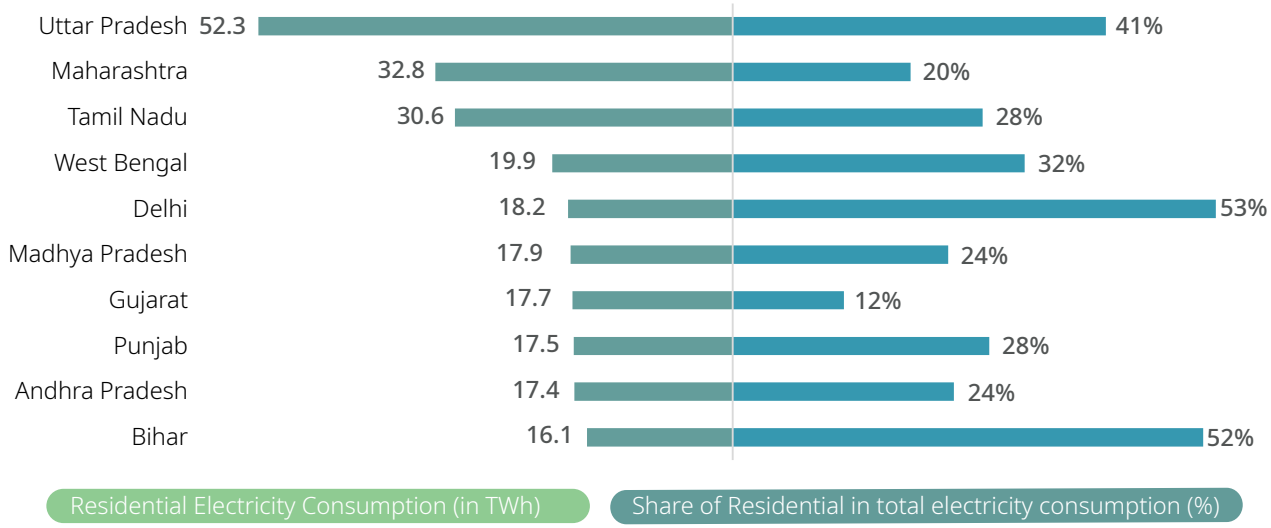


Figure 73: *Top 10 states with highest Residential Electricity Consumption in 2022-23*

Source: (CEA d, 2024)

- Uttar Pradesh has the highest residential electricity consumption at 52.3 TWh (41 percent share), indicating a significant household demand for electricity
- Tamil Nadu (30.6 TWh, 28 percent) and Maharashtra (32.8 TWh, 20 percent) also show substantial residential electricity consumption, though Maharashtra's lower percentage share suggests commercial and industrial electricity usage
- Bihar (16.1 TWh, 52 percent) and Delhi (18.2 TWh, 53 percent) exhibit high residential shares, reflecting predominant household usage. In contrast, Gujarat (17.7 TWh, 12 percent) demonstrates strong industrial demand.

Heat waves and increasing ambient temperature drive the Space cooling needs in buildings

Increasing buildings and floor space nationwide, along with changing climate patterns like higher temperatures and intense heat waves, are expected to increase India's demand for cooling. 57 percent of India's cooling energy demand emerges from buildings (Kumar et al., Oct, 2018). Cooling produces 7 percent of global GHG emissions, and this is expected to double by 2050. By that time, India will account for 30 percent of global emissions from space cooling, up from 8 percent in 2016. (IEA, 2018)

India's Cooling Action Plan (ICAP) is laid down over 20-year time horizon i.e. from 2017-18 to 2037-38 to meet the rising demand. It will also assist nation in meeting the broader goals listed below:

(i) Reduction of cooling energy requirement by 25 percent to 40 percent

(ii) Reduction of cooling demand by 20 percent to 25 percent

Room air conditioners are widely used in residential buildings, constituting the dominant share of the sector's cooling energy consumption – around 40 percent in 2017-18 and growing to around 50 percent in 2037-38. Once considered a luxury in India, air conditioners have increasingly become a necessity in recent years. However, only about 8 percent of households have room air conditioners in 2017-18. This figure is expected to increase to 21 percent by 2027-28 and 40 percent by 2037-38 (MoEFCC, Mar, 2019).

Despite residential sectors using more electricity overall, commercial buildings have a higher demand for air conditioning. Commercial buildings, like hotels, hospitals, malls, offices and airports, rely on chiller systems, packaged direct expansion and variable refrigerant flow systems for cooling.

AC sales increased from 8.4 million in 2021-22 to 10.9 million in 2023-24. This reflects a growing market with a notable preference for 3 Star units (refer to Figure 74). Higher-rated air conditioners are growing, but middle-tier units dominate the market, possibly due to cost considerations. The detailed production data for appliances, categorised by star ratings, can be found in Annexure - Table V.

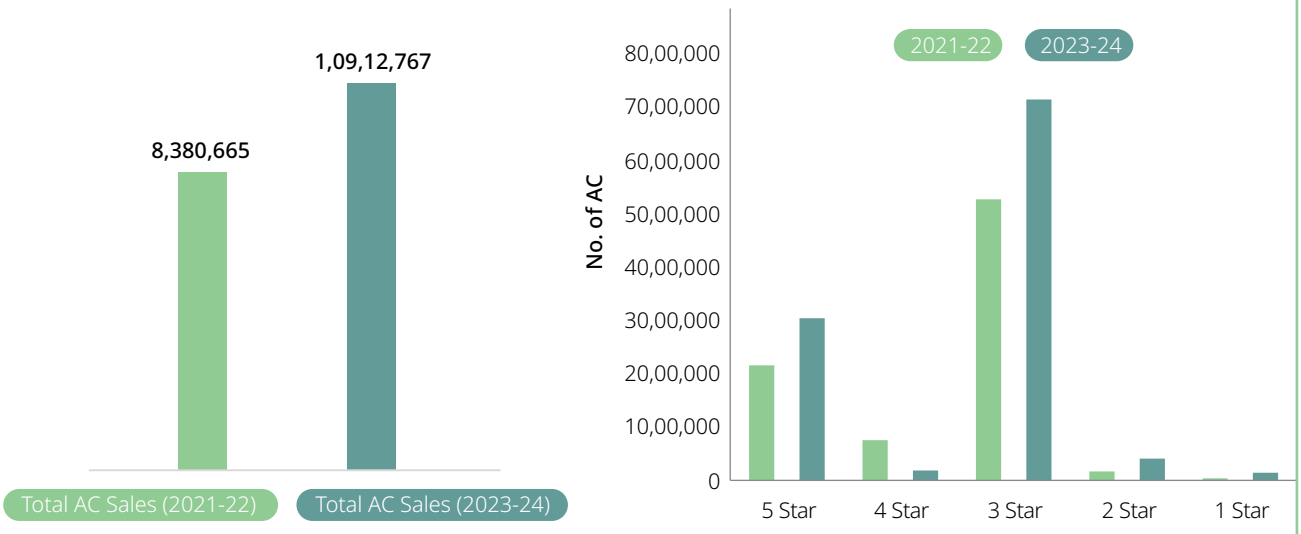


Figure 74: *Total AC Sales and star-rated AC Production Comparison for 2021-22 and 2023-24*

Source: BEE S&L Database (Nov 2024)

Fans and air coolers are widely prevalent in residential buildings and small to medium commercial buildings. In 2019-21, 88 percent of Indian households owned electric fans, with 84 percent of rural households also having them due to increased electrification (MoH&FW, Mar, 2022).

Ceiling fans make up about 40 percent of India's residential electricity consumption. Encouraging energy-efficient fans (brushless direct current) could mitigate consumption by nearly 20 percent. (PIB, Nov, 2023), They are only used by 3 percent of households, showing room for improvement in energy efficiency (IEA, 2023).

For Residential sector, BEE has initiated a study that with an objective to estimate residential energy consumption in India to help establish energy use baseline, appliance ownership and usage pattern. This study is intended to provide insights into the factors driving energy demand, fuel consumption and identify areas for energy efficiency improvements for the residential sector. It is a PAN-India survey of households to develop a model for estimating residential energy consumption and usage of key appliances at the national level. The sampling approach is designed to capture a diverse range of households across different climatic zones, urban-rural divides, and socio-economic strata, ensuring robust representation from each state and climatic region.

3.2.2 Commercial Buildings

The major categories of commercial buildings include hotels and restaurants, hospitals, educational institutions, retail spaces, office buildings, assembly areas, transit buildings and warehouses (MoEFCC, Mar, 2019). With India's economic growth, both the number of these buildings and their energy consumption are expected to rise. In 2023-24, commercial buildings consumed 14 Mtoe, accounting for 18 percent of the building sector's total energy use, with electricity comprising 77 percent of this consumption.

Table 16: Average Built-up Area for Commercial Buildings

Type of Buildings	Category	Average Area (m^2)
Hospitality	Below 3 Stars	50
	Above 3 Stars	80
	Others	40
Office	Public Offices	15
	Private Offices	10
	Others	12
Retail	Unorganised	25
	Organised	230
	Hypermarts	3,717
Airports	International	50,000
	Domestic	10,000
Railways	Suburban	15,000
	Non-Suburban	50,000
	Halts	5,000
Metro	Station	8,000

Source: (CSTEP, 2024)

Fuel Usage in Commercial Buildings

In commercial buildings, LPG is predominantly used for cooking, laundry, heating, cooling and hot water generation. Additionally, LPG finds extensive use in refrigeration and cooling applications, such as in warehouses and cold storage units within commercial buildings. LPG consumption outweighs kerosene in the commercial buildings, where the use of kerosene has remained minimal and steadily declined over time (refer to Figure 75).

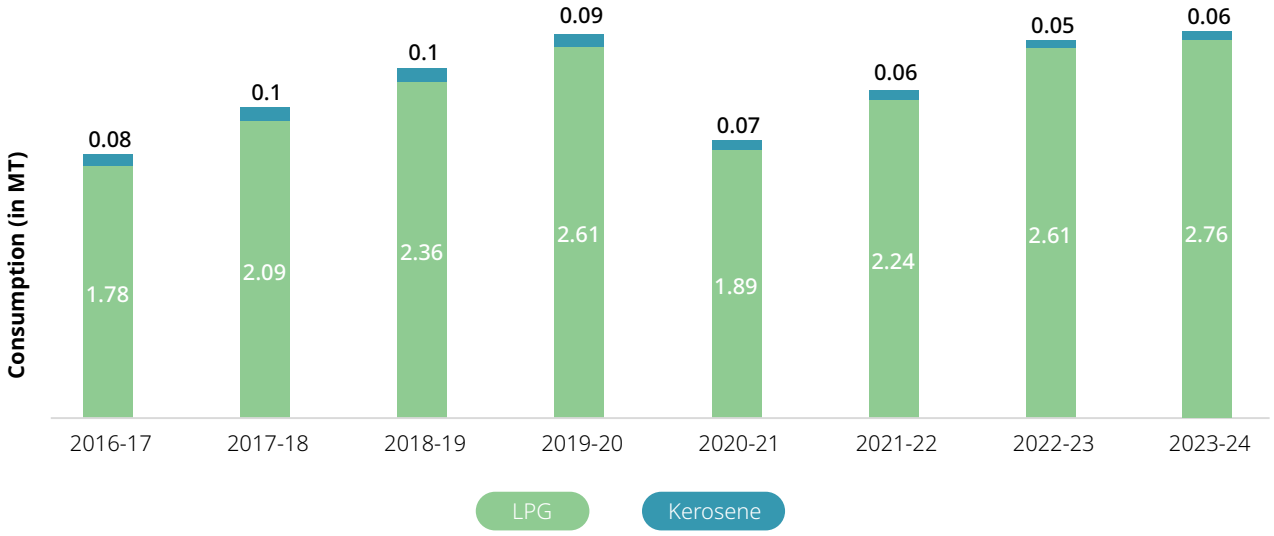


Figure 75: *Petroleum Product Consumption in the Commercial Sector*

Source: (MoPNG, 2024)

- LPG consumption in commercial buildings increased by 55 percent from 2016-17 to 2023-24. There is a visible dip in LPG consumption in 2020-21, possibly due to the closure of commercial activities during the pandemic
- There is an increase in the LPG consumption after 2020-21 possibly due to economic activities picking up after pandemic-related disruptions
- Kerosene consumption has remained minimal, ranging from 0.05 to 0.1 MT over the observed period. It declined by 26 percent from 2016-17 to 2023-24.

Electricity Consumption in Commercial Buildings

Electricity in commercial buildings is predominantly used for lighting, heating, ventilation, air conditioning (HVAC), office equipment and other operational needs. In 2023-24, commercial buildings represented approximately 8 percent of India's total electricity consumption and contributed around 25 percent to the building sector's total electricity consumption, with residential buildings consuming the remaining 75 percent.

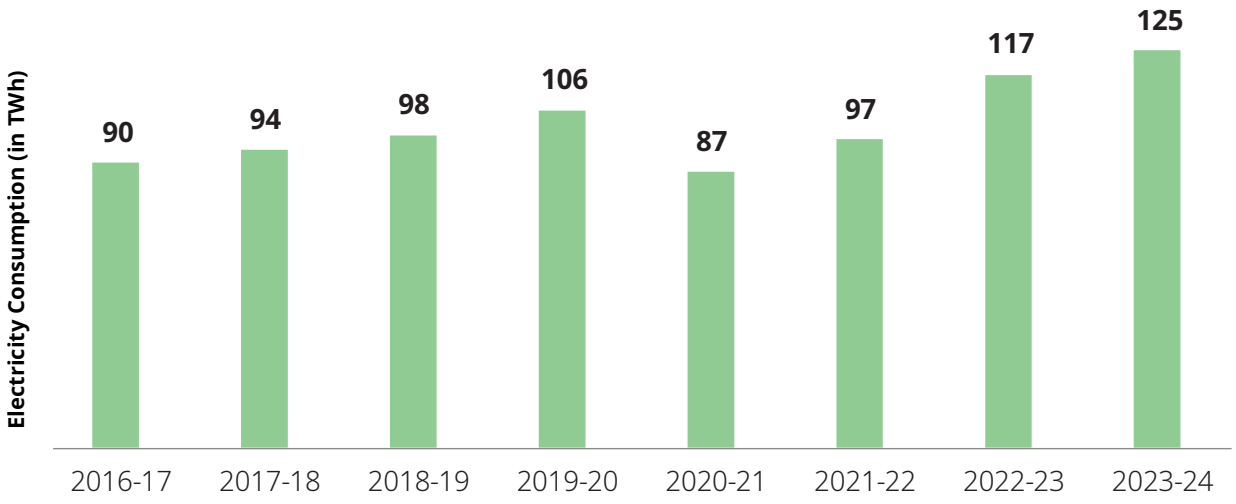


Figure 76: *Electricity Consumption in the Commercial Sector*

Source: CEA f. (2024)

- In 2020-21, decrease in electricity consumption was noticed. Consumption dropped approximately by 18 percent from 2019-20 (106 TWh) to 2020-21 (87 TWh), due to the impact of COVID-19 pandemic, which led to reduced economic activity and energy demand during that period.
- In 2021-22, there is a recovery in electricity consumption to 97 TWh, indicating a partial rebound from the previous year.
- By 2023-24, electricity consumption further increased to 125 TWh. This recovery suggested a return to economic growth and increased commercial activities as pandemic-related restrictions eased.

Detailed Analysis of Total Electricity Consumption in Buildings

Building electricity consumption in India accounts for nearly one-third of the country's total electricity use, which was 1543 TWh in 2023-24. Of this, residential buildings consumed 375 TWh, while commercial buildings used 125 TWh (CEA f. 2024). The Indian appliance sector is expanding rapidly, with thousands of models and soaring demand. While appliances are crucial for managing extreme temperatures and daily needs, improving their efficiency is essential to meet the Paris Agreement's goal of limiting global temperature rise to 1.5°C. Hence, there is a need to understand appliance-wise consumption, which can unlock significant opportunities for optimising energy use, implementing targeted energy efficiency interventions and promoting sustainable building practices. Data from the S&L programme, which provides reliable information to analyse electricity consumption at the appliance level and its end uses, such as cooling, lighting and water heating, among others.

As per CEA, the building sector consumed 500 TWh in the fiscal year 2023-24. Of this total, the BEE has mapped 197.7 TWh at the appliance and end-use energy consumption level under its S&L scheme (as presented in the Table 17 and Figure 77). The largest share of 123 TWh comes from cooling, including room air conditioners (both at variable and fixed speed), ceiling fans and light commercial Acs while 37 TWh are for lighting, 3 TWh for water heating, and 34 TWh for other appliances like refrigerators, colour TVs, washing machines etc. The gap amongst CEA data and data captured through policy interventions of BEE needs to be estimated. Accordingly, BEE would conduct a survey of the building sector to address the gap.

Based on the overall electricity consumption & other technical data for appliances/equipment used under the ambit of star labelling program, the electricity consumption distribution in buildings across HVAC & lighting sector was consolidated for the year 2023-24 as shown in Table 17.

Table 17: Annual Electricity Consumption by Appliances (estimated) as per the S&L Scheme in 2023-24

Appliances	Electricity Consumption in 2023-24 (in TWh)
Cooling	
RAC[4]	104.34
LCAC	0.31
Ceiling Fans	18.14
Lighting	
TFL	4.82
LED	32.67
Water Heating	
Electric Water Heater	3.15
Other Appliances	
Colour Television	5.15
Refrigerator[5]	27.38
Washing Machine	1.72
Total (as per S&L)	**197.70**

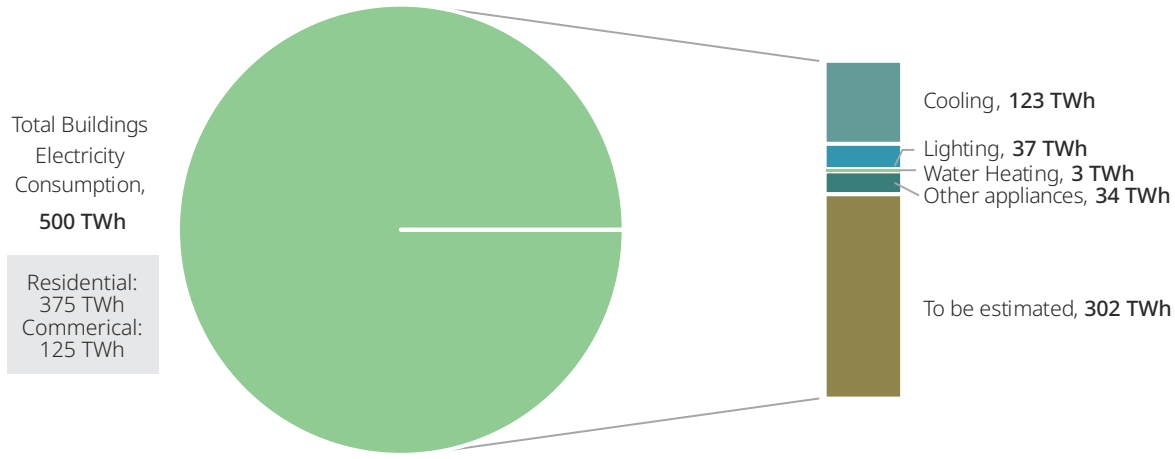


Figure 77: *Total Building Electricity Consumption and End-use Category Breakdown (in TWh)*

Source: BEE S&L Database (Nov. 2024)

The data reveals that cooling accounts for about 62 percent of the total usage. The significant share is driven by the increasing needs for thermal comfort. Water heating represents a comparatively smaller share, accounting for 2 percent of the total consumption. Lighting consumes 19 percent of the electricity, while various other appliances, including colour televisions, refrigerators, and washing machines, use another 17 percent (Figure 78). The percentages may differ based on individual residential and commercial buildings.

4 Included Room Air Conditioner (Fixed Speed) and Room Air Conditioner (Variable Speed)

5 Include Direct Cool Refrigerator (DCR) (Single Door), Frost Free Refrigerator (FFR) (Double Door) and Deep Freezers

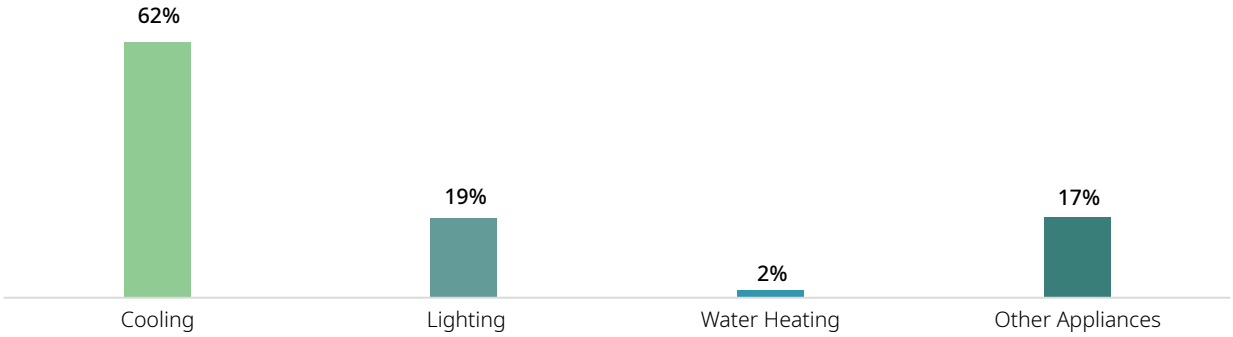


Figure 78: *Distribution of End-uses in Buildings Electricity Consumption (Residential + Commercial)*

Energy Efficiency Trends in Commercial Buildings

The following graphs illustrate the Energy Performance Index (EPI) for different categories of commercial buildings under the BEE Star Rating for Commercial Building programme. These graphs depict EPI values for a total of 290 buildings categorised into office buildings and Business Process Outsourcing (BPOs) across various star ratings.

For office buildings and BPOs, there is a clear trend of decreasing EPI values with higher star ratings, indicating better energy performance in higher-rated commercial buildings.

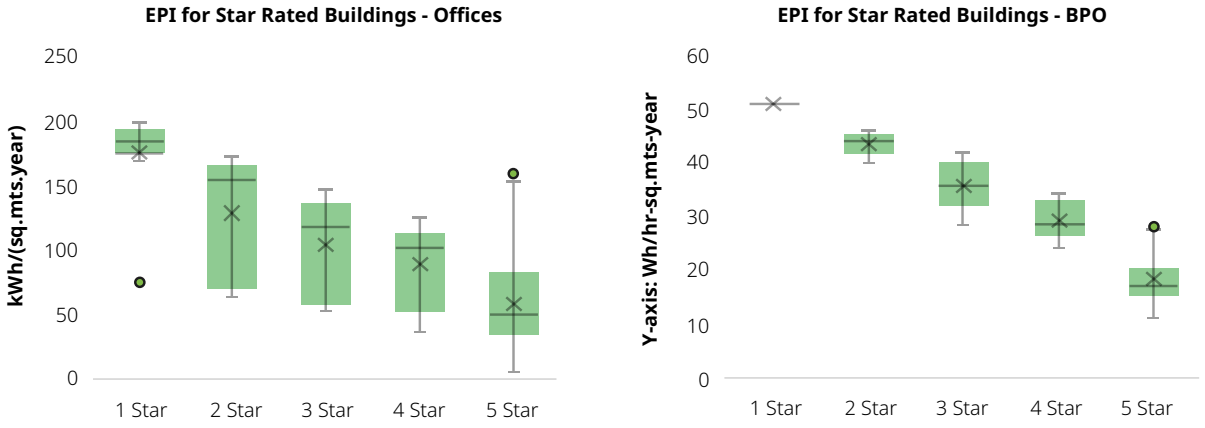


Figure 79: *Energy Performance Index (EPI) for star-rated Commercial Buildings*

Source: (BEE, Jan, 2024)

Commercial Buildings Survey

A comprehensive survey of energy data in commercial buildings is crucial for India as the country experiences rapid urbanization and economic growth, leading to increased energy demand in sectors like hospitality, retail, and office spaces. Commercial buildings consume a significant portion of the total energy, primarily for lighting, air conditioning, and other electrical appliances. Without accurate data, it becomes challenging to design effective energy efficiency policies and programs that can help reduce energy consumption, lower operational costs, and mitigate the environmental impact of rising energy demand. The absence of such data also hampers the Government's ability to set realistic energy efficiency targets and measure the impact of ongoing initiatives, like the Perform, Achieve, and Trade (PAT) scheme.

Conducting energy surveys in commercial buildings can also help identify inefficiencies, create benchmarks for energy consumption, and inform the design of energy-saving technologies. This data is invaluable for shaping the regulatory framework for energy audits and compliance, encouraging

energy-efficient systems, and supporting India's broader climate goals. Additionally, reliable energy data enables commercial building owners and operators to make informed decisions about retrofitting their infrastructure with advanced energy-saving technologies, thus contributing to long-term cost savings and sustainability efforts. With the above perspective, BEE is currently actively exploring the options for conducting such survey/study in the Commercial Building Sector.

Energy Consumption by Hospitals in India - A Study

A survey on hospital energy consumption by Alliance for Energy Efficient Economy (AEEE) and Centre for Chronic Disease Control (CCDC), under the National Programme on Climate Change and Human Health (NPCCHH), covered 341 hospitals. Hospitals accounted for around 9 percent of India's commercial electricity consumption in FY 2019-20, totalling it to 9.7 TWh/year. Over 90 percent of hospitals' energy supply comes from grid electricity, on-site solar PV and on-site DGs. (refer to Figure 80) Electricity sourced from off-site solar PV plants or through open access modes is included in grid electricity (National Centre for Disease Control, Aug, 2023).

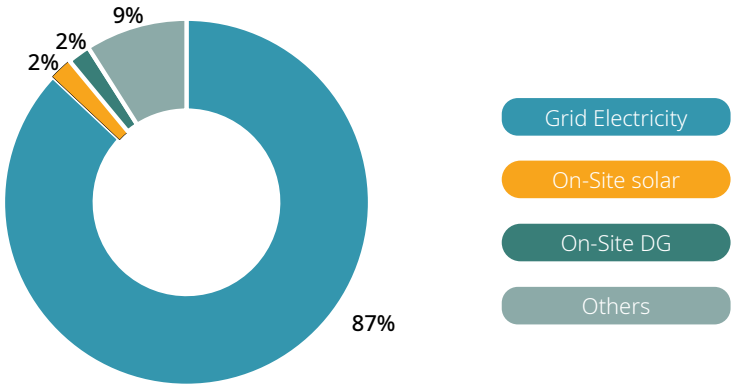
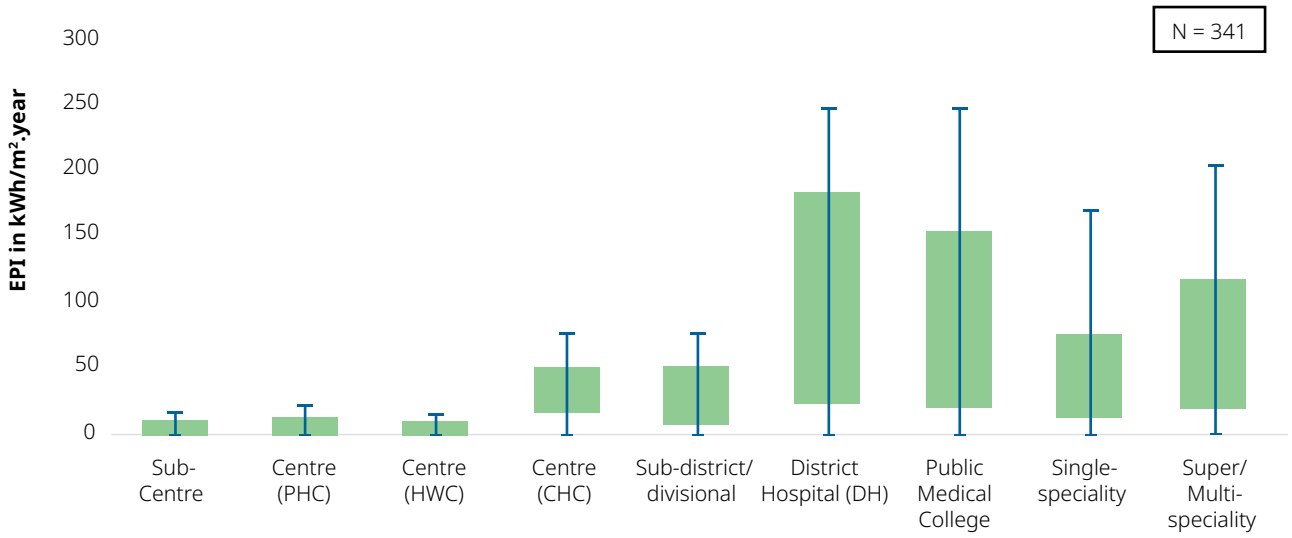


Figure 80: *Distribution of Hospitals' Total Primary Energy use by Energy Source*

Source: (National Centre for Disease Control, Aug, 2023)

As per the survey, 17 percent of private and 11 percent of public hospitals have on-site solar PV systems. Public Community Health Centres (CHC) have the highest number of installations, followed by the District Hospitals and the Medical Colleges. Amongst the 18 public facilities, 11 use off-grid solar PV without battery storage. However, hospitals typically rely on the DGs for critical load backup during power failures. LPG is the primary fuel, with natural gas, furnace oil and firewood, also used in hospitals.

The survey revealed significant EPI variations within the same hospital type influenced by two types of energy efficiency factors. Of which, one is energy efficiency of end-use appliances and behavioural energy efficiency. The second is non-energy efficiency factors like air-conditioned space, level of medical services, operating hours, climatic conditions, and extent of service outsourcing (refer to Figure 81).



	Sub-centre	Primary Health Centre (PHC)	Health and Wellness Centre (HWC)	Community Health Centre (CHC)	Sub-district/ divisional Hospital (SDH)	District Hospital (DH)	Public Medical College	Single speciality Hospital	Super-/Multi-speciality hospital
1st quartile (Q1)	2	4	4	15	7	24	27	14	18
3rd quartile (Q3)	7	11	10	48	25	172	138	74	114

Figure 81: *Distribution of EPI within every Hospital Typology*

Source: (National Centre for Disease Control, Aug, 2023).

Hotels as Designated Consumers under the PAT Scheme

Hotels consume large amounts of energy due to their 24/7 operations and various services like air conditioning, heating, kitchen equipment, laundry, lighting, and other amenities. These energy requirements make hotels ideal candidates for energy-saving measures, especially in the context of reducing their carbon footprint.

Hotels covered under the PAT scheme are identified based on their energy consumption levels. They are required to meet specific energy-saving targets determined by BEE based on their baseline energy consumption. These targets are typically expressed in terms of energy performance indices (e.g., energy consumption per square meter of floor area).

While the PAT scheme initially focused on high-energy-consuming sectors such as cement, iron, steel, textiles, and aluminium, it was expanded to include commercial buildings, particularly hotels. The hotel industry in India, being a significant consumer of energy for lighting, air conditioning, heating, and other services, has immense potential for energy conservation. Hotels have now become one of the sectors targeted under the PAT scheme due to their capacity to reduce energy consumption and contribute to India's broader energy efficiency goals.

Key Focus Areas for Energy Efficiency in Hotels

1. **Lighting**: Hotels tend to have extensive lighting needs, both in guest rooms and common areas such as lobbies, restaurants, and conference halls. By upgrading to energy-efficient lighting systems like LEDs and using smart lighting controls, hotels can significantly reduce energy consumption.
2. **Heating, Ventilation, and Air Conditioning (HVAC)**: HVAC systems are among the largest consumers of energy in hotels. Upgrading to more efficient HVAC systems, using heat recovery technologies, and implementing intelligent control systems to manage temperature and humidity can drastically reduce energy usage.
3. **Hot Water Systems**: Hot water is crucial for guest rooms, kitchens, and laundry services. Hotels can optimize energy use in hot water systems by installing solar water heaters, heat pump systems, and insulation for pipes to minimize heat loss.
4. **Building Management Systems (BMS)**: Implementing a BMS allows hotels to monitor and control their energy consumption more effectively. A BMS can optimize energy use by automatically adjusting lighting, HVAC, and other systems based on occupancy and real-time demand.
5. **Renewable Energy Integration**: Some hotels are exploring the integration of renewable energy sources, such as solar panels, to offset their electricity consumption. Renewable energy can contribute to meeting energy-saving targets and enhance the hotel's green credentials.

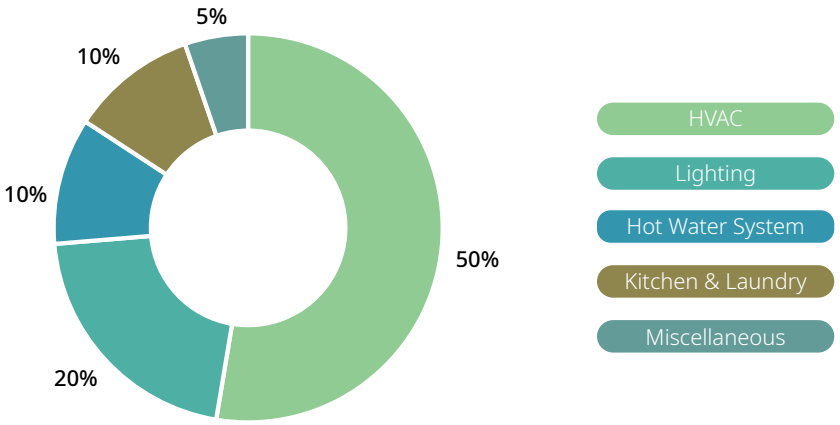


Figure 82: *Energy consumption pattern for hotel sector (indicative)*

The inclusion of hotels under the Perform, Achieve, and Trade (PAT) scheme is a progressive step towards enhancing energy efficiency in the commercial building sector in India. Hotels have immense potential to reduce their energy consumption through various measures, including upgrading HVAC systems, installing energy-efficient lighting, integrating renewable energy, and optimizing building management systems. By participating in the PAT scheme, hotels can not only contribute to India's national energy efficiency goals but also benefit from cost savings, enhanced market competitiveness, and environmental sustainability.

Despite challenges such as the high initial investment and technical expertise requirements, the long-term benefits of improved energy efficiency in the hotel sector are significant. With continued Government support, increased awareness, and the development of more affordable energy-saving technologies, the hotel industry can play a crucial role in India's transition to a low-carbon economy.

Currently, 132 Hotels are covered as Designated Consumers (DCs) under PAT scheme and its total consumption is 0.153 MTOE (approx. 1.8 BU).

3.3 Transport Sector

The rapid growth in India's urbanisation, population and wealth in the past few decades has yielded as a positive effect on the country's mobility. India's demand for transport has multiplied about 8 times since 1980 (NITI Aayog, 2018) which is more than any other Asian country. This unprecedented growth has fuelled the development of a thriving auto industry and allied economic growth. While the expansion and improvement of transport infrastructure typically act as catalysts for socio-economic development, the transport sector's substantial energy consumption and emissions pose significant challenges.

The increasing demand for mobility is steady. A consistent increase in transportation is driven by factors such as the rise of e-commerce and the post-pandemic surge in rising tourism. The growth of the transport sector corresponds to increase in energy consumption (see Figure 83), except for 2020-21 due to the covid-19 pandemic.

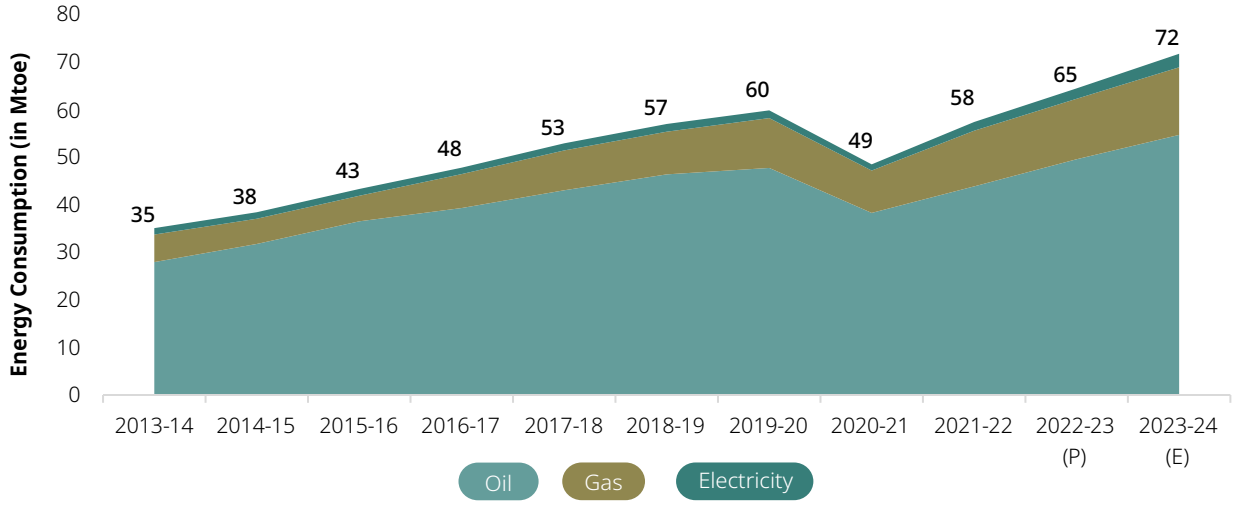


Figure 83: *Energy Consumption in the Transport Sector*

*Gas consumption also includes consumption in City or Local Natural Gas Distribution Network and Internal Consumption for Pipeline System

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

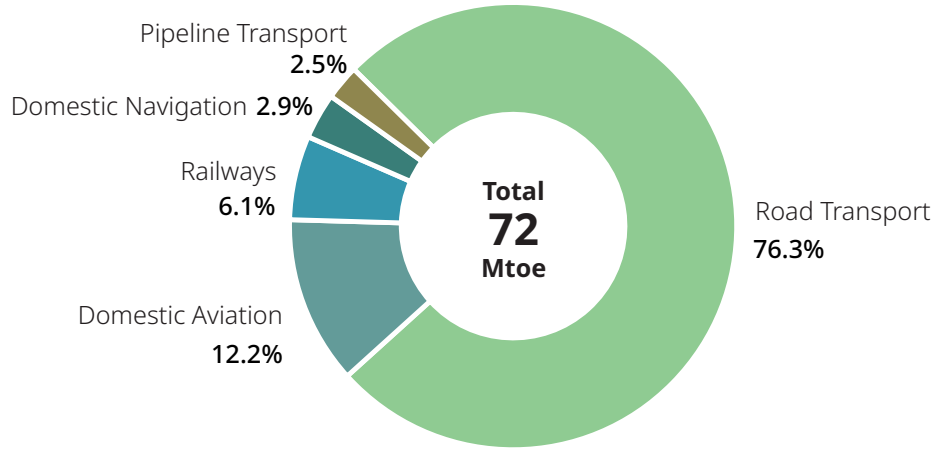


Figure 84: *Sector-wise Energy Consumption in Transport Sector for 2023-24 (E)*

Source: The figures are calculated based on actual data from various ministries

While both oil and gas maintain a steady growth across the past decade, the stabilised electricity consumption has begun to increase in the last 2 years of the decade. Further, Figure 84 gives a bifurcation of the sub-sectoral energy consumption within the transport sector. The road transport being responsible

for the highest share (75.9 percent), followed by domestic aviation (12.2 percent), railways (6.1 percent), domestic shipping (3.3 percent) and others. 'Others' represents energy consumed by Pipeline Transport.

Petroleum Products Consumption Trends

Transport is a major sector contributing to petroleum product consumption in the country. Figure 85 provides an overview of the breakdown of oil products consumed by this sector. Following the economic recovery from the pandemic, the decline in consumption observed during 2020-21 has been revived. It can be observed that the petrol consumption has increased from 2016-17 to 2023-24, with a CAGR of 7 percent.

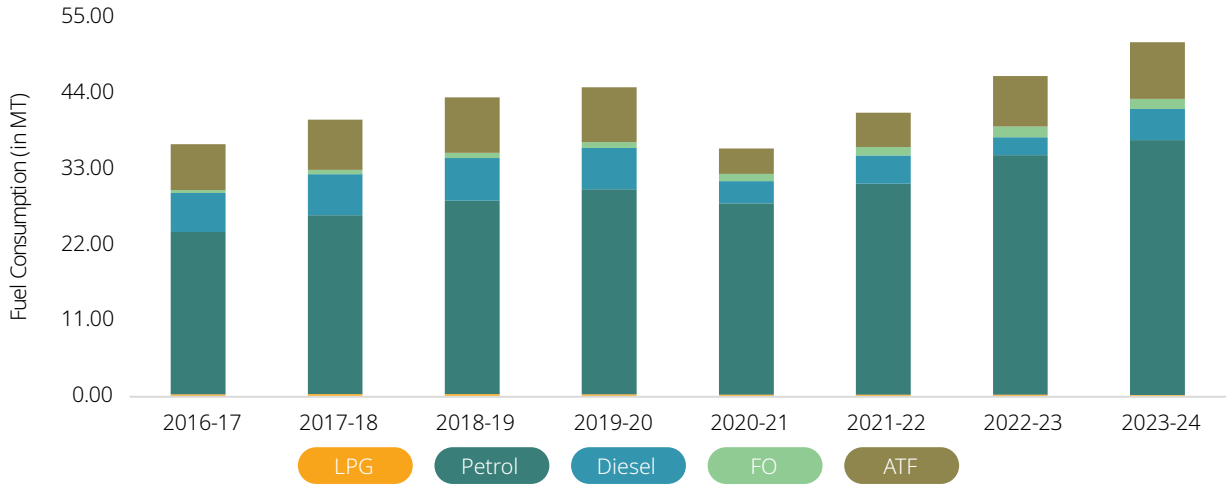


Figure 85: *Petroleum Product Consumption in the Transport Sector*

* For Diesel: This graph only accounts for diesel consumption reported in transport sector, however actual usage is higher which is reported in Reseller/Retailer category

Source: (MoPNG, 2024)

3.3.1 Road Transport

India's transport sector is dominated by the Road Transport. As per MoRTH's data, India's road network spanned over 63.32 Lakh KMs as of 2019. This includes National Highways, State Highways, District Roads, Rural Roads (including Jawahar Rozgar Yojana (JRY) Road), Urban Road and Project Road (MoRTH, Apr, 2023). Plying on these road networks, the size of India's motor vehicles' population has risen to 326.3 million in 2020. As the Indian market strives to leverage the rising demand for mobility and goods' transport, it is likely that the energy use as well as CO_2 emissions from road transport may double by 2050 (IEA & NITI Aayog, Jul, 2023).

With the rising mobility trends, the Indian cities grapple with growing traffic congestion, air pollution and rising emissions, the policy focus has been towards promoting sustainable mobility. Furthermore, India's recent global climate commitments and net-zero goal have also been one of the key factors in shaping these policies. Against this backdrop, some key policies like the National Urban Transport Policy and the National Electric Mobility Mission Plan have aimed to encourage the use of public transportation as well as non-motorised transport means like cycling.

On the electrification of the current vehicle fleet, the Government has undertaken policies such as the FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) to facilitate the adoption of EVs by users. Apart from this, the Central Government has also enabled supply-focused policies such as PLI Scheme and the Advanced Chemistry Cell (ACC) PLI Scheme which seek to boost production of the EVs too. In addition to these policies adopted by the Central Government, 29 states also approved their state

EV policies as of November 2024. The states are Delhi, Maharashtra, Haryana, Kerala, Madhya Pradesh, Tamil Nadu, Telangana, Odisha, West Bengal, Jharkhand, Rajasthan, Uttar Pradesh, Bihar, Uttarakhand, Gujarat, Goa, Karnataka, Andhra Pradesh and Punjab, to name a handful (BEE a, 2024).

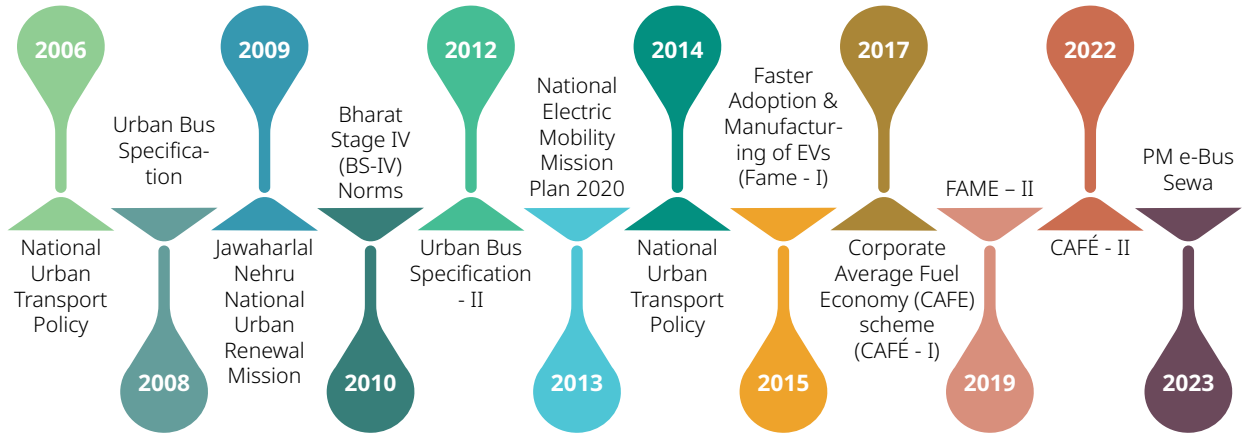


Figure 86: *Key Road Transport Policies in India*

Furthermore, Emission norms like Bharat Stage-IV (BS-IV) and the Bharat Stage-VI (BS-VI) standards have also driven the adoption of cleaner vehicle technologies to reduce emissions. In addition to this, in 2017, the Government introduced Corporate Average Fuel Efficiency (CAFÉ) norms to reduce fuel consumption and lower CO_2 emissions, aiming to decrease oil dependency and air pollution. These norms are applicable for petrol, diesel, liquefied petroleum gas (LPG), CNG, hybrid, and electric passenger vehicles with gross vehicle weight (GVW) <3500kgs. These standards were introduced in two phases—the first CAFÉ Norms Stage I fuel consumption standards were introduced effective 2017–18, and the CAFÉ Norms Stage II standards came into force in 2022–23. The CAFÉ scheme results in significant energy savings, CO_2 reduction, and cost savings. Apart from this, the Urban Bus Specification I & II as well as the PM e-Bus Sewa policies have aimed at upgrading the existing public bus infrastructure and making it more inclusive. This evolution in the policy landscape reflects India's dedication to developing a sustainable and low-carbon transportation system. This system can support its growing economy and population while addressing critical environmental and public health concerns.

Mobility Trends

The growing adoption of all categories of vehicles has led to steady growth in both passenger and freight KMs. Figure 87 offers an overview of the trends in individual and goods mobility, both of which have shown consistent growth.

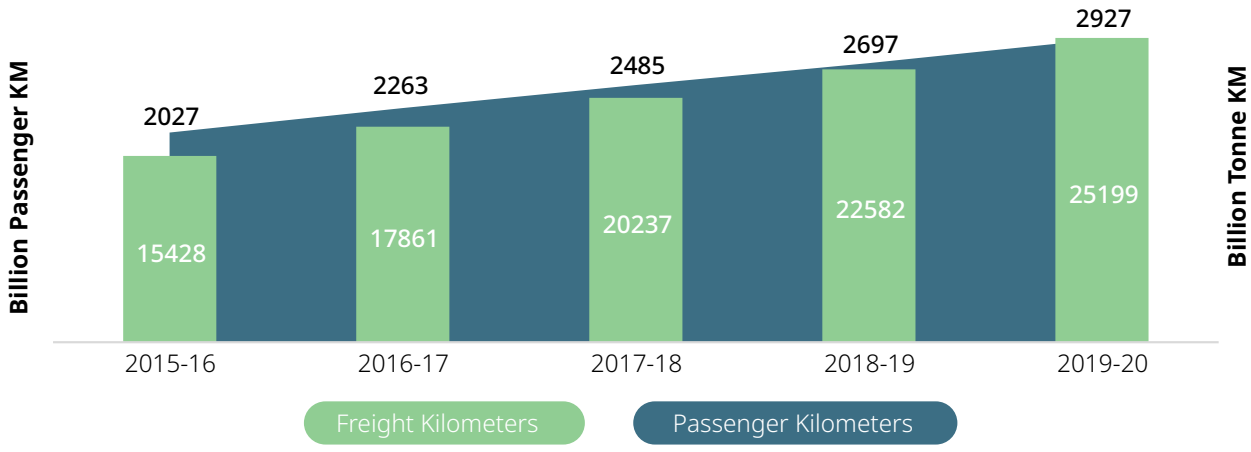


Figure 87: *Road Transport's Passenger & Freight Kilometres in India*

Source: (MoRTH, Apr, 2023)

Year on Year Vehicles Registered in India

Owing to increased demand for mobility, vehicle registrations have rebounded after the decline caused by the COVID-19 pandemic. Figure 88 showcases that vehicle registrations in India are now almost at par with the pre-covid levels.

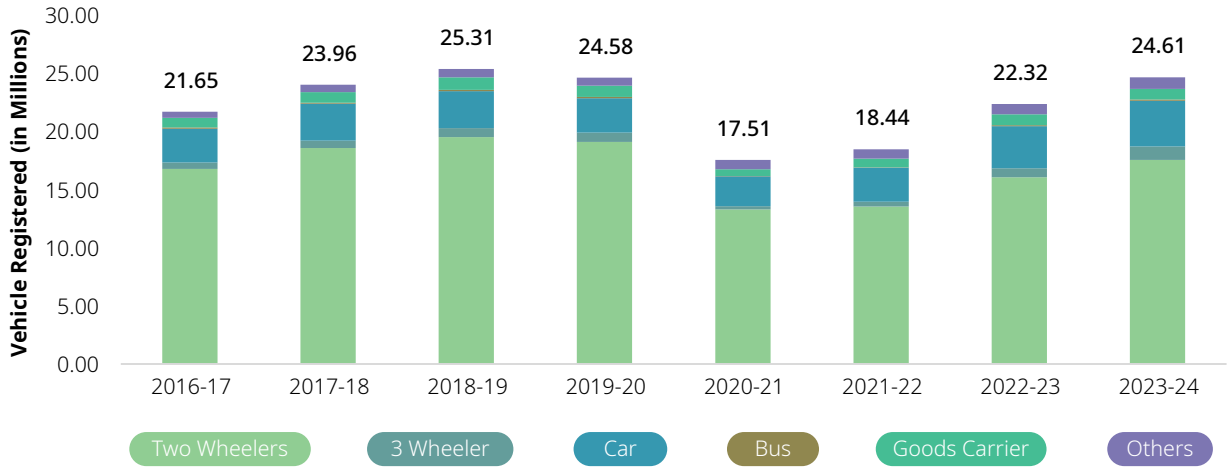


Figure 88: *Category-wise Vehicles Registered in India*

Source: (Vahan Dashboard, 2024)

India's vehicle fleet has been dominated by two-wheelers which has continued to maintain more than 70 percent registrations year by year. However, during 2016-17 to 2023-24, its share has decreased from 77 percent to 71 percent. At the same time, the share of three-wheelers and cars have increased from 2.4 percent to 4.7 percent and 13.4 percent to 16 percent respectively. This indicates a shift in the trend of vehicle categories plying on the road.

Alongside the growth in overall vehicle registrations, EV registrations are also seeing a rapid growth. With rising emphasis on adopting the less carbon-intensive pathways for mobility, electrification of India's transport sector is one of the biggest ongoing transitions. The EV market in India is witnessing a significant rise, owing to consumer-friendly EV policies, fiscal and monetary incentives from the Government. The rising concerns of air pollution and its effect on health, increased enthusiasm of lower carbon-footprint at an individual level and other reasons are also contributing factors.

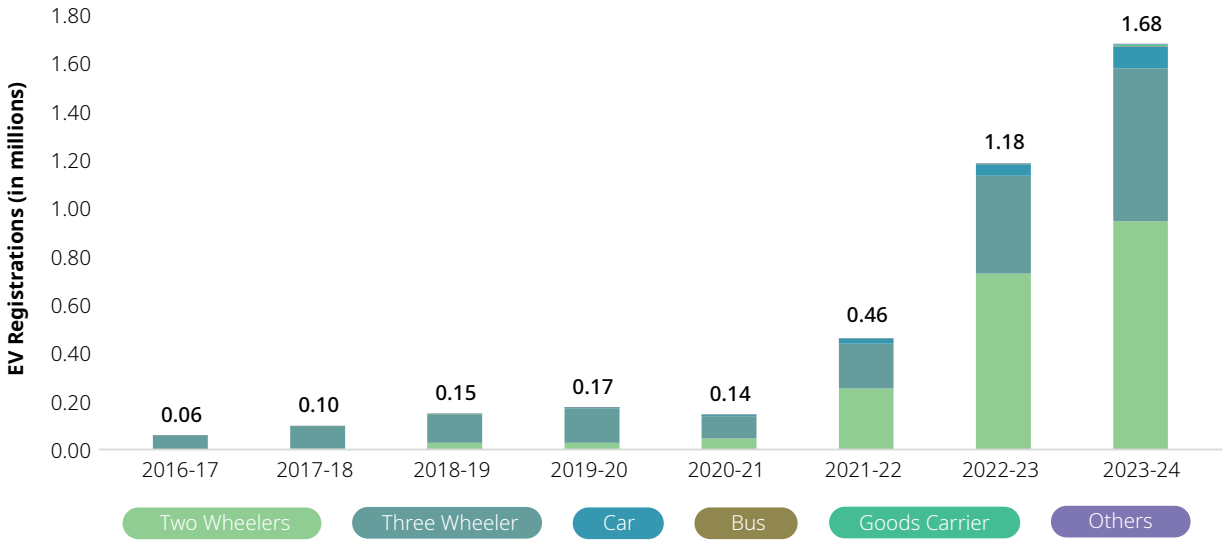


Figure 89: *Electric Vehicles Registered in India*

Source: (Vahan Dashboard, 2024)

According to the Figure 89, the EV adoption in India has grown over the last 3 years, especially in the aftermath of the COVID-19 pandemic. After 2021, EV registrations in India have more than doubled every single year. To be precise, they have increased at a tremendous CAGR of 129 percent. Driving this growth, two-wheelers and three-wheelers are the key segments in which EV adoption dominates.

This steep growth may be attributed to the policies directed at increasing EV adoption, launched by both - Central and State Government. To get a detailed picture of state-wise EVs' penetration, the state with highest EV registration in 2023-24 is Uttar Pradesh followed by Maharashtra, Karnataka and Tamil Nadu (as Figure 90).

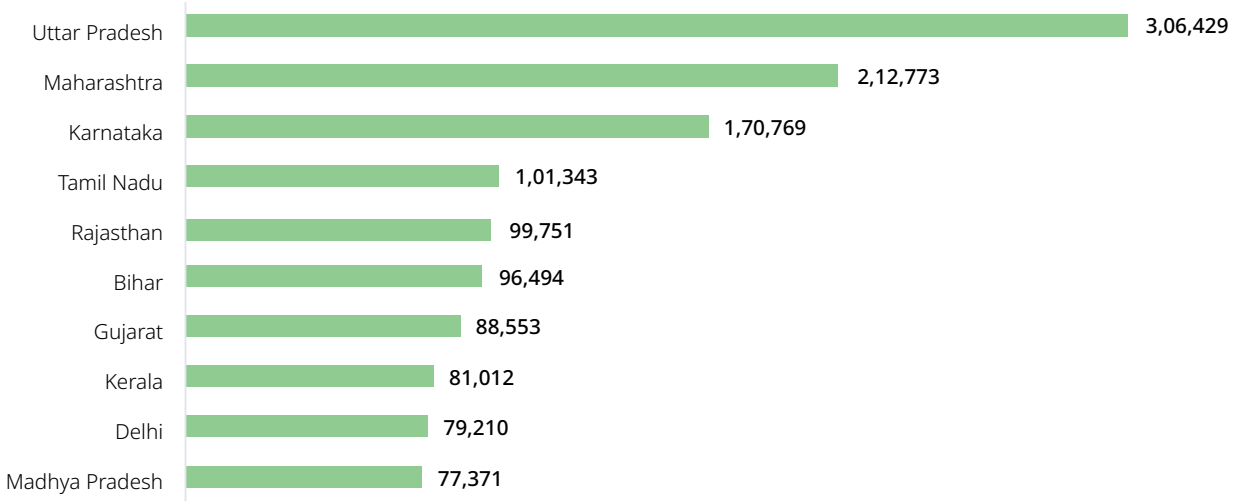


Figure 90: *Top 10 States with Highest EV Registration in FY 2023-24*

Source: (Vahan Dashboard, 2024)

Fuel Consumption in the Road Transport Sector

The fuel consumption in India's increasing vehicle population is dominated by oil products. A quick glimpse at the overall Fuel Consumption data in Road Transport (Table 18) and the HSD Distribution data via Resellers/Retailers (Table 19) showcases that HSD is the dominant fuel in this sector.

Table 18: Fuel Consumption in Road Transport

Fuel Consumption (in TMT)	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
HSD*	2709	2731	2727	2660	1374	1694	146	2282
MS (Petrol)	23642	26050	28156	29849	27847	30729	34870	37112
FO	37	20	110	121	132	172	178	174
LDO	0	3	5	2	2	2	2	2
Auto LPG	167	184	180	172	118	122	107	88

*This only accounts for diesel consumption reported in road transport, however actual usage is higher which is reported in Reseller/Retailer category
Source: (MoPNG, 2024)

A significant portion of diesel is consumed by road transport; however, due to data reporting issues, this consumption is not accurately reflected in the Road Transport category but is instead recorded under the Reseller/Retail category in the Indian Petroleum and Natural Gas Statistics report. As per the Energy Statistics report, approximately 78 percent of the High-Speed Diesel (HSD) within the Reseller/Retail category is used for road transport. Table 19 illustrates the distribution of HSD within the Reseller/Retail category across various end-use sectors.

Table 19: Distribution of HSD under Reseller/Retail category into different End-Use sectors (in 000'tonnes)

FY	Road Transport	Shipping	Railways	Agriculture	Power Generation	Other Consumer/ Industrial Goods	Others	Total
2021-22	51,663	531	1394	3187	1062	4183	4383	66,404
2022-23 (P)	62,260	640	1681	3841	1280	5042	5282	80,026

Source: (MoSPI, 2024)

With the high share of diesel consumption by the road transport sector in India, the sector accounts for 87 percent of the total diesel sales in 2020-21 (CRISIL & PPAC, 2022). A breakdown of vehicle-wise diesel consumption in 2020-21 in the sector is given below. Trucks dominate the diesel sales since most of the freight mobility needs is covered by the trucks. They have the highest average daily distance travelled amongst all the vehicle segment (250-400 KMs).

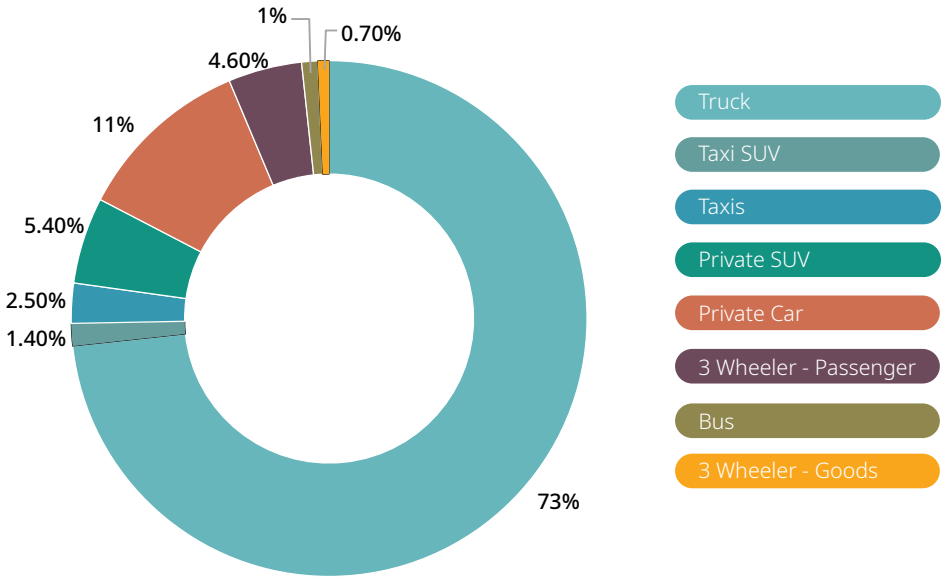


Figure 91: *Vehicle Category wise Diesel Consumption in 2020-21*

Source: (CRISIL & PPAC, 2022)

Likewise, the breakdown of vehicle-wise petrol consumption in 2020-21 in the sector is given below. The Figure 92 shows that petrol consumption has been the highest by two-wheelers (59 percent), later being followed by private cars (28 percent) and private SUVs (8.62 percent). The share of trucks is low since

most of them run on diesel. The share of three-wheelers is also low because of the higher penetration of Compressed Natural Gas (CNG) and Liquid Petroleum Gas (LPG) based three-wheelers plying on the road.

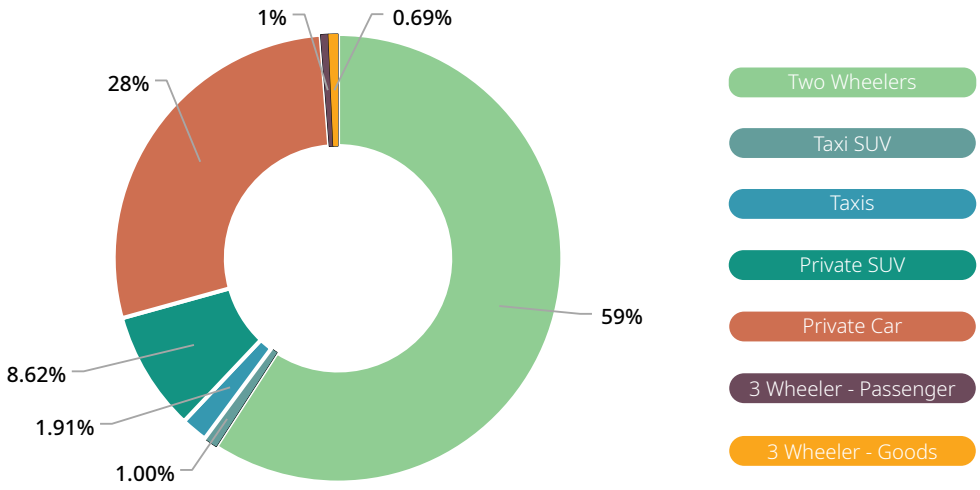


Figure 92: *Vehicle Category wise Petrol Consumption in 2020-21*

Source: (CRISIL & PPAC, 2022)

Electricity Consumption by Public EV Charging Stations

With the uptake of EVs, the transport sector is also witnessing an increase in the electricity consumption. The public EV charging stations recorded electricity consumption at 465.85 MU in 2023-24, more than doubled as compared to 204.84 MU in 2022-23. This is likely to go up since multiple efforts are being made to increase EV adoption in the country.

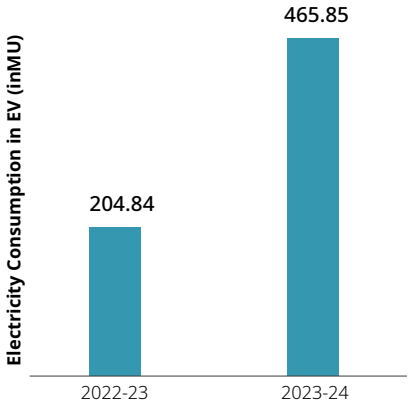


Figure 93: *Electricity Consumption by Electric Vehicles via EV Charging Stations (*till January 2024)*

Source: (CEA e, 2024)

3.3.2 Railways

Indian Railways (IR) has one of the largest railway networks in the world, spanning over 117,996 track kilometres (66,030 route km), connecting 8,073 stations (Indian Railways, a). Currently, it is pursuing a comprehensive strategy to become more environmental friendly and reduce its carbon footprint. It has set the target to become net-zero carbon emitter by 2030 (PIB, Mar, 2023).

Furthermore, IR has been undertaking modernisation initiatives since the 1980s to improve efficiency and upgrade its technology. However, in recent years, it has placed a strong focus on 'greening' its operations and reducing environmental impact. To attain this, some of the key policies aimed at greening of the IR infrastructure. An extension of PAT Scheme has been introduced to IR. IR Energy-Efficiency Action Plan & Policy (IREAP) and 'Mission 100 percent Electrification' (Indian Railways, Feb, 2021).

At the same time, to achieve an ambitious goal of net-zero carbon emitter by 2030, IR estimates a requirement of around 30,000 MW of RE capacity by the same year. As of December 2023, it has commissioned about 216.36 MW of solar power plants (both rooftop and land-based) and about 103.4 MW of wind power plants. It has also secured an additional 2,150 MW of renewable energy capacity.

Mobility Trends

In India, railways are primarily used for passenger travel and freight shipments. It has 13,523 passenger trains and 9,146 freight trains running daily (Invest India, Jul, 2024). The mobility trends in the railways for both passengers as well as freight is portrayed in the Figure 94. While freight mobility is witnessing growth each year despite the covid pandemic, the passenger mobility has taken a hit due to the pandemic which is reflected in the fall of billion passenger KMs during 2020-2021 and 2021-2022.

IR's success on greening the sector:

55 Industrial Units, including 39 workshops, 7 Production Units (PUs), 8 Loco Sheds, and 1 Stores depot, are 'GreenCo' certified. These include 2 platinum and 15 Gold Ratings

32 Railway stations & 32 Railway buildings, including schools and hospitals, have been 'GreenCo' certified

Around 700 Railway Stations are certified for the implementation of the Environment Management System ISO: 14001

Source - https://indianrailways.gov.in/railwayboard/uploads/directorate/stat_econ/2023/PDF%20Year%20Book%202021-22-English.pdf

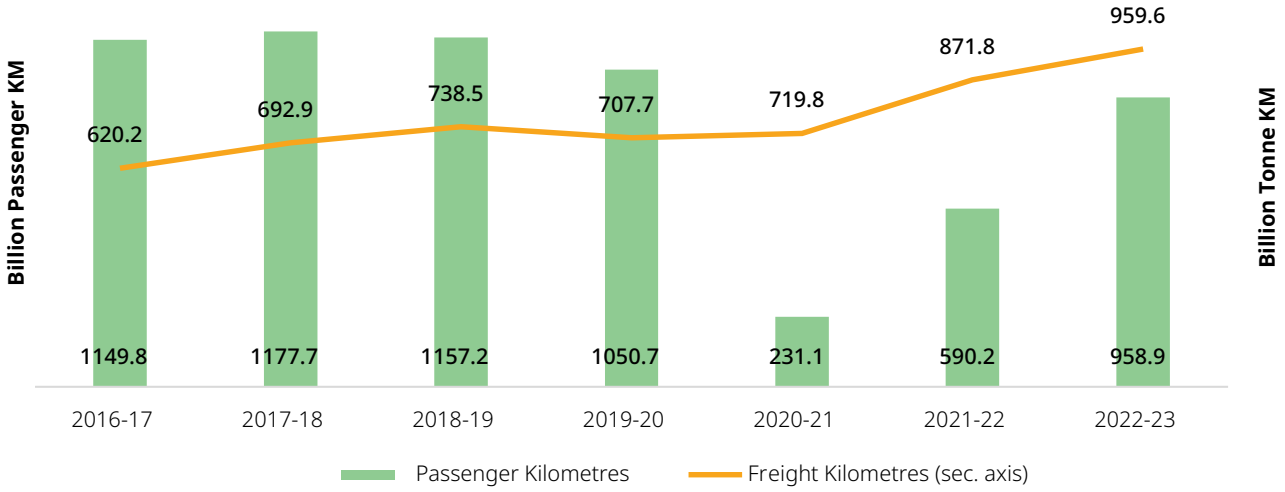


Figure 94: *Railways' Passenger & Freight Kilometres in India*

Source: (Indian Railways, 2024)

Fuel Consumption by Railways

As shown in Table 20, HSD remains the primary fuel used, while LPG, LDO, and FO contribute only marginally to various ancillary activities. However, with the continued expansion of electrification across the railway network and a corresponding increase in electricity consumption, HSD usage has significantly

declined. Specifically, HSD consumption has decreased by 45 percent, from 2,651 TMT in 2016-17 to 1,458 TMT in 2023-24..

Table 20: Fuel Consumption by Indian Railways (in TMT)

Fuel	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
HSD	2651.0	2635.7	2715.6	2539.3	1222.3	1748.4	1715.0	1457.6
LPG	1.0	0.7	0.8	0.9	0.7	1.0	1.7	1.2
FO	0.0	0.0	0.1	0.0	0.0	0.4	0.4	0.1
LDO	0.6	0.5	0.5	0.4	0.3	0.3	0.4	0.4

Source: (MoPNG, 2024)

Electrification of Railways & Electricity Consumption

As per the 2021 policy, Mission 100 percent Electrification was introduced to electrify the Broad Gauge (BG) network of Indian Railways (Indian Railways, Feb, 2021). As of 01st April 2024, 96.35 percent of the BG network is electrified with 63,456 route KMs out of the total. This showcases remarkable progress by Indian Railways towards the goal of achieving 100 percent BG network electrification.

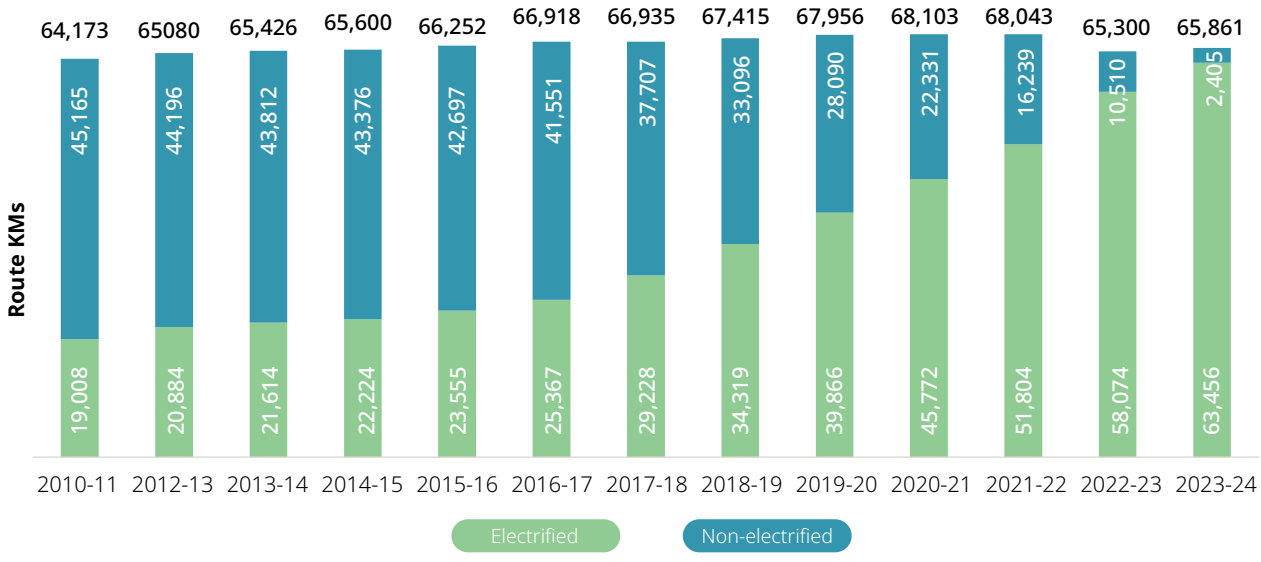


Figure 95: *Electrification of Railways' BG Network Route*

Source: (Indian Railways, 2024) and (Indian Railways, Apr, 2024)

(Note: The non-electrified Route KMs for 2023-24 only depict BG network and does not include Metre Gauge (MG) and Narrow Gauge (NG) network)

Due to the rapid electrification of the BG network, the electricity consumption in railways is also on the rise, captured in the Figure 95. The electricity consumption has grown at a CAGR of 11 percent between 2016-17 and 2023-24. A temporary dip in electricity consumption occurred in 2020-21 due to the COVID-19 pandemic; however, post-pandemic, consumption has rebounded and continued to rise. resumed its upward trajectory. In 2023-24, electricity consumption doubled to 33 TWh from 16 TWh in 2016-17.

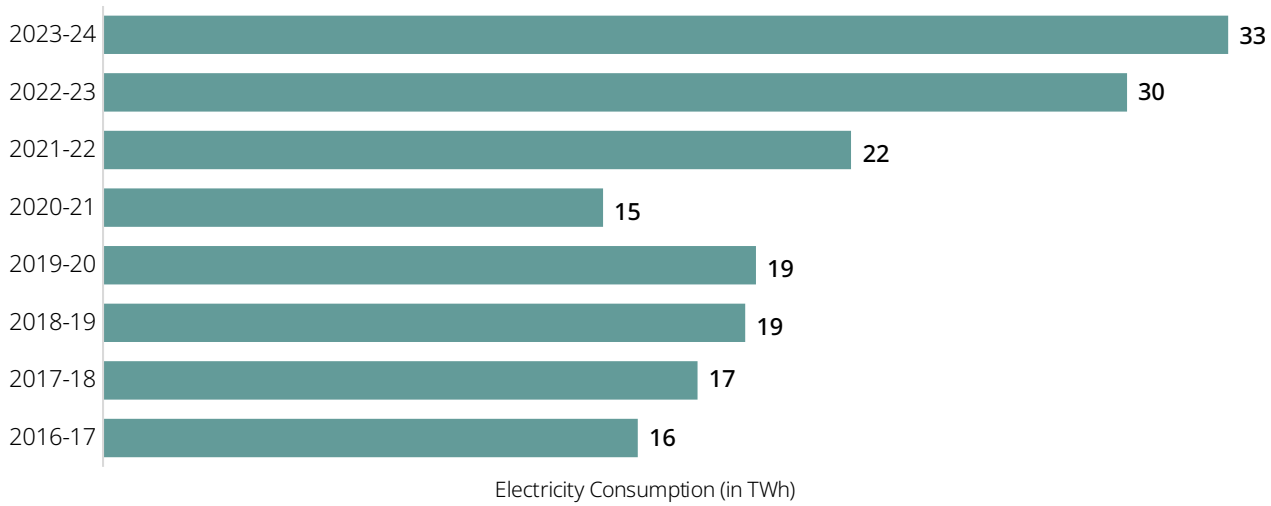


Figure 96: *Electricity Consumption in Railways*

Source: (CEA d, 2024)

3.3.3 Aviation

India has soared to become the third-largest aviation market in the world with the expansion of budget airlines, improved infrastructure, a growing consumer spending power and a booming tourism sector (Invest India, Apr, 2023). Over the years, the total number of airports in India has expanded from 74 in 2013-14 to 147 in 2022, and is expected to reach 220 by 2024-25 (Ministry of Civil Aviation, 2024).

GoI has implemented various policies and initiatives to promote sustainable practices in the aviation sector, recognizing its significant contribution to energy consumption and carbon emissions. These include the Airport Carbon Accreditation (ACA) programme (2014), the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (2016), the National Civil Aviation Policy (NCAP) (2016) and the National Policy on Bio Fuels (2018, amended in 2022). India's National Biofuels Coordination Committee, formed under MoPNG, has recommended blending Sustainable Aviation Fuel (SAF) with ATF in the near future. The initial indicative blending percentages are 1 percent in 2027, 2 percent in 2028, and 5 percent by 2030, with these targets initially apply to international flights. Additionally, the Government is working towards achieving Carbon Neutrality & Net Zero which includes the use of 100 percent Green Energy. Noteworthy achievements include Mumbai, Cochin, and 25 Airport Authority of India airports are already using 100 percent green energy, with Cochin Airport being the first fully solar-powered green airport in the world (PIB a, Mar, 2023).

Considering both domestic and international travel, India's air passenger traffic is likely to reach 395 million by 2023-24 (Invest India, Apr, 2023). The mobility trends of aircrafts, passengers as well as freight for 2020 to 2022 are captured in the figure below.

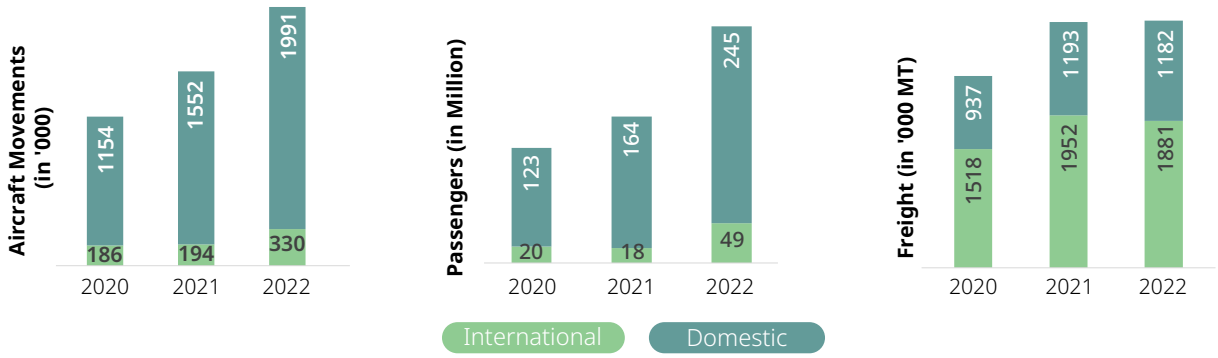


Figure 97: *Aircraft, Passenger and Freight Movement in Aviation Sector*

Source: (Ministry of Civil Aviation, 2024)

Fuel Consumption in Aviation

Table 21 illustrates fuel consumption in the aviation sector from 2016-17 to 2023-24. ATF consumption dipped in 2020-21 due to the COVID-19 pandemic but has since rebounded, surpassing pre-pandemic levels, rising from 6,662 TMT in 2016-17 to 8246 TMT in 2023-24. While HSD showed an upward trend until 2019-20, its consumption for miscellaneous activities has declined in 2022-23.

Table 21: Fuel Consumption in Aviation Sector (in TMT)

Fuel	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24 (P)
ATF	6661.8	7334.8	8043.3	7998.6	3696.6	5007.1	7376.7	8245.6
HSD	2.0	2.9	3.2	3.5	2.3	2.7	1.2	1.2

Source: (MoPNG, 2024)

3.3.4 Shipping

India has an extensive 7,517 km long coastline with 12 major ports and 205 minor or intermediate ports (Ministry of Shipping, 2016). Further, India has identified 111 National Waterways (NWs) to facilitate cargo and passenger movement through inland waterways. India has implemented several policies and initiatives that aim at greening the shipping industry, pushed by the need for sustainable development in the maritime sector. The Sagarmala Programme, launched in 2015, is a flagship initiative focused on developing India's maritime sector through port-led development. This includes the infrastructure and connectivity along the coastline and inland waterways.

In 2016, the National Waterways Act was introduced to develop and utilise India's inland waterways for cargo and passenger movement. Additionally, the Maritime India Vision 2030, a 10-year blueprint for the maritime sector, includes the Indian Coastal Green Shipping initiative. Under this initiative, ports have undertaken activities to reduce GHG emissions. These include using electrically powered port equipment, adopting alternative fuels like LNG/CNG and transitioning towards Renewable Energy. Moreover, India's major ports are aiming for a significant boost in RE usage, targeting 60 percent of their total power needs from renewable sources. Currently, these ports rely on the renewables for less than 10 percent of their energy requirements (PIB. (Feb, 2023)).

The shipping industry plays a crucial role to global trade, accounting for 95 percent of the country's trade by volume and 68 percent by value (Ministry of Ports, Shipping and Waterways, 2024). The mobility trends of freight via shipping have been captured in the Figure 98.

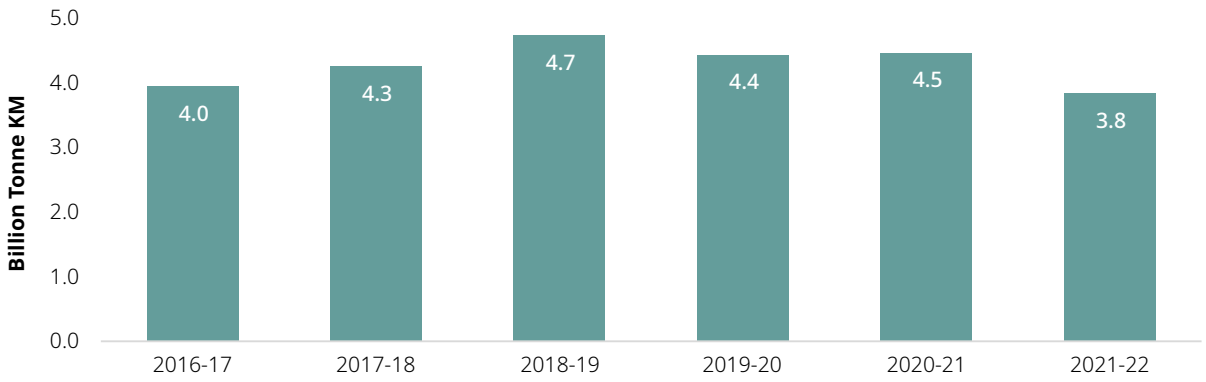


Figure 98: *Freight Mobility Trends of Inland Waterways in Shipping*

Source: (Ministry of Ports, Shipping and Waterways, Mar, 2023)

Fuel Consumption in Shipping

Figure 99 provides a year-on-year fuel consumption. It showcases that FO and HSD are the most consumed fuels by the sector. FO continue to witness a healthy growth with CAGR of 18 percent from 2016-17 to 2023-24. HSD consumption grew at a CAGR of 15 percent during the same period.

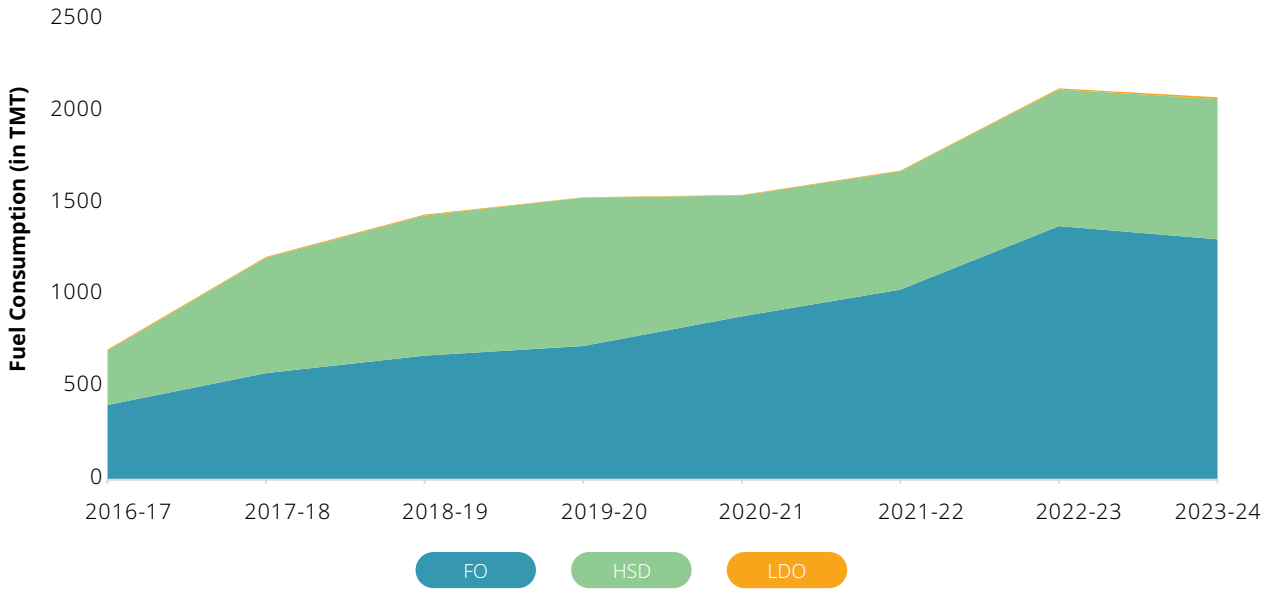


Figure 99: *Fuel Consumption in Shipping*

Source: (MoPNG, 2024)

3.4 Agriculture

The agriculture sector plays an extremely important role in the Indian economy and for the employment of the masses of the country. Often referred to as the backbone of the nation's economy, it contributes to 18.1 percent of India's Gross Value Added (GVA) at current prices in the year 2022-23 (MoSPI, May, 2024) A significant 54.6 percent workforce of India is engaged in agriculture and allied sector activities as per 2011 Census. However, the share of the agriculture sector in India's economy has been gradually decreasing over the last few decades.

The Indian agricultural practices are developed according to its agro-climatic zones, soil diversity and availability of land. The green revolution, other policy changes, mechanisation and now digitalisation, significantly shaped the agriculture sector. Alongside, it is increasingly being recognised that the agricultural sector is vulnerable to climate change and is in a precarious position.

Energy is used in the sector along the value chain from the preparation of land for sowing, to cultivation, irrigation, harvesting, processing, transport and storage. Indirectly, the large-scale use of chemical fertilisers, which are energy intensive to produce, can indirectly contribute to energy usage. In terms of fuel consumption practices, there is an extensive use of electricity for irrigation, while fuel is mostly used for tractors, harvesters or other farm machinery. Figure 100 indicates that the biggest contributor of fuel consumption in the sector over these years has been electricity which continues to increase. In 2023-24, electricity made up to 97 percent of the total fuel consumption in the sector.

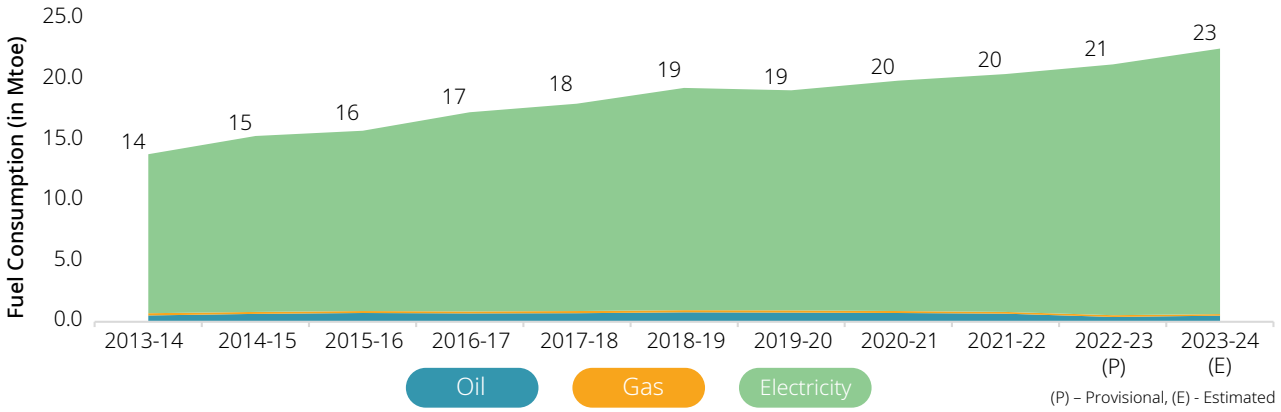


Figure 100: *Energy Consumption Trend in the Agriculture Sector*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministrie

Certain cultivation practices, policies and schemes intended to support farmers and encourage agriculture production, are also contributing to energy intensity of the sector. The agriculture sector receives high amounts of subsidies, particularly for fertilisers and electricity.

The current system of providing subsidies for fertilisers has led to their excessive usage. This overuse poses a major problem due to improper and unsafe handling of these harmful chemicals. Given the implications of the climate crisis, the threat of land and soil degradation and the looming concern of depleting water levels, there is a recognition to transform the agriculture practices. It is imperative to change existing patterns in order to reduce energy usage and minimise environmental impact.

Policies

Enhancing energy efficiency and cutting down on energy usage in the agricultural industry can bring several advantages. It can help accelerate the efforts to reduce carbon emissions, improve agricultural output, and reducing economic burden on DISCOMs and the state by lowering the costs of energy subsidies. Accordingly, the policies introduced into this sector are targeting towards reduction of energy usage and dependence on the subsidised power supply. Discouraging over pumping is largely a matter of change in behaviour. Since farmers currently do not have any incentive to invest in changing their current water and electricity consumption patterns. Therefore, efforts are focused on three aspects-

1. Replacing the traditional water pumps with more energy efficient pumps
2. Encouraging adoption of solar water pumps
3. Feeder separation, as well as solarisation of agriculture feeders.

The **Agricultural Demand-side Management (AgDSM)** programme, is introduced to promote energy efficiency and reduce the total quantum of consumption. Through this programme, inefficient agricultural pump sets are being replaced with BEE 5 star rated and high efficiency pump sets. As of August 2024, a total of 81,180 pumps have been installed in the state of Andhra Pradesh and Uttar Pradesh by the Energy Efficiency Services Limited (EESL) (Ministry of Power, 2024), resulting in peak load demand reduction of 38,932 kW. Other pilot projects were also completed in Maharashtra, Karnataka and Rajasthan.

The DDUGJY scheme, launched in 2014, focuses on separating agriculture and non-agriculture feeders. Maharashtra began this with Gaothan Feeder Separation in 2006. This separation addresses the technical issues and power cuts, benefiting rural consumers and the farmers by dedicating 6-8 hours of power to agricultural feeders. It reduces the financial burden on the DISCOMs, curbs groundwater exploitation, and enhances rural electricity quality. States like Uttar Pradesh, Andhra Pradesh, Karnataka, Gujarat and Punjab actively support feeder segregation.

Other initiatives promote energy-efficient agricultural practices. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) includes programmes like 'Per Drop More Crop' and the 'Micro Irrigation Fund' to enhance water use efficiency. The National Food Security Mission supports millet cultivation, aiming to improve soil fertility and diversify crops needing less energy and water. Aligning these policies with goals of energy efficiency and reduced consumption holds significant potential for enhancing agricultural sustainability.

With the push towards scaling up renewable energy, the **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) Scheme** was introduced in March 2019. The primary objective was to phase out diesel from the farm sector, provide energy and water security to farmers, enhance their income and reduce environmental pollution (PIB a, Feb, 2024). The scheme has three components, the last two which directly target phase out of diesel energised pump sets:

Component A	**Component B**	**Component C**
Setting up 10,000 MW of Decentralised Ground/ Stilt Mounted Grid Connected Solar or RE based Power Plants on farm land	Installation of 14 lakh standalone off-grid solar water pumps	Solarization of 35 lakh existing grid-connected agriculture pumps and through feeder level solarisation (FLS)

Off-grid solar pumps will also give increased access to irrigation facilities in areas that are currently not connected to grid electricity or are dependent on erratic power supply.

Pump Sets Usage

In line with de-dieselisation efforts and other energy efficiency measures there has been a 28 percent decline in the number of diesel pump sets used from 2016-17 to 2020-21.

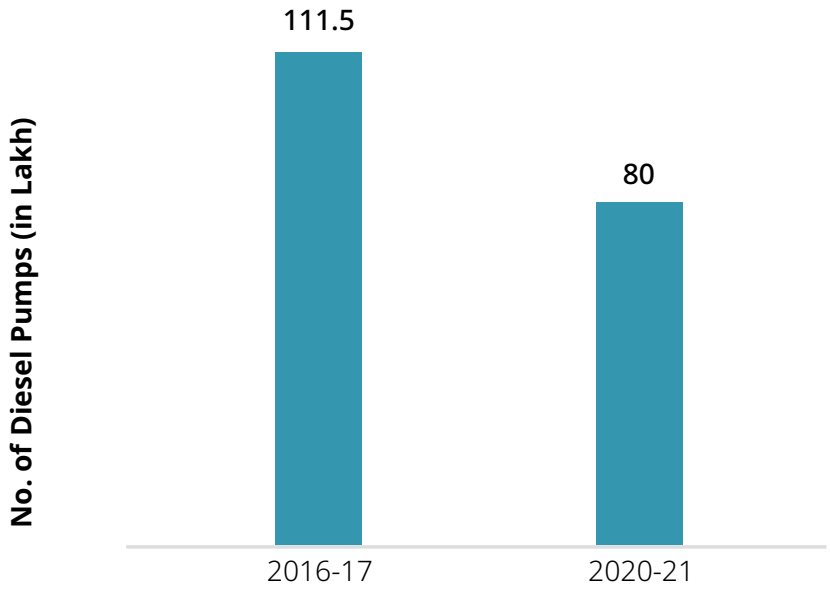


Figure 101: *Number of Diesel Pumps*

Source: (Ministry of Agriculture & Farmers Welfare, 2021)

To improve access to irrigation, energisation of pump sets has been an ongoing process over the past few years with the number of pump sets energised by the end of the 2022-23 totalled to 271.6 Lakhs,

- After a slow increase in setting up of energised pump-sets from 2016-17 onwards, 2020-21 to 2022-23 witnessed a 23 percent increase in energised pump sets.
- The installation of solar pumps has increased by a CAGR of 28 percent from 2016-17 to 2022-23.

Table 22: Number of Pump Sets energised and Solar Pumps (in lakhs)

Year	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Pump sets Energised (in Lakhs)	207.8	215.1	218	220.4	220.9	266.7	271.6
Solar Pumps (in Lakhs)	1.2	1.71	2.37	2.56	2.87	3.5	5.27

Source: (CEA d, 2024) and (MoSPI, 2024)

Out of the total pump sets in the country, Maharashtra, had the highest number of energised pump-sets, accounting for 16.4 percent in 2022-23. Karnataka and Madhya Pradesh followed at 11.48 and 11.44 percent, respectively. (CEA d, 2024). Other states like West Bengal, Telangana, Tamil Nadu and Gujarat also have a significant number of energised pump sets. Recent policy pushes through, PM-KUSUM are encouraging uptake of solar water pumps even further.

Table 23 presents statistics on the implementation status of the PM-KUSUM scheme with regards to the pump sets installation, till 30th September 2024.

Table 23: Status of Component B & C of PM-KUSUM

	Component B	Component C	
	Pumps	Individual Pump Solar (IPS)	Feeder Level Solar (FLS)
Total Sanctioned (No.s)	13,42,327	1,71,640	33,85,494
Total Installed (No.s)	4,99,319	4,759	32,512

Source: (National Portal (PM-KUSUM), 2024)

- Under component B, standalone solar pumps of capacity up to 7.5 HP are being installed in areas where grid electricity supply is not available. Under this component, Haryana and Maharashtra have the highest number of standalone pumps installed.
- Under component C, Rajasthan is leading in solarisation of existing grid connected pumps of capacity up to 7.5 HP. In terms of installing feeder level solar plants, Kerala and Maharashtra are leading.

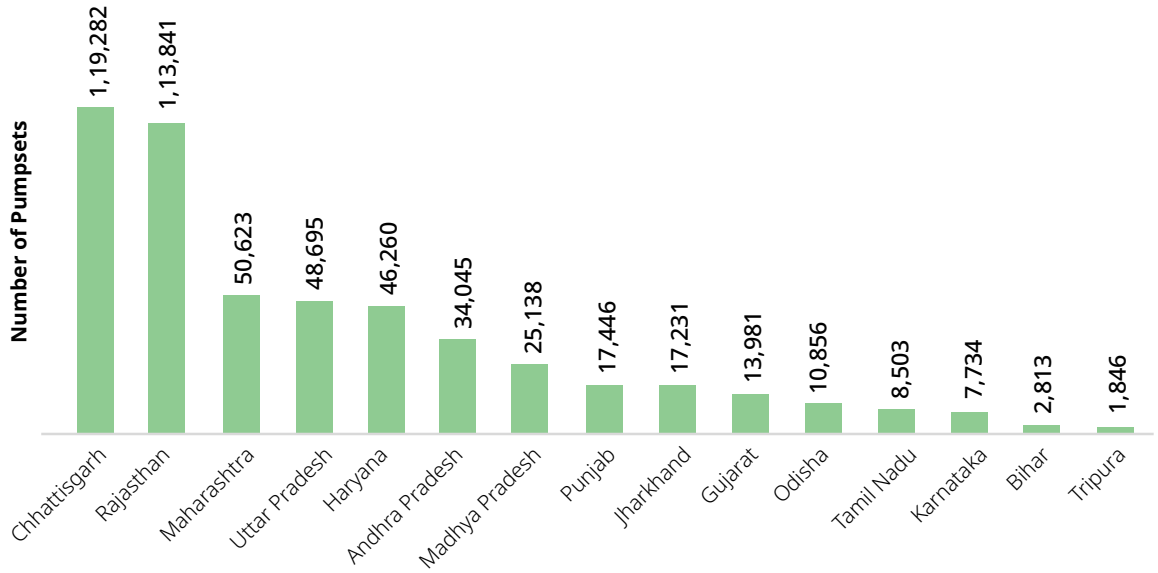


Figure 102: *Top 15 states with highest Number Installation of Solar Photovoltaic Pump Sets till 2023*

Source: (MoSPI, 2024)

- The states of Chhattisgarh and Rajasthan have the highest number of solar water pumps as of 2023.
- Installation of solar pumps is comparatively lower in some energy intensive states like Karnataka and Tamil Nadu.

Agriculture Sector Energy Consumption Trends

a. Electricity Consumption

Figure 103 shows the changes in the electricity consumption patterns. Various factors are influencing this trend such as increase in land area sown with the access to irrigation. 52 percent of cultivable land had access to the irrigation for the first time in 2022-23 (APEDA, May, 2023). It should also be noted that as climate change causes more erratic weather patterns, the dependency of farmers on ground water irrigation, instead of monsoon fed irrigation will likely increase. Such factors can potentially increase the demand for electricity.

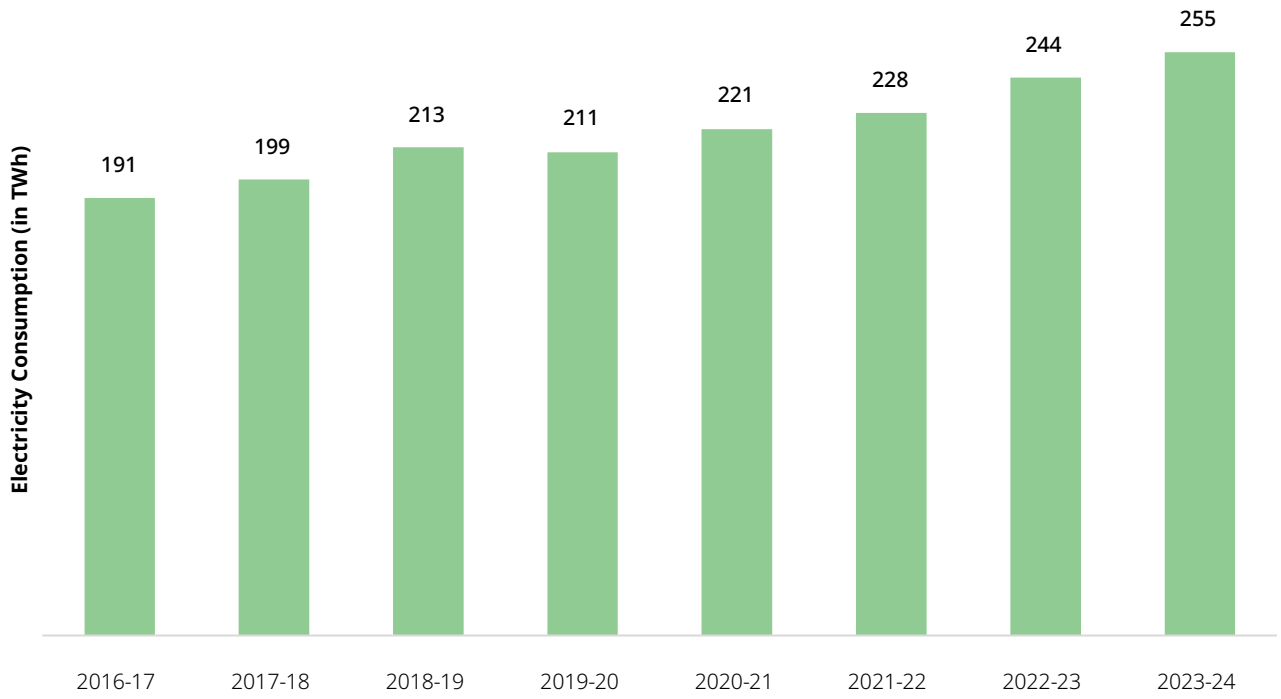


Figure 103: *Electricity Consumption in the Agriculture Sector*

Source: (CEA d, 2024)

Electricity consumption in the agriculture sector has risen at an annual growth rate of 4.2 percent from 2016-17 to 2023-24. This steady rise highlights a growing demand for electricity within the sector over this period.

State Insights on Agriculture Electricity Consumption:

Figure 104 gives an overview of the top 10 states with the highest electricity consumption in the agriculture sector in India, with the share of the agriculture sector in their total electricity consumption.

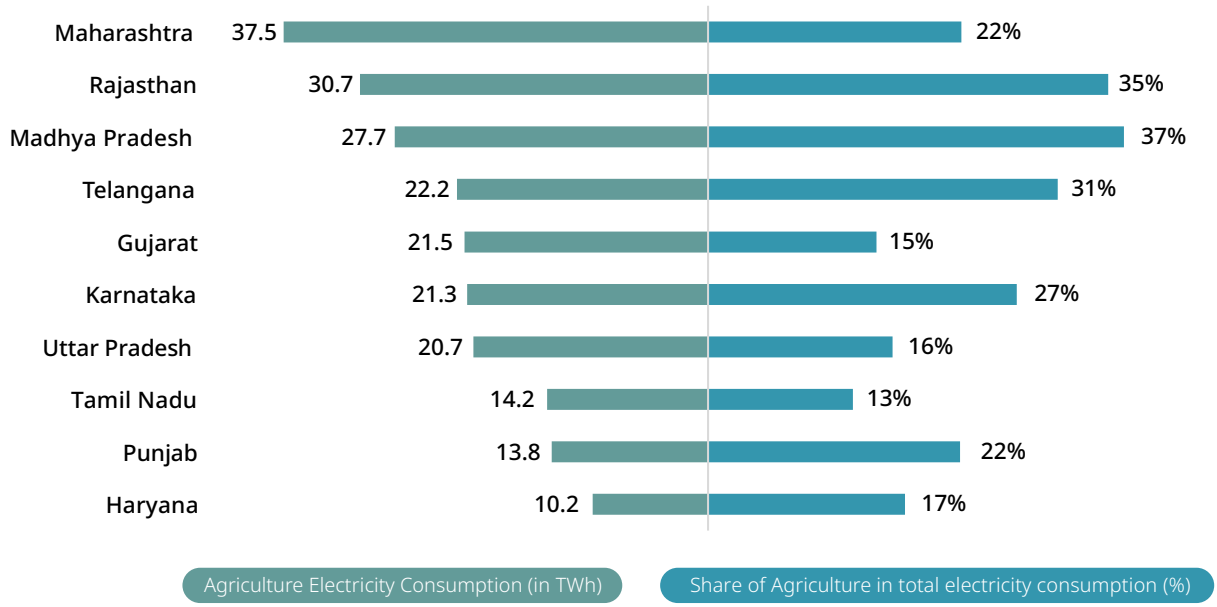


Figure 104: *Top 10 States with Highest Agriculture Electricity Consumption in 2022-23*

Source: (CEA d, 2024)

Given the significance of agriculture for the economy, many states are dependent on the sector, making it an important contributor to their Gross Value Addition (GVA). Figure 105 demonstrates both the percentage share of the agriculture sector in the state GVA alongside the percent share of agriculture in their state's electricity consumption.

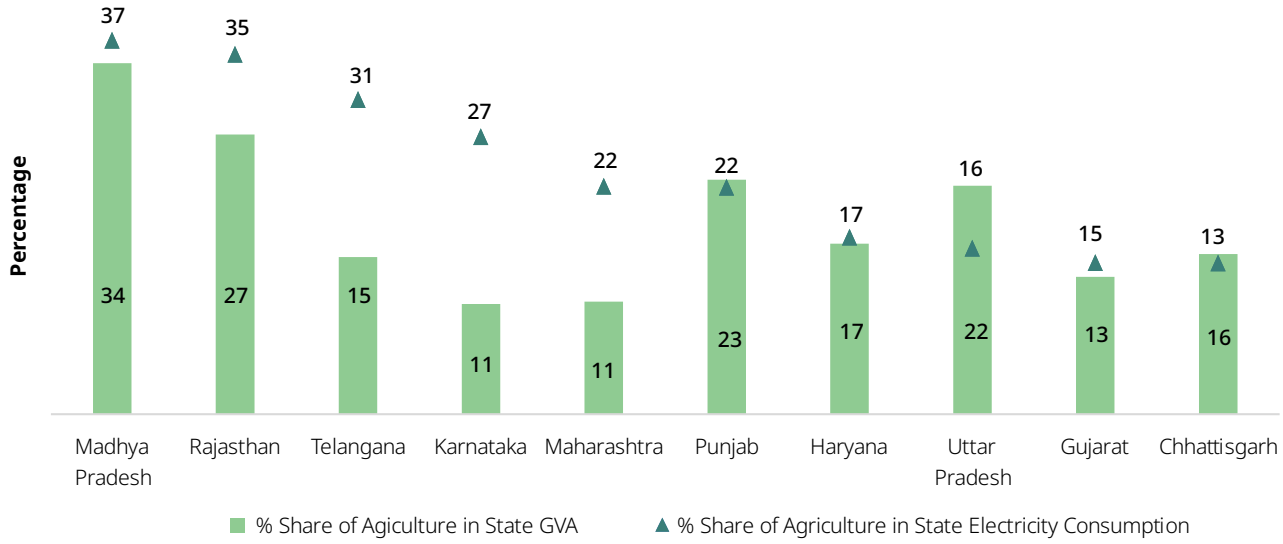


Figure 105: *Top 10 states with share of Agriculture in State Electricity Consumption to Share in State GVA for year (2022-23)*

Source: (Agriculture Statistics, 2022)

- States such as Karnataka, Telangana and Maharashtra have significantly higher electricity consumption compared to the contribution of the agriculture sector to their state's GVA.
- For states such as Nagaland, Arunachal Pradesh, Tripura, Andhra Pradesh, Manipur, Meghalaya, and West Bengal the contribution of the agriculture sector to the state's GVA is higher than their electricity consumption. It can be noted that the states mentioned above witness high rainfall which reduces their need for pumping water for irrigation.

b. Petroleum Product Usage

The Government's push to de-dieselise agriculture by 2024 is bringing considerable change in the usage of petroleum and fuel-based products. This shift is influenced by the push for solarisation of water pumps and exploration of alternate non-fossil-based fuel sources for operating tractors and harvesters.

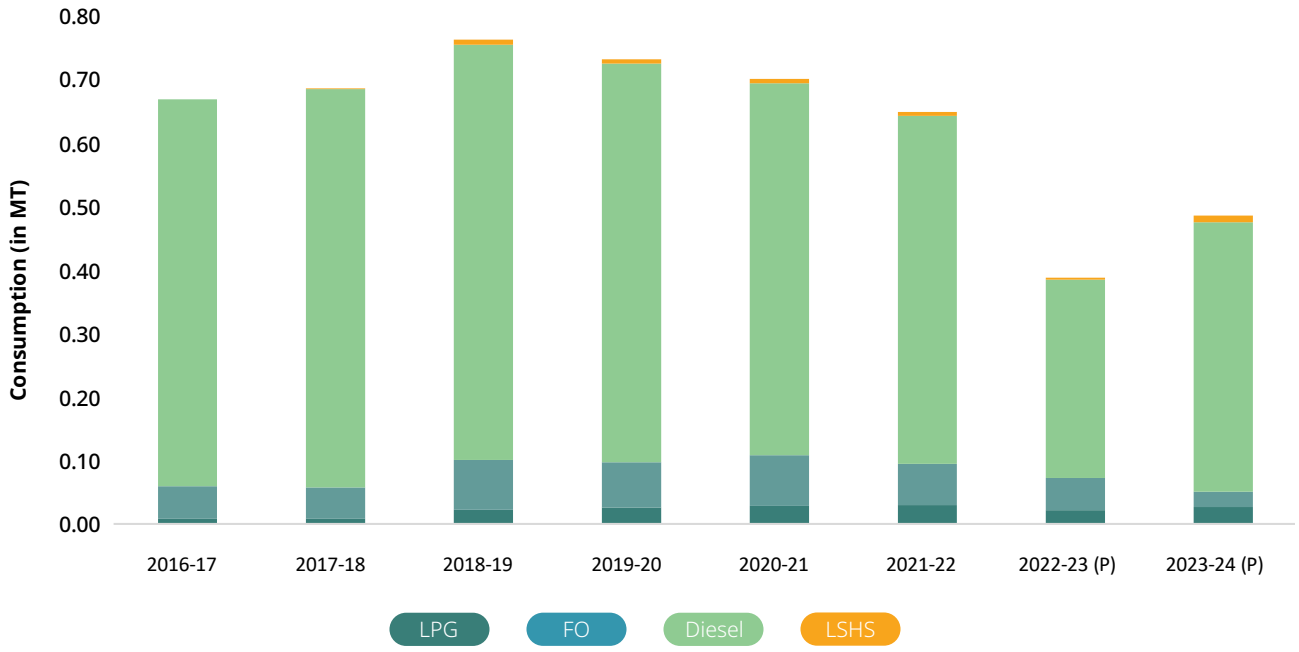


Figure 106: *Petroleum Product Consumption in Agriculture Sector*

Source: (MoPNG, 2024)

- Diesel (including Light Diesel Oil and High-Speed Diesel) is the highest consumed fuel given its usage primarily for running tractors, harvesters and threshers
- There has been a fall in the consumption of diesel after 2019-20, it has reduced by 32 percent in 2023-24 from 2019-20, due to the higher electrification of irrigation pumps and high rain.
- Following diesel, Furnace oil was the second highest fuel source consumed. Its usage rose during 2017-18 to 2020-21 but has dipped again to 0.02 MT in 2023-24.

Data on diesel and electric pump sets is important to track progress on solarisation and de-dieselisation of the agriculture sector. There are, however, data gaps which may make it harder to measure the accurate progress and identify the areas which need more intervention. There is a lack of historical data on diesel pump-sets, as well as year-wise data on the total stock of agricultural irrigation pumps in India. Moreover, energy usage in the sector is not confined to irrigation. Agro-machinery used for cultivation, land preparation and post-harvest operations also use substantial fuel and electricity. Having category wise fuel usage data, electricity consumption for post-harvest processing and installed capacity of cold storages across all states, can be important in further guiding policy intervention for reducing energy consumption in the sector.

The agriculture sector also is tied to usage of natural resources like water and land. It is important to combine the decarbonisation and energy efficient measures with efforts to alter consumption and behavioural patterns to manage energy demand. Here, creating awareness, financial and technical support and providing economic incentives to farmers can help them change their consumption patterns for the better. One example of economically incentivizing prudent and efficient energy usage for pumping is by offering incentives like selling excess solar power generated into the grid, which is an option given under Component C of the PM-KUSUM schemes.

4. Energy Supply and Demand Trend Analysis

Primary Energy Supply

India's primary energy supply is characterised by a dynamic environment influenced by the nation's growing population, rapid urbanisation and industrial expansion. As one of the world's fastest-growing economies, India's energy needs are substantial and diverse. In 2023-24, 88 percent of the country's total primary energy needs are met by coal and oil. The need for coal has grown substantially in the power and industrial sectors, remaining as a predominant fuel in the primary energy mix.

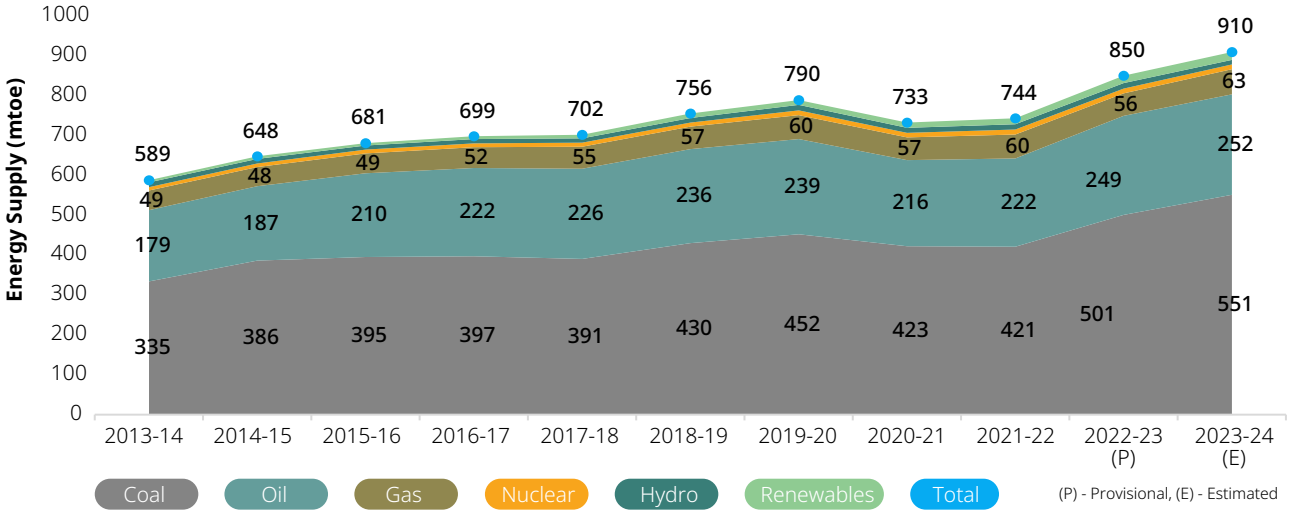


Figure 107: *Source-wise Primary Energy Supply*[6]

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

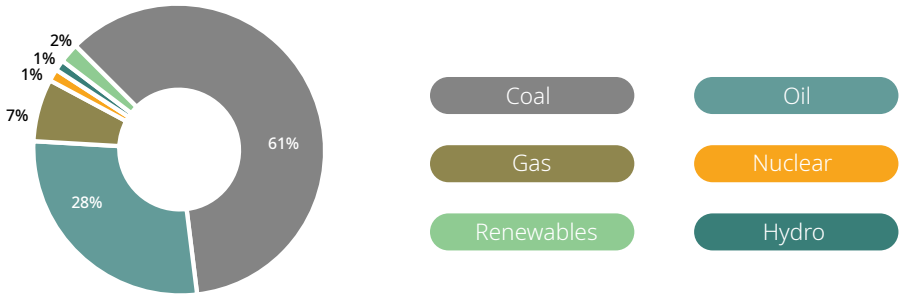


Figure 108: *Source-wise Primary Energy Supply during 2023-24 (Estimated)*

Source: The figures are calculated based on actual data from various ministries

6 Biomass and other non-commercial energy sources are not included

Oil also plays a crucial role, particularly in the industrial and transportation sectors. Over the last ten years, the country has exhibited a high dependence on imported crude oil, consistently exceeding 80 percent. In 2023-24, this dependency rose to 89 percent due to increasing demand. The rise in crude oil imports, coupled with volatile crude oil prices influenced by geopolitical factors underscores the need to ensure a stable energy supply. Changes in vehicle ownership and road transport usage also play a significant role in this dynamic.

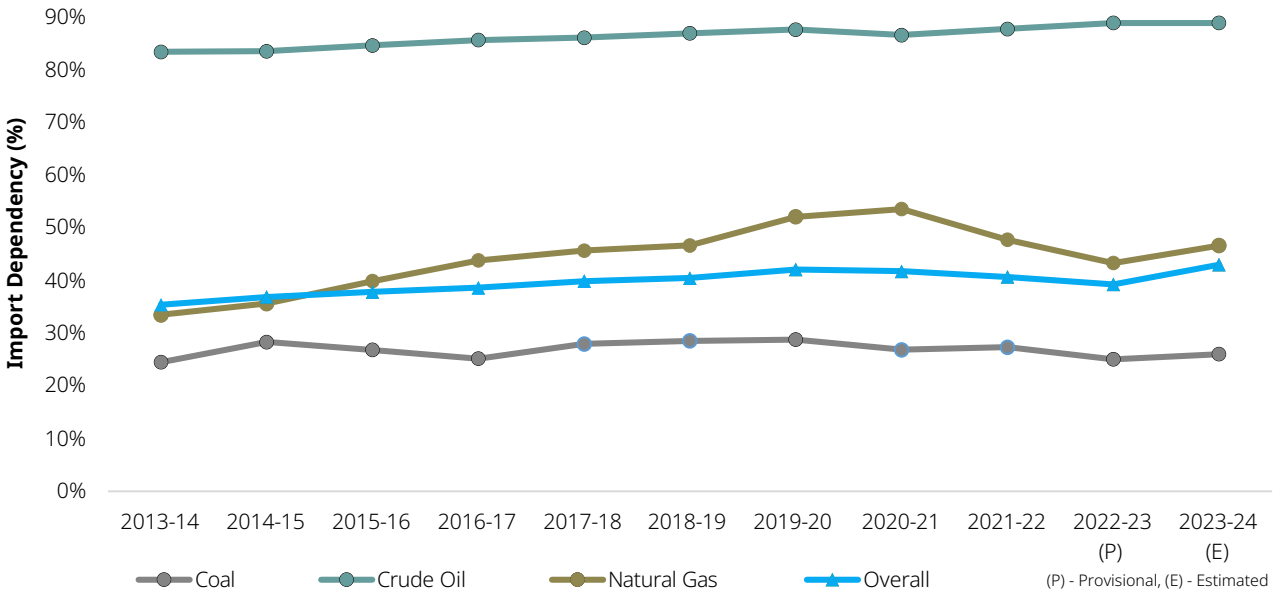


Figure 109: *Import Dependency of the Primary Fuel Supply*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

With an ambitious vision to provide a secure, affordable and sustainable energy to all, India's energy mix has seen substantial contributions made by Renewable Energy (RE). Notably, RE sources experienced a growth of 7 percent in the COVID-19 pandemic year i.e. 2020-21, as compared to 2019-20. India has made a significant progress in adding renewable energy capacity (incl. large hydro) increased from 76 GW in 2013-14 to 191 GW in 2023-24. As a result, it now holds a 3.4 percent share in the primary energy supply. Consistent policy support coupled with steep reductions in RE technology cost and associated market growth favoured to enable this transition.

Natural gas, considered as a cleaner alternative to coal and oil, is gaining traction for expanded use in residential, industrial, transport, and power generation. In 2023-24, natural gas accounts for 6.9 percent of India's primary energy supply mix. In line with the country's commitment to combat air pollution and transition towards cleaner fuel sources, the target is to increase this share to 15 percent by 2030. India imports a significant portion of its natural gas, with 46 percent of its supply coming from Liquified Natural Gas (LNG) terminals, making India the fourth-largest importer of LNG, globally.

Final Energy Consumption

India is the third-largest consumer of energy in the world, after China and the United States (Enerdata, 2024). Traditionally, fossil fuels like coal and oil have dominated the global energy landscape, accounting for over 70 percent of the country's consumption for many years. In 2023-24, oil products had the maximum share of about 39.9 percent, followed by coal with 31.2 percent, electricity with 22.2 percent and natural gas with 6.7 percent (Figure 110).

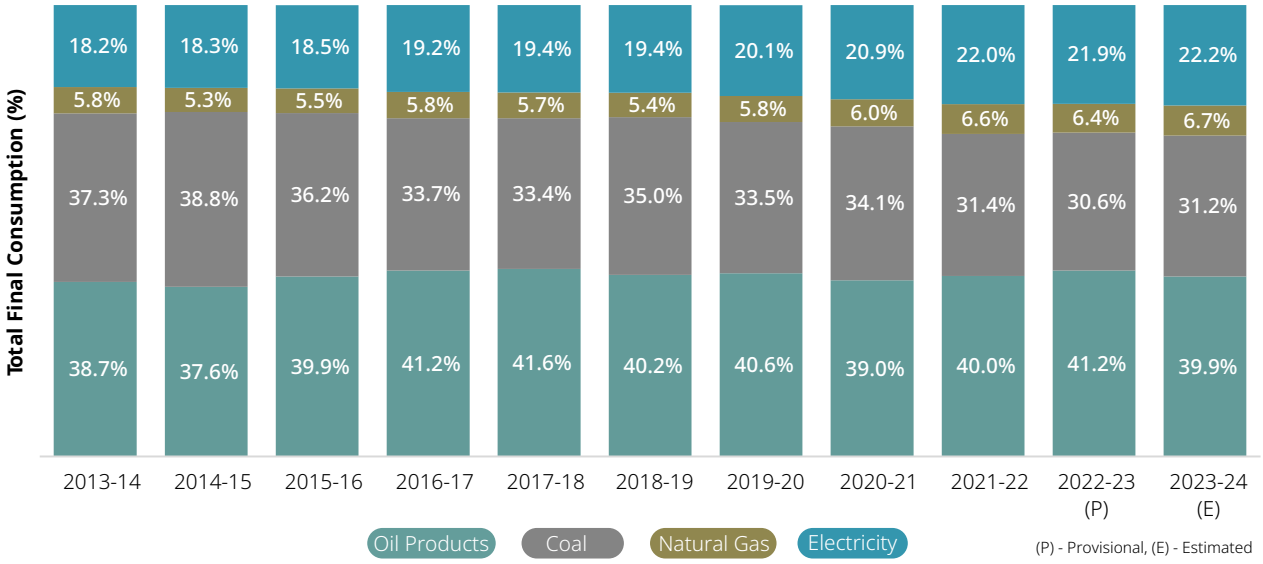


Figure 110: *Fuel-wise share in Total Final Consumption (TFC)*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

Oil products continue to dominate the energy consumption basket, driven by the rapid growth in the country's demographic and economic sectors. This trend is expected to continue in the coming years, particularly in industry, transport, and agriculture.

However, there are signs of significant shifts in India's energy landscape. The share of electricity has steadily increased by 4 percent over the past decade, while the dependence on coal has declined by 6 percent. The growing addition of non-fossil fuel capacity and the rising electrification of end-uses are expected to play a key role in decarbonising India's energy transition.

Sector-wise Energy Consumption

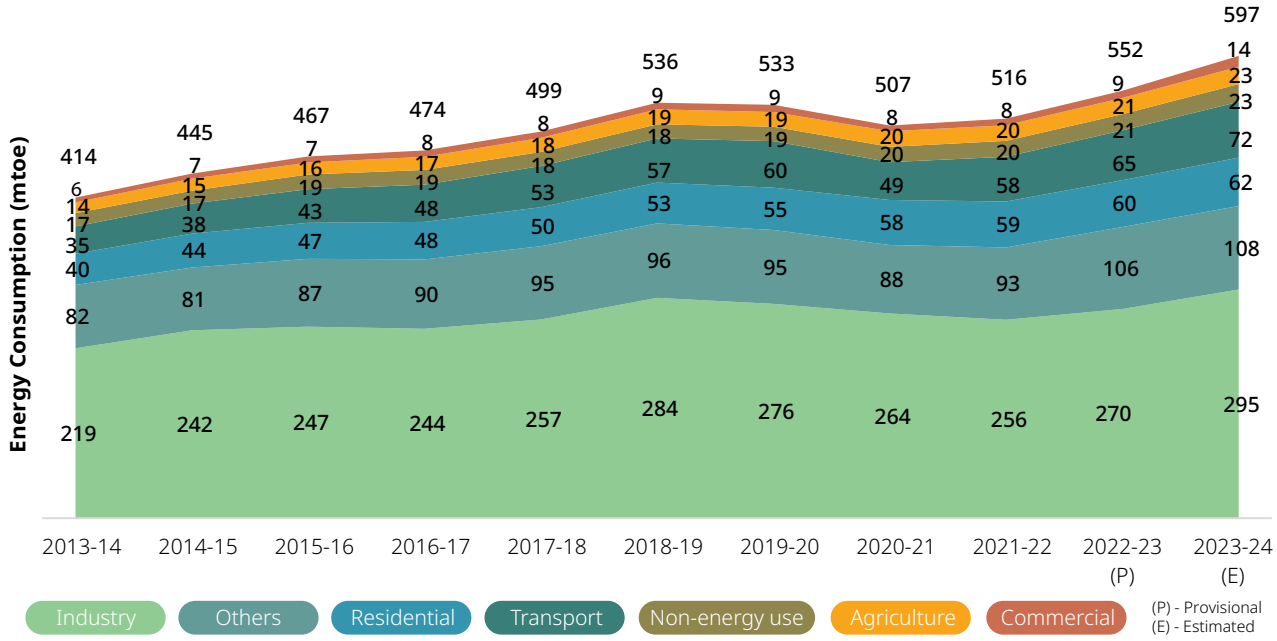


Figure 111: *Sector-wise Energy Consumption*[7]

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

7 Biomass and other non-commercial energy sources are not included

India's demand for energy grew considerably, over the past decade. The total final energy consumption increased from 414 Mtoe in 2013-14 to 597 Mtoe in 2023-24. The industry sector remains the dominant energy consumer, accounting for a significant 49.5 percent share. This demand is primarily driven by key industries like steel, cement, and a large MSME sector, all of which rely heavily on energy for their production processes.

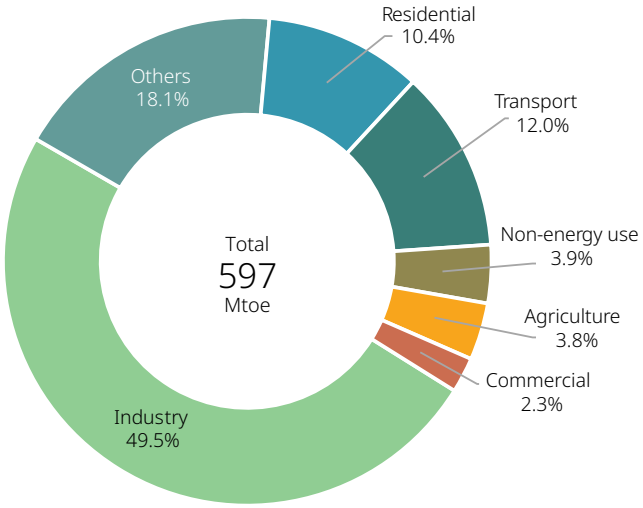


Figure 112: *Sector wise Energy Consumption during 2023-24 (Estimated)*

Source: The figures are calculated based on actual data from various ministries

The transport sector follows industry as a major consumer of energy, accounting for 12 percent of the total consumption in 2023-24. Notably, it witnessed the most significant sectoral increase of 104 percent over the last decade, rising from 35 Mtoe in 2013-14 to 72 Mtoe in 2023-24. This growth is reflected in its rising share from 8 percent to 12 percent within India's energy consumption basket, during the same period. This surge is propelled by growing vehicle usage in the road transport segment and the expansion of transportation infrastructure. Oil remains the dominant energy source in this sector. However, the Indian Government is actively promoting the adoption of electric vehicles, in response to the increasing focus on climate change and the shift towards a low-carbon economy, both globally and nationally. There is an exponential rise in the ownership of Electric Vehicle (EV) in the country rising from a meagre 0.3 percent in 2016-17 to 7 percent in 2023-24.

Indian households account for 10.4 percent share in overall energy consumption in 2023-24 becoming significant contributors in the country's energy consumption. Electricity is the major source of fuel or energy in the residential sector. The residential electricity consumption approximately doubled in 2023-24, rising at 375 BU from 200 BU in 2013-14. The primary factors behind this surge are rising living standards leading to increased appliance ownership and usage and a growing frequency of extreme weather events. More frequent heatwaves and cold spells necessitate greater reliance on cooling and heating systems, further pushing up residential energy demand. Promoting efficient practices for end-use consumption is crucial in recognising the residential sector's substantial energy footprint.

Energy use per Capita

India's per capita energy use has shown a gradual increase over the past decade. From 2013-14 to 2023-24, the total primary energy supply per person rose from 0.47 to 0.65 toe, at an annual growth rate of 3.3 percent in energy availability. Concurrently, the per capita final energy consumption experienced 2.6 percent annual growth, from 0.33 toe per person in 2013-14 to 0.43 toe per person in 2023-24. The per

capita electricity consumption surged significantly at a CAGR of 4.7 percent, from 698 kWh in 2013-14 to 1106 kWh in 2023-24, highlighting both greater access to electricity and increased demand.

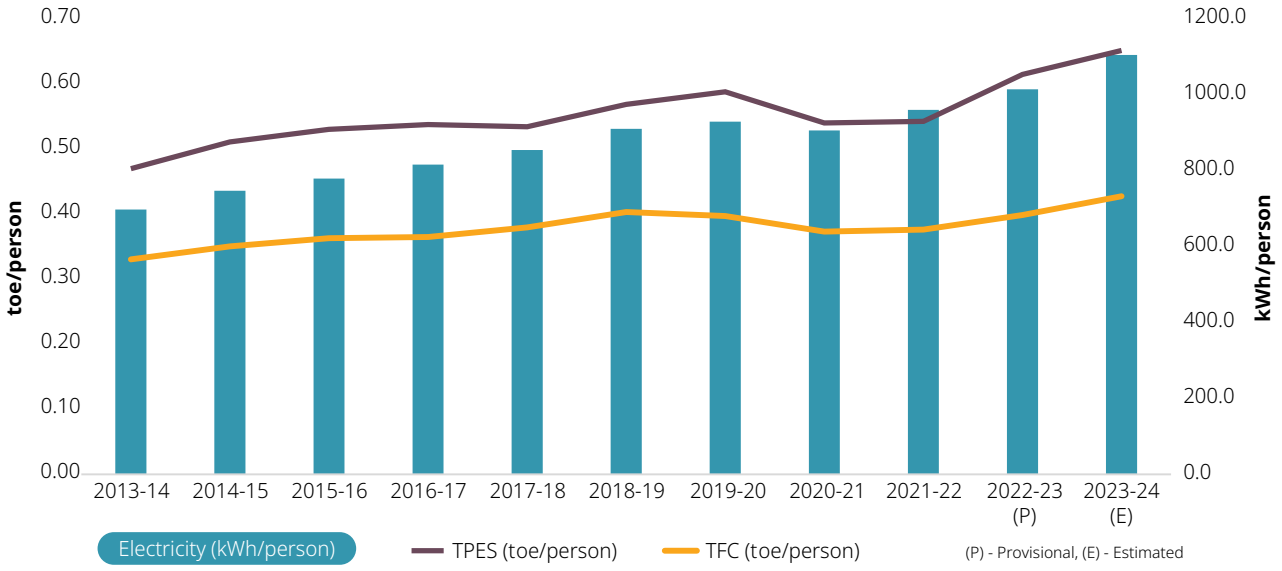


Figure 113: *Energy use per Capita*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

Energy use per unit of GDP

Energy intensity, defined as energy consumption per unit of GDP, serves as a key indicator of a country's energy efficiency and developmental progress. Data reveal that the total primary energy supply per 1,000 rupees of GDP declined from 0.006 toe/1000'rupees in 2013-14 to 0.005 toe/1000'rupees in 2023-24, suggesting enhanced energy efficiency and utilization. Similarly, total final energy consumption per 1,000 rupees of GDP decreased by 2 percent annually, over the past decade.

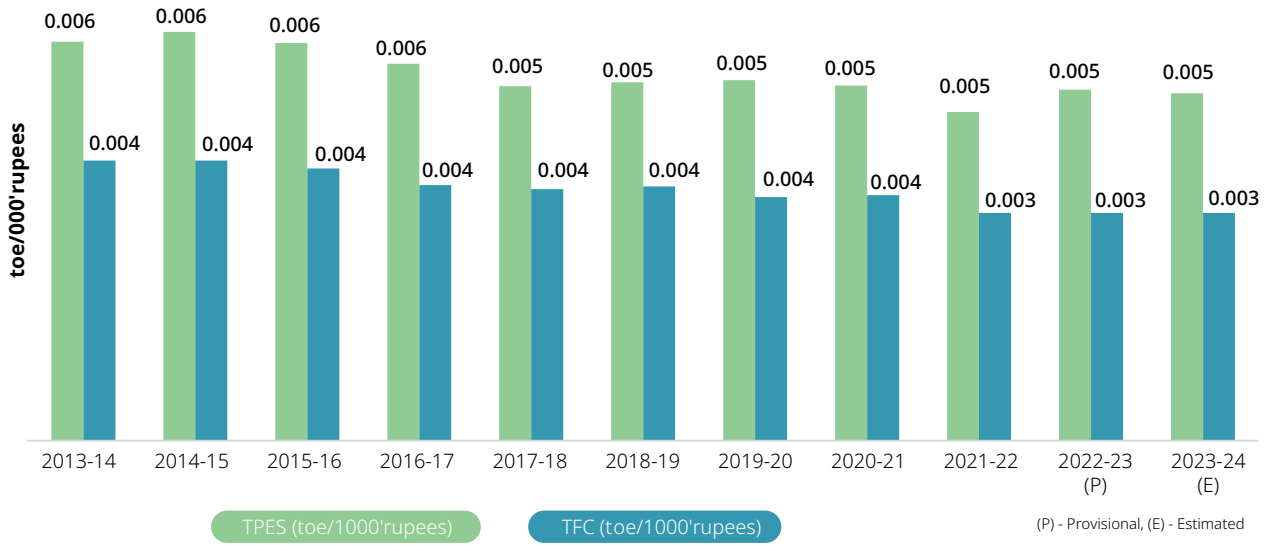


Figure 114: *Energy use per unit of GDP*

Source: (MoSPI, 2024) and for 2023-24, calculated based on actual data from various ministries

Energy Flow

India's energy flow for the year 2023-24 is illustrated through a Sankey Diagram Figure 115. A Sankey diagram demonstrates an entire input and output energy flow within an energy system following energy balance calculations. The width of the line indicates the amount of energy involved. It visually illustrates the flow of energy traced from energy sources to end-use consumption.

During 2023-24, the total primary energy supply reached 910 Mtoe. The coal and oil were predominant sources, collectively making to 88 percent of the primary energy mix. The total consumption in the same period was 597 Mtoe. The industrial sector was the largest consumer, accounting for 49.5 percent of final energy consumption, followed by the transport sector at 12 percent and the residential sector at 10.4 percent.

Conversion losses during the same period amounted to 51 Mtoe, comprising 27 Mtoe from oil refinery losses and 24 Mtoe from transmission and distribution losses.

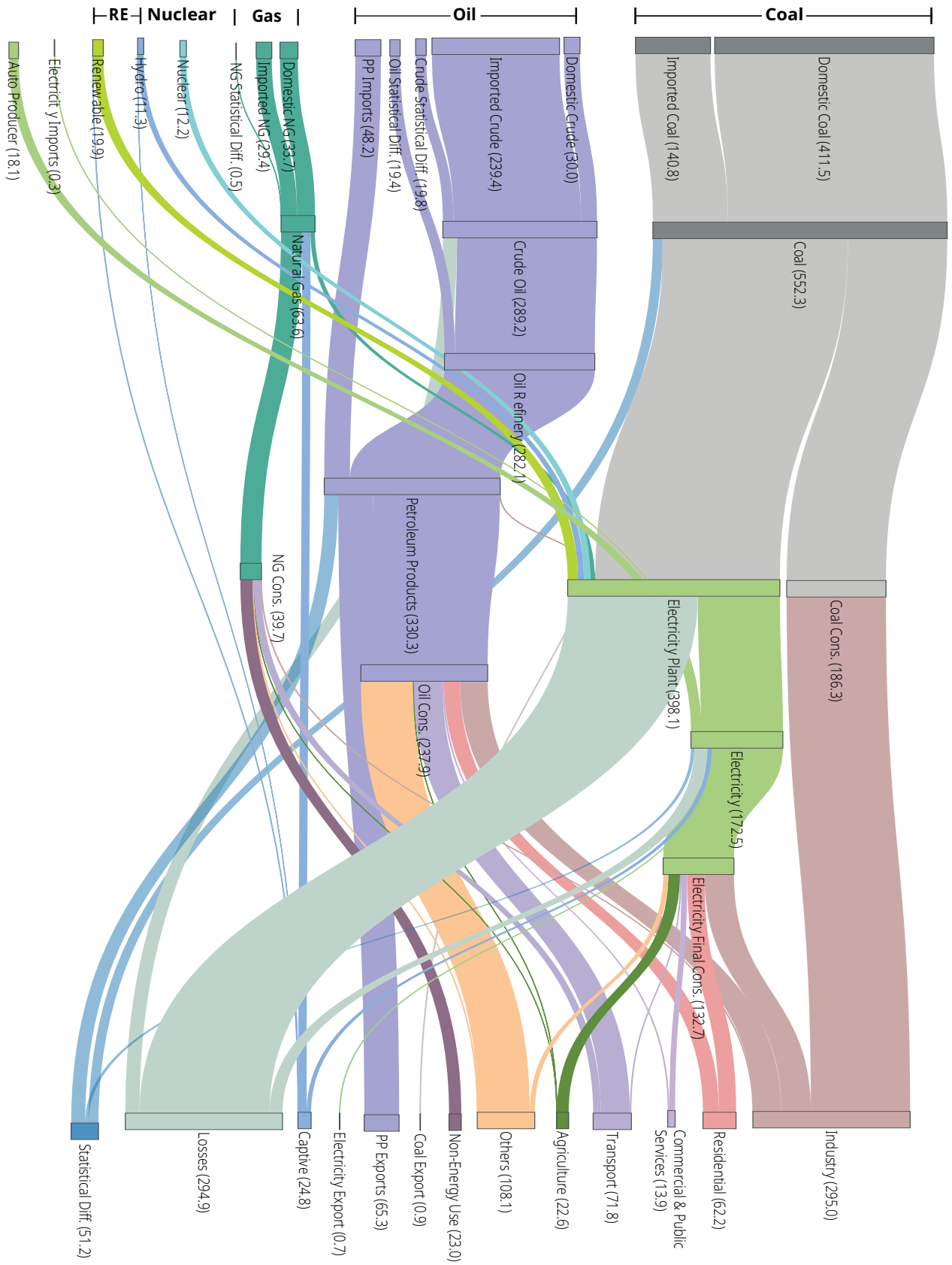


Figure 115: *Sankey Diagram of Overall Energy Flow in India during 2023-24 (in Mtoe) (Estimated)*

Losses include oil refinery losses, thermal losses in electricity power plants, and transmission and distribution losses.

Disclaimer: The energy balance/Sankey diagram for 2023-24 is based on actual data from MoC, MoPnG, CEA, and MoSPI, with values converted into energy units. While every effort has been made to ensure accuracy, minor variations may occur due to data estimation and conversions. All conversion factors are sourced from MoPNG Energy Statistics report.

Energy Balance Breakdown: Analysis Based on Various Schemes Data

In the 2023-24, India's total primary energy supply was 910 Mtoe, while final energy consumption amounted to 597 Mtoe. The industrial sector emerged as the largest energy consumer, accounting for 295 Mtoe, or 49.5 percent of total final energy consumption. Industrial energy consumption data indicates that large quantum of energy usage is linked to unspecified industries, with no further segmentation or detailed insights available for these sectors. To gain clarity on this, data from PAT scheme was analysed to unpack energy consumption across industries. The analysis revealed that the Iron & Steel was the largest energy consumer, utilising 80 Mtoe (27 percent), followed by Cement with 29 Mtoe (10 percent), Fertiliser with 20 Mtoe (7 percent), and Aluminium with 17 Mtoe (6 percent) and 33 Mtoe (11 percent) in other industries (refer Table 24). However, non-specified industries still account for 39 percent (116 Mtoe) of the total industrial energy consumption, which requires further identification and allocation to specific subsectors.

Similarly, there is limited data available for energy consumption at appliance level within buildings, particularly for activities such as cooking, cooling and lighting. To address this gap and enhance further understanding; data from the star labelling program for various appliances was analysed to understand disaggregated energy consumption patterns within buildings. Among the identified categories, cooking represents the largest energy demand share followed by cooling and lighting. However, 26 Mtoe (34 percent) remains unaccounted for, highlighting the need for further mapping and data collection to comprehensively understand appliance level building energy consumption patterns.

Table 24 provides the details on source wise primary energy supply and final energy consumption in different sectors:

Table 24: Energy Balance of India for 2023-24 (Estimated) (All figures are in Mtoe)

	Coal	Lignite	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Electricity	Total
Total Primary Energy Supply	**542**	**10**	**269**	**-17**	**63**	**12**	**11**	**20**	**-0.4**	**910**
Production	402	10	30	-	34	12	11	20	-	519
Imports	141	-	239	48	29	-	-	-	0.3	458
Exports	-1	-	-	-65	-	-	-	-	-1	-67
Total Final Consumption	**185**	**2**	**-**	**238**	**40**	**-**	**-**	**-**	**133**	**597**

	Production	Imports	Exports	Total Primary Energy Supply (in Mtoe)
Coal	402	141	-1	542
Lignite	10	-	-	10
Crude Oil	30	239	-	269
Oil Products	-	48	-65	-17
Natural Gas	34	29	-	63
Nuclear	12	-	-	12
Hydro	11	-	-	11
Solar, Wind, Others	20	-	-	20
Electricity	-	0.3	-1	0
Total	**519**	**458**	**-67**	**910**

Total Final Consumption (in Mtoe)	**597**
Industry	**295**
Iron and Steel	80
Cement	29
Fertilizer	20
Aluminium	17
Petrochemical	5
Chlor Alkali	3
Textile	3
Pulp and Paper	3
New Sectors*	8
MSME#	11
Non-specified Industries (others)	116
Transport	**72**
Road	55
Aviation	9
Rail	4
Pipeline transport	2
Shipping	2
Residential, Commercial & Public Services	**76**
Cooking	33
Cooling	11
Lighting	3
Water Heating	0.3
Other Appliances	3
Non-specified	26
Agriculture/Forestry	**23**
Non-specified (others)	**108**
Non-energy use	**23**

* New sectors include, Automobile, Ceramic, Chemical, Copper, Dairy, Glass, Port, Trust, Tyre manufacturer, Zinc and mining industries.
\# MSME includes, Bricks, Chemical, Food processing, Forging, Foundry, Glass & Refractory, Leather, Paper, Pharma, Steel re-rolling and Textile.

Disclaimer: The energy balance for 2023-24 is based on actual data from MoC, MoPnG, CEA, and MoSPI, with values converted into energy units. While every effort has been made to ensure accuracy, minor variations may occur due to data estimation and conversions. All conversion factors are sourced from MoPNG Energy Statistics report.

5. Energy Conservation: Measures in India

Energy efficiency has become a critical component in India's strategies to sustainably address the growing energy demand. As the world's fastest-growing economy, India faces significant challenges in balancing economic growth with environment preservation. Improving energy efficiency is the key to address such challenges, reduce Greenhouse Gas emissions and minimise reliance on fossil fuels. Implementing energy efficiency measures is a strategic approach in addressing these challenges.

In this context, India implemented its first energy efficiency policy, the Energy Conservation Act, 2001, to optimise the country's energy use. The act further led to the establishment of the BEE which promotes energy efficiency and conservation across various sectors. Since then, the BEE has launched numerous energy efficiency and demand side initiatives that has resulted in significant energy savings across various sectors.

In 2023-24, India's per capita energy consumption was approximately 27.3 gigajoules (GJ). This figure is notably lower than the global average reflecting the country's status as a rapidly developing nation with a large population. This low consumption reflects the country's current stage of economic development and its efforts to ensure energy access for its vast and diverse population.

This chapter delves into the nation's comprehensive efforts in advancing sustainable energy practices and reducing the carbon footprint.

5.1 Impact Assessment of Energy Efficiency (EE) Measures in India

BEE conducts an annual study to assess the impact of various schemes/programmes. The assessments measure the impact by comparing actual energy consumption with the estimated energy consumption that would have occurred in the absence of the current energy efficiency measures, referred to as counterfactual. The primary objective of the study is to evaluate the total energy saved and the reduction in CO_2 emissions resulting from all energy efficiency initiatives in India.

Table 25 highlights the energy savings from various schemes of BEE.

Table 25: Energy Savings from Various Schemes of BEE, 2023-24

Program/ Scheme	Sector	Electricity Savings (BU)	Total Energy Savings (Mtoe)	GHG Reduction (MTCO2e)	Monetary Savings (INR Crore)
PAT-VI	Large Industry		1.30	4.55	
PAT- V		0.008	0.68	2.68	1256.66
PAT- IV		0.009	0.75	2.96	1385.75
PAT- III		0.62	1.59	5.59	3223.20
PAT- II		36.47	14.08	68.43	43078.10
PAT- I		3.01	8.67	31.00	9500.00
BEE-GIZ	MSME	0.00	0.00	0.00	0.74
ECBC	Commercial Buildings	0.64	0.36	0.53	102.02
BEE Star Rating	Commercial Buildings				
GRIHA					
ENS	Residential Buildings				
S&L	Appliances	89.84	7.72	63.7864	56535.8
UJALA	LED Lamps	182.00	15.65	129.22	72800
SLNP	Municipal	8.8	0.7568	6.25	5535
CAFE	Transport		2.04	6.06	6795.56
Total		**321.39**	**53.60**	**321.06**	**200212.84**

Source: BEE database from various scheme (As of Nov. 2024)

Table 25 shows the energy savings from various schemes/programmes of BEE. The implementation of energy efficiency schemes and programmes resulted in saving total energy of 53.60 Mtoe. It accounts for around 6 percent of the total primary energy supply in the country for the year 2023-24.

A total of 25.96 Mtoe thermal energy and 321.39 BU of electricity saving have been achieved through the implementation of various energy efficiency schemes. These energy savings have led to substantial cost reductions of INR 200212.84 crores, as well as a reduction of 321.06 $MTCO_2e$ in greenhouse emissions.

During FY 2023-24, the total saving of energy by the PAT scheme was 51 percent, followed by S&L and UJALA collectively accounting for 44 percent. The share of various schemes in the total energy savings in 2023-24 is presented in the figure below:

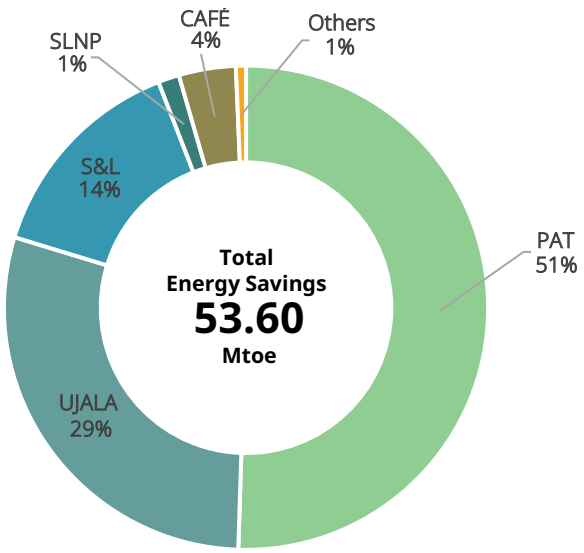


Figure 116: *Scheme wise Total Energy Savings, FY 2023-24*

Source: BEE database from various scheme (As of Nov. 2024)

5.2 Sector-wise Energy Efficiency Achievements

The energy consumption is rising across the various sectors, with the rapid growth of urbanisation and industrialisation. Energy efficiency schemes are implemented in multiple demand sectors, each contributing differently to overall energy savings. The industry sector has the highest contribution with a share of 50 percent while the domestic sector has contributed 44 percent in the total savings achieved.

Table 26: Sector-wise Energy Saving Summary, 2023-24

Sector	Electrical Saving (BU)	Total energy savings (Mtoe)	Emission reduction (Million Tonne of CO2/year)	Estimated monetary savings (INR crore)
Industry[8]	40.11	27.08	115.21	58444.46
Domestic[9]	271.84	23.37	193.01	129335.80
Buildings[10]	0.64	0.36	0.53	102.02
Transport (CAFÉ)	-	2.04	6.06	6795.56
Others (including Municipal)	8.80	0.76	6.25	5535.00
Total	**321.39**	**53.60**	**321.06**	**200212.84**

Source: BEE database from various scheme (As of Nov. 2024)

8 Industry Sector includes the savings from PAT (Excluding – DISCOM, Buildings, Railways) and MSMEs
9 Domestic Sector includes the savings from S&L (except pump sets and DTs) and savings from UJALA programme
10 Includes both commercial and residential buildings

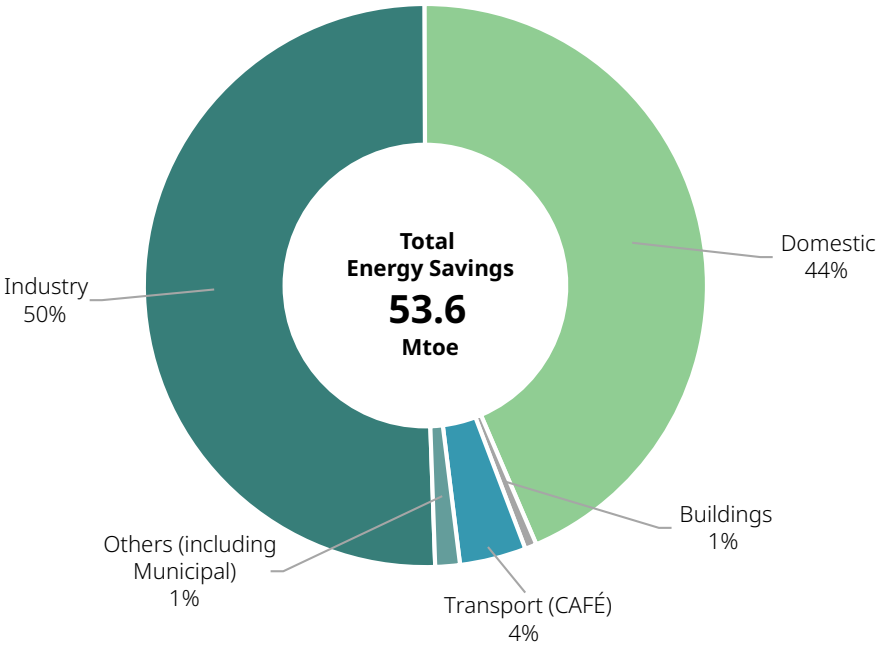


Figure 117: *Industry wise Break-up of Total Energy Savings, 2023-24*

Source: BEE database from various scheme (As of Nov. 2024)

The energy savings data shows that various programmes and schemes have promoted energy efficiency. The implementation of such programmes successfully generated significant savings across major sectors—Industry, Domestic, Buildings and Transport. The cumulative savings from 2013-14 to 2023-24 are illustrated in Figure 118.

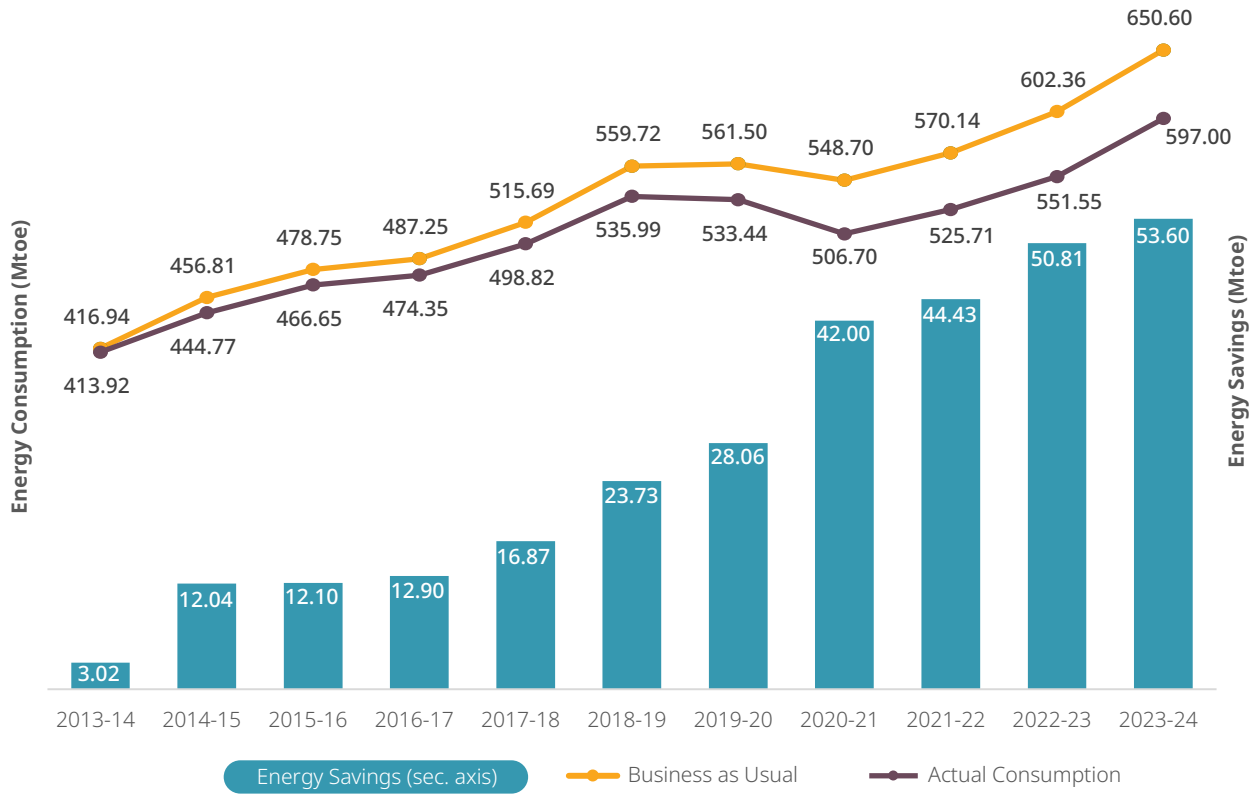


Figure 118: *Impact of Various EE Measures on the Energy Consumption of the Country*

Source: BEE database from various scheme (As of Nov. 2024)

Promoting energy efficiency alongside renewable energy policies lays a robust foundation for meeting future energy demands and mitigating the climate change. These interventions have not only achieved significant energy savings but also enhanced the institutional capacity and heightened awareness of the energy efficiency across India. This dual approach ensures sustainable energy management and fosters a culture of efficiency and environmental responsibility.

6. Sectoral Data Gaps

Robust and efficient data on energy is essential for policymakers and researchers to formulate and analyse comprehensive energy policies. Ensuring data accuracy, consistency and accessibility requires collaboration with various Government bodies and agencies at the National and State Levels. Timely primary data collection, central data repository and, digitalisation remains the cornerstone for an effective and improved data regime. However, it is critical to understand that data on energy sector requires an integration from multiple departments and agencies involved both at national and sub-national level in collecting and managing the energy data across geographies. Numerous studies have identified issues related to inconsistencies and data gaps, offering various recommendations for improving the data quality and usability. This chapter closely examines the energy data management and highlights the data gaps presented in both the supply side and demand side.

6.1 Energy Data Management

Energy data management and data access is an important element to ensure data driven informed policy decisions for robust development planning. In recent times, the data management systems in India have undergone major transformations, with user friendly data dashboards or repository of information being set up by various Ministries and Agencies of both Government of India as well as at the States Level. Some of the robust data management and access systems particularly in the energy sectors are managed by Ministries/Agencies such as the Ministry of Power, Ministry of Coal, Ministry of Petroleum and natural Gas, Ministry of New and Renewable Energy, Ministry of Statistics and Programme Implementation to name a few and agencies such as the Bureau of Energy Efficiency (BEE), Central Electricity Authority (CEA), POSOCO, Petroleum Planning and Analysis Cell (PPAC), National Institute for Transforming India (NITI Aayog), Directorate of Hydrocarbons and Petroleum Conservation Research Association, to name a few. At the state level, a number of State Renewable Energy Development Agencies, District Industry Centres and other departments further contribute to creating reliable and robust data repositories and portals.

However, India's electricity and energy sector is listed in the concurrent list of seventh schedule of the Constitution of India, which primarily means that both the Central and State Governments have jurisdiction of the sector. Further, the sector also has multiple stakeholders, including the private sector playing a substantial role on various aspects of the energy and electricity value chain.

Therefore, while India as a whole has taken a number of admirable and comprehensive initiatives on creating robust data repositories and management of the data repositories; challenges remain in collecting granular and real time data. Further, inconsistencies also persist due to fragmented data collection and

differing methodologies and processes adopted in data collection and management across the sub-national entities.

In order to address this, efforts should be made to identify data gaps and also provide comprehensive solutions such as exploring the creation of common methodologies and approaches and templates for all sub-national entities to guide them on data collection, management and transmission of data for creation of robust centralised data repositories.

6.2 Identification of Data Gaps

In determining the energy demand and supply for the baseline and historical years, the analysis relied on various publicly available data sources published by different ministries and departments. However, this data is often fragmented and difficult to consolidate due to inaccuracies, inconsistencies, reporting delays, limited or inaccurate on-ground surveys, lack of common energy units and the lack of standardised definitions. Additionally, the energy sector contends with issues of data granularity, as most energy-related information is available solely at the national level, rather than at State, District or Sectoral levels. Moreover, accessing archival data frequently poses its own challenges.

Table 27 highlights critical data gaps identified during the data collection exercise. These data are vital for national and state-level policy development, energy planning, and decarbonization strategies. The data on captive power plants is crucial for industrial electrification and estimating GHG emissions, while solar and wind plant mapping is essential for transmission and utility planners, project developers and site selection for installation. Data on biomass availability, potential, and bioenergy projects is crucial for planning and implementing sustainable bioenergy solutions.

On the demand side, detailed information on building stocks, floor space area, and appliance usage is important for understanding energy consumption patterns and designing energy efficiency programs. For instance, air conditioning systems, which are increasingly essential due to extreme summer heat, significantly impact electricity demand and require proper electricity supply planning. Similarly, in the transport sector, data on vehicle fuel consumption and public transport energy use is key for planning sustainable transport solutions and reducing emissions. Additionally, state-wise sectoral fuel consumption and MSME data is needed for developing targeted energy efficiency strategies and decarbonisation pathways.

Table 27: List of sectoral data gaps

Sources	Demand/ Supply Side	Data Gaps	Granularity	Potential Sources
Coal	Supply	List of Captive Coal Power Plants	Plant level	Central Electricity Authority (CEA)
Solar	Supply	Segregation of Solar Generation	Off-grid, Ground mounted and rooftop – State level	Ministry of New and Renewable Energy (MNRE)
	Supply	Plant level information on location, commissioning, capacity, generation and curtailment.	Plant level	MNRE, CEA, National Institute of Solar Energy (NISE)

Sources	Demand/ Supply Side	Data Gaps	Granularity	Potential Sources
Wind	Supply	Plant level information on location, commissioning, capacity, generation and curtailment.	Plant level	MNRE, CEA, National Institute of Wind Energy (NIWE)
Small Hydro	Supply	Plant level information on location, commissioning, capacity, generation.	Plant level	MNRE
Biopower	Supply	Plant level information on location, commissioning, capacity, generation.	Plant level	MNRE, National Institute of Bioenergy (NIBE)
Biomass	Supply	Biomass Supply, Potential & Sectoral Uses	State & Sector level	MoPNG
Bioenergy/ Biofuels	Supply	Biofuel/Bioenergy details	Source of biofuels, beneficiary name, type of biofuels, name of implementing agency, location, production capacity, date of tender award, date of commissioning	MNRE, MOPNG, State Development Agencies (SDA's), State Biofuel authority,
Coal	Demand	Imported coal consumption	State and Sector level (such as cement, washery, steel and others)	Coal Controller's Organisation, Ministry of Coal (MOC)
	Demand	Location of mines, operational status, Implementing agency	Mine wise	Coal Controller's Organisation, MOC
Natural Gas	Demand	Consumption	State and Sector wise sectoral natural gas consumption	PPAC, MOPNG, Directorate General of Hydrocarbons (DGH)

Sources	Demand/ Supply Side	Data Gaps	Granularity	Potential Sources
Petroleum Products	Demand	Sector wise consumption of petroleum products at state level	State wise sectoral consumption of Petroleum products (petrol, diesel, etc)	MOPNG, Annual Survey of Industries, MOSPI, Department of Heavy Industries (DHI), Ministry of Heavy Industries and Public Enterprises, PPAC
Industries	Demand	Sectoral electricity consumption in the industrial sector and its source (grid or captive)	Industry wise and State-wise	CEA, DISCOMs
	Demand	Consumption of different fuels in the industrial sector (break-up of non-specified Industries) and its usage (power, process, feedstock etc.)	Industry wise and State-wise	MoC, MoPnG, MoSPI, ASI

Sources	Demand/ Supply Side	Data Gaps	Granularity	Potential Sources
Buildings (Domestic and Commercial)[11]	Demand	Building Stocks, Floor Space/Area	State/District/City level	Ministry of Housing and Urban Affairs (MoHUA), Urban Local Bodies (ULBs), Municipal Corporation, NSSO, Ministry of Health and Family Welfare, Ministry of Ayush, Ministry of Education Department of School Education and Literacy
	Demand	No. of appliances and corresponding electricity consumption (ACs, Fans, TV, refrigerators, LEDs etc.)	State/District/City level	BEE, NSSO
	Demand	Number of LEED (Leadership in Energy and Environmental Design) and GRIHA Certified Buildings, ECSBC/ECBC complaint buildings	National Level	BEE, GRIHA

11 For commercial buildings: ULBs collect floor area data, as property tax is directly linked to floor area but it is not available in public domain

Sources	Demand/ Supply Side	Data Gaps	Granularity	Potential Sources
Agriculture	Demand	Diesel consumption for pump sets, tractors, for power tiller, combine harvesters, for irrigation, and other machines (weeders, sprayers etc)	Diesel needed per hour, Annual diesel requirement, average hours of machine operations	MoPNG, Ministry of Agriculture, Survey based
	Demand	No. of diesel pump-sets	Historical and year on year data	Department of Agriculture & Farmers welfare, State's Agriculture Department
	Demand	Total stock of agriculture irrigation pump-sets	Yearly	Department of Agriculture & Farmers welfare, State's Agriculture Department
Fisheries	Demand	Fuel consumption (such as diesel)	Sector (marine, inland, aquaculture) & State level	Department of fisheries
Transport	Demand	Load factor / Occupancy Rate	For all type of transport, State level	Ministry of Road Transport and Highways (MoRTH), Surveys
Road Transport	Demand	Vehicle Stock	Historical Data	MoRTH
	Demand	Break-up of HSD consumption	Resellers /Retail sector	MoPNG
	Demand	Public commute (Metro, State bus transport etc.)	No. of passengers, Fuel consumption, Electricity consumption, at State/District/City level	State-wise metro rail corporation websites, DISCOMs

Sources	Demand/ Supply Side	Data Gaps	Granularity	Potential Sources
Air Transport	Demand	Passenger and freight KMs	Yearly	Directorate General of Civil Aviation (DGCA), Ministry of Civil Aviation
	Demand	Energy consumption of airports	Airport level	Airport Authority of India/Ministry of Civil Aviation
	Demand	Solar energy installation/ consumption at airports	Airport level	Airport Authority of India/Ministry of Civil Aviation
	Demand	Aviation Turbine Fuel, Sustainable Aviation Fuel consumption in passenger and freight air transport	Passenger and Freight aircrafts wise	DGCA, Ministry of Civil Aviation
Shipping	Demand	Energy consumption at ports	Port wise	Ministry of Ports, Shipping & Waterways
	Demand	Inland waterways shipping (passenger)	No. of Passengers	Ministry of Ports, Shipping & Waterways
Non-Energy Intensive Industry-MSME	Demand	Cluster details (location, type of industries etc.), production capacity, fuel consumption, electricity consumption,	Cluster level, State level, District level	BEE, Ministry of Micro, Small and Medium Enterprises (MSME), State Industry Departments, ASI

6.3 Recommendations/Suggestions for Effective Energy Data Management

India's ambitious climate and development goals, including the 'Viksit Bharat 2047' and 'Net Zero 2070' vision, necessitate a comprehensive and granular understanding of the energy sector and its developments. Such credible data repositories would help track the progress of various programmes and targets; inform budgetary allocations, enable robust monitoring and verification and facilitate evidence-based decision making.

Further as stated in the earlier sections, since the energy / electricity sector is listed in the concurrent list of seventh schedule of the Constitution of India, which primarily means that both the Central and State Governments have jurisdiction of the sector and with multiple stakeholders involved in decision making and operations of the various functions of the energy and electricity value chain, having a robust and a common methodology and approach in data collection, management and access of the system is absolutely essential to minimise the data gaps.

Therefore, in order to address sectoral gaps in India's energy sector and particularly the key gaps identified and listed out in section 6.2 of this report, the following recommendations are proposed:

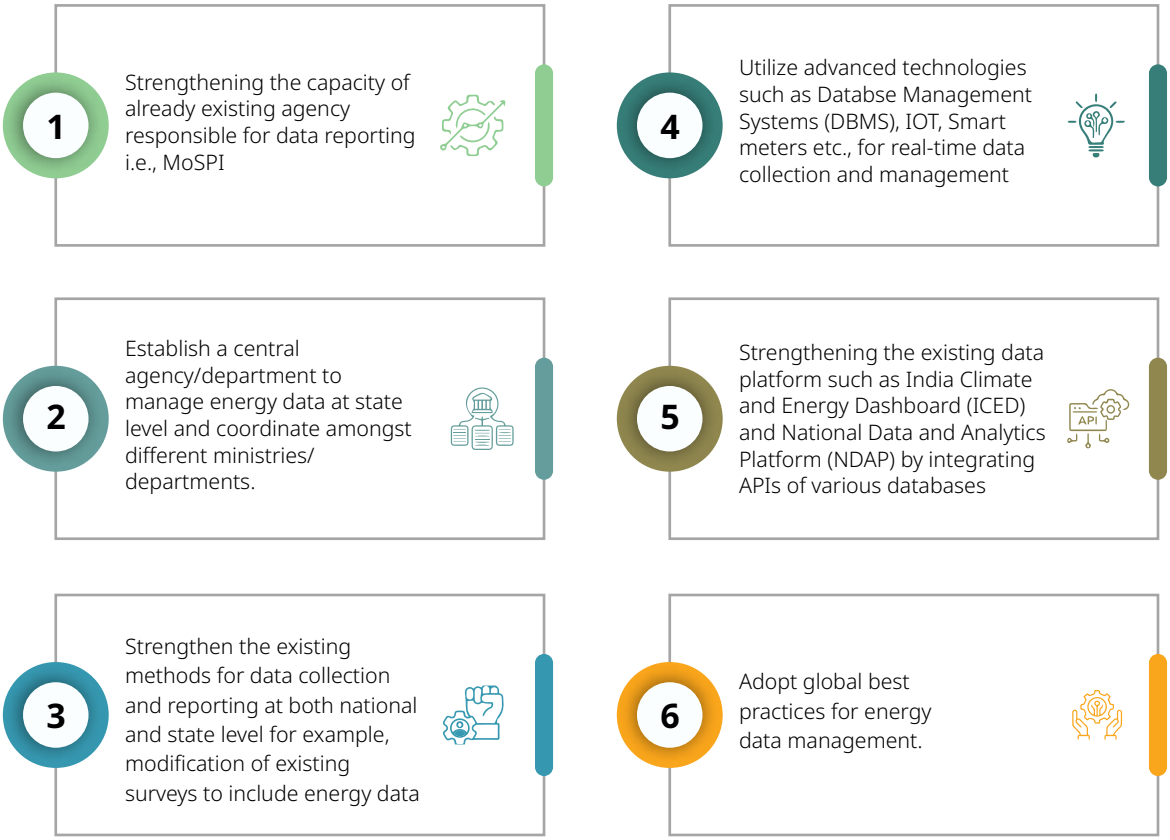


Figure 119: *Recommendation for Addressing Data Gaps Challenges*

In conclusion, as India marches on its energy transition and Viksit Bharat journey, coordinated efforts are already being made by all Ministries/Agencies/Departments of Government of India and sub-national entities in coming up with innovative and impactful approaches informed by data and information in order to meet its set targets. With robust data management, these efforts could further be strengthened and scaled up.

Annexures

Table I: Grade Wise Production of Coking and Non-Coking Coal in India, **Source:** MoC

Type	Grade Type	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Production of Coking Coal	Steel-I	0	0.15	0.04	0.02	0	0.23	0	0.00
	Steel-II	1	0.05	-	0.13	0.01	0	0.06	0.10
	SC-1	0.1	0.18	0.25	0.25	0.22	0	0.25	0.22
	Wash-I	0.3	0.18	0.06	0.14	0.2	0.23	0.17	1.23
	Wash-II	3.4	4.55	4.34	2.3	2.37	2.5	3.78	3.44
	Wash-III	10.8	3.99	6.58	7.36	1.82	1.54	2.64	4.60
	Wash-IV	46	31.04	29.87	33.09	26.94	25.74	31.21	35.55
	Wash-V				9.64	12.8	20.17	22.48	21.21
	Wash-VI				0.01	0.43	1.29	0.17	0.48
	SLV1		-	0	-	-	-	-	-
Total Coking		**61.7**	**40.14**	**41.13**	**52.93**	**44.78**	**51.7**	**60.75**	**66.82**
Production of Non-Coking Coal	G1	2.4	1.7	0.1	0	0	0	0	0.05
	G2	0.3	0.3	0.5	0.3	0	0.09	0.08	0.09
	G3	5.3	3.5	3.3	3.2	2.7	2	1.7	2.59
	G4	17.3	14.5	15.5	14.5	14.2	13	16.1	18.01
	G5	13.6	14.7	12.5	14.6	9.7	8.7	9.9	9.22
	G6	14.1	10.9	7.9	4.6	4.3	5.5	6.6	7.45

Type	Grade Type	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Production of Non-Coking Coal	G7	35.6	36.8	41.3	40.9	37.4	40.7	46.4	55.51
	G8	29.6	41	54.4	45.5	47.7	46.4	53.7	57.81
	G9	38.9	27.5	35.6	37.9	36.7	43.6	53.2	78.41
	G10	98.2	91.5	84.2	78.1	69.9	62.4	73.2	69.53
	G11	143.2	180	199.7	193.9	194.7	223.1	247.6	271.96
	G12	91.8	53.4	66.3	71.6	73.3	77.6	103.6	121.23
	G13	90.9	101.7	111.2	86.9	80.9	100.4	100.1	115.27
	G14	6.4	44.6	41	58.8	66.3	81.2	92.6	93.15
	G15	3.3	7.9	6.9	17.6	26.2	14	17.9	24.59
	G16	4.5	3.5	3.8	4	6.8	7.4	4.3	4.32
	G17	0.5	1.5	3.1	5.3	0.2	0.4	5.4	1.91
	Ungraded	0.3	0.1	0.1	0.2	0.2	0	0.1	-
Total Non-Coking		**596.2**	**635.3**	**687.6**	**677.9**	**671.3**	**726.5**	**832.4**	**931.01**
Total Coal		**657.9**	**675.4**	**728.7**	**730.9**	**716.1**	**778.2**	**893.2**	**997.83**

Table II: Coal Import and Export from 2016-17 to 2023-24 (in MT), **Source:** MoC

Years	Non-Coking		Coking		Others		Total	
	Import	Export	Import	Export	Import	Export	Import	Export
2016-17	149.3	1.7	41.6	0	4.3	0	195.3	1.8
2017-18	161.3	1.4	47	0.1	4.6	0	212.8	1.5
2018-19	183.5	1.2	51.8	0.1	4.9	0	240.3	1.3
2019-20	196.7	1	51.8	0	2.9	0	251.5	1
2020-21	164.1	2.9	51.2	0	2.5	0	217.7	2.9
2021-22	151.8	1.3	57.2	0	2.5	0	211.5	1.3
2022-23	181.6	1.1	56.1	0	3.6	0	241.3	1.2
2023-24	202.8	1.30	58.1	0.08	4.0	0	264.9	1.4

Table III: Overview of Electricity Supply (utility) in the States in 2023-24

States	Region	Installed Capacity (GW)	Share in Total Capacity (%)			Generation (BU)	Share in Total Generation (%)		
			Fossil	Non-Fossil	Renewable Energy		Fossil	Non-Fossil	Renewable Energy
Andaman and Nicobar Islands	ER	0.13	73%	27%	27%	0.38	89%	11%	11%
Andhra Pradesh	SR	29.15	62%	38%	38%	90.08	79%	21%	21%
Arunachal Pradesh	NER	1.26	0%	100%	100%	4.28	0%	100%	100%
Assam	NER	1.89	71%	29%	29%	9.43	89%	11%	11%
Bihar	ER	9.51	95%	5%	5%	58.70	99%	1%	1%
Chandigarh	NR	0.07	0%	100%	100%	0.01	0%	100%	100%
Chhattisgarh	WR	25.37	93%	7%	7%	165.19	98%	2%	2%
Dadra and Nagar Haveli	WR	0.01	0%	100%	100%	0.01	0%	100%	100%
Daman and Diu	WR	0.04	0%	100%	100%	0.02	0%	100%	100%
Delhi	NR	2.55	87%	13%	13%	4.48	84%	16%	16%
Goa	WR	0.09	51%	49%	49%	0.07	0%	100%	100%
Gujarat	WR	52.95	45%	55%	52%	135.40	63%	37%	32%
Haryana	NR	7.59	76%	24%	24%	29.85	94%	6%	6%
Himachal Pradesh	NR	11.36	0%	100%	100%	38.95	0%	100%	100%
Jammu and Kashmir	NR	3.77	5%	95%	95%	16.28	0%	100%	100%
Jharkhand	ER	5.97	93%	7%	7%	35.98	99%	1%	1%
Karnataka	SR	31.83	30%	70%	67%	91.47	49%	51%	43%

States	Region	Installed Capacity (GW)	Share in Total Capacity (%)			Generation (BU)	Share in Total Generation (%)		
			Fossil	Non-Fossil	Renewable Energy		Fossil	Non-Fossil	Renewable Energy
Kerala	SR	3.92	18%	82%	82%	7.36	0%	100%	100%
Ladakh	NR	0.14	0%	100%	100%	0.39	0%	100%	100%
Lakshadweep	SR	0.03	84%	16%	16%	0.06	100%	0%	0%
Madhya Pradesh	WR	31.33	70%	30%	30%	164.78	90%	10%	10%
Maharashtra	WR	46.14	59%	41%	38%	169.04	81%	19%	14%
Manipur	NER	0.16	23%	77%	77%	0.31	0%	100%	100%
Meghalaya	NER	0.40	0%	100%	100%	0.88	0%	100%	100%
Mizoram	NER	0.14	0%	100%	100%	0.22	0%	100%	100%
Nagaland	NER	0.11	0%	100%	100%	0.25	0%	100%	100%
Odisha	ER	12.37	77%	23%	23%	73.03	90%	10%	10%
Puducherry	SR	0.08	39%	61%	61%	0.24	95%	5%	5%
Punjab	NR	8.84	64%	36%	36%	41.26	79%	21%	21%
Rajasthan	NR	40.09	29%	71%	68%	116.85	53%	47%	41%
Sikkim	ER	2.34	0%	100%	100%	8.62	0%	100%	100%
Tamil Nadu	SR	39.93	38%	62%	56%	123.31	61%	39%	27%
Telangana	SR	17.05	55%	45%	45%	65.67	87%	13%	13%
Tripura	NER	1.10	97%	3%	3%	6.36	100%	0%	0%
Uttar Pradesh	NR	33.03	81%	19%	17%	165.05	93%	7%	5%
Uttarakhand	NR	5.64	12%	88%	88%	15.46	4%	96%	96%
West Bengal	ER	15.55	87%	13%	13%	94.25	95%	5%	5%

Table IV: Overview of Electricity Consumption and Peak Demand in the States

State	Peak Demand in 2023-24		Peak Demand Season	Peak Demand Growth Rate (%)	Electricity Consumption (BU) (in 2022-23)	Electricity Consumption Growth Rate (%)	Sector Contributing Most to Total Electricity Use	Share of the dominating Sector in Total Electricity Use (%)	Per-capita Electricity Consumption (kWh) (in 2022-23)
	GW	Month		2016-17 to 2023-24		2016-17 to 2022-23			
Andaman and Nicobar Islands	0.1	Mar	Dec-Mar	7.2%	0.3	1.1%	Domestic	56.2%	932.0
Andhra Pradesh	13.2	Mar	Feb-Jun	7.5%	71.6	5.6%	Industry	42.8%	1634.0
Arunachal Pradesh	0.2	Feb	Dec-Mar	3.3%	0.6	7.8%	Domestic	40.6%	651.0
Assam	2.4	Sep	May-Sep	5.4%	11.3	7.2%	Domestic	43.0%	398.0
Bihar	8.0	Aug	May-Sep	11.0%	31.0	9.9%	Domestic	51.8%	348.0
Chandigarh	0.4	Aug	Jun-Sep	1.9%	1.7	0.6%	Domestic	48.0%	1674.0
Chhattisgarh	6.1	Mar	Jan-Mar	6.8%	46.3	4.3%	Industry	62.5%	2117.0
Dadra and Nagar Haveli and Daman and Diu	1.3	Aug	Jun-Oct	2.5%	9.4	3.8%	Industry	95.4%	8870.0
Delhi	7.4	Aug	May-Sep	2.3%	34.1	4.2%	Domestic	53.2%	1848.0
Goa	0.8	Jun	Feb-Jun	5.2%	5.1	6.0%	Industry	56.1%	3360.0
Gujarat	24.8	Sep	Jun-Oct	7.8%	144.6	4.2%	Industry	65.4%	2393.0
Haryana	13.1	Aug	Dec-Mar	5.1%	58.6	8.7%	Industry	38.8%	2360.0
Himachal Pradesh	2.2	Jan	Nov-Mar	5.5%	11.1	5.4%	Industry	58.8%	1799.0
Jammu and Kashmir	3.2	Jan	Dec-Mar	2.5%	9.8	3.6%	Domestic	46.1%	1526.0

State	Peak Demand in 2023-24		Peak Demand Season	Peak Demand Growth Rate (%)	Electricity Consumption (BU) (in 2022-23)	Electricity Consumption Growth Rate (%)	Sector Contributing Most to Total Electricity Use	Share of the dominating Sector in Total Electricity Use (%)	Per-capita Electricity Consumption (kWh) (in 2022-23)
	GW	Month		2016-17 to 2023-24		2016-17 to 2022-23			
Jharkhand	2.2	Aug	Apr-Aug	5.6%	34.2	5.0%	Industry	70.7%	992.0
Karnataka	17.2	Mar	Jan-Apr	7.7%	78.1	1.4%	Industry	34.2%	1425.0
Kerala	5.3	Mar	Feb-Jun	3.6%	26.0	3.6%	Domestic	48.1%	882.0
Lakshadweep	0.0	Mar	Feb-May	6.0%	0.1	1.4%	Domestic	71.9%	960.0
Madhya Pradesh	18.3	Jan	Oct-Feb	6.8%	75.4	7.1%	Agriculture	36.7%	1230.0
Maharashtra	31.2	Aug	Apr-Sep	4.8%	167.5	4.6%	Industry	42.3%	1676.0
Manipur	0.3	Jan	Dec-Mar	6.8%	0.8	8.7%	Domestic	61.4%	354.0
Meghalaya	0.4	Jan	Dec-Mar	2.9%	1.8	6.7%	Industry	56.6%	730.0
Mizoram	0.2	Jan	Oct-Feb	7.4%	0.5	5.7%	Domestic	62.6%	564.0
Nagaland	0.2	Aug	Jun-Oct	2.3%	0.7	1.3%	Domestic	60.1%	445.0
Odisha	6.4	Jun	Mar-Jun	7.0%	79.7	10.5%	Industry	81.2%	2419.0
Puducherry	0.5	May	May-Aug	5.1%	3.0	1.9%	Industry	62.6%	2145.0
Punjab	15.3	Jun	Jun-Sep	4.3%	62.0	4.9%	Industry	37.3%	2574.0
Rajasthan	18.1	Jan	Nov-Jan	7.9%	87.0	6.0%	Agriculture	35.3%	1501.0
Sikkim	0.1	Feb	Dec-Mar	2.5%	0.5	2.0%	Industry	59.1%	954.0
Tamil Nadu	19.0	Apr	Feb-Jun	3.6%	111.2	3.3%	Industry	42.4%	1763.0

State	Peak Demand in 2023-24		Peak Demand Season	Peak Demand Growth Rate (%)	Electricity Consumption (BU) (in 2022-23)	Electricity Consumption Growth Rate (%)	Sector Contributing Most to Total Electricity Use	Share of the dominating Sector in Total Electricity Use (%)	Per-capita Electricity Consumption (kWh) (in 2022-23)
	GW	Month		2016-17 to 2023-24		2016-17 to 2022-23			
Telangana	15.6	Mar	Dec-Apr	7.9%	71.8	7.1%	Agriculture	30.9%	2349.0
Tripura	0.4	Jun	Apr-Jul	3.5%	1.2	4.3%	Domestic	55.5%	444.0
Uttar Pradesh	28.7	Jul	May-Sep	7.6%	127.1	5.7%	Domestic	41.1%	723.0
Uttarakhand	2.6	Jan	Dec-Feb	3.7%	14.4	2.6%	Industry	54.4%	1536.0
West Bengal	11.6	Jun	Apr-Sep	5.6%	61.9	4.9%	Industry	40.9%	819.0

Table V: Star wise Appliances Production (FY 2023-24)

S. No	Appliances	5 Star	4 Star	3 Star	2 Star	1 Star	Total Sales
1	Frost Free Refrigerators	0	420	687628	2890163	275197	3853408
2	TFL	0	0	311205	18000	16757722	17086927
3	Room Air Conditioner (Fixed Speed)	10725	2169	1047847	371192	123386	1555319
4	Direct Cool Refrigerators	1669268	874326	3701464	2342972	2753261	11341291
5	Distribution Transformer	48987	18	65	148991	242193	440254
6	Colour Television	25553	222478	1358298	2100800	2707054	6414183
7	Stationary Storage Type Electric Water Heater	3324354	1715212	516957	54004	618	5611145

S. No	Appliances	5 Star	4 Star	3 Star	2 Star	1 Star	Total Sales
8	Room Air Conditioner (Variable Speed)	3013289	180142	6077471	23588	278	9294768
9	LED LAMPS	263450	72300	136016784	239516853	42944844	418814231
10	Ceiling Fan	7746231	64437	507243	1199821	51700658	61218390
11	Deep Freezers	400553	163407	206356	8612	3852	782780
12	Light Commercial Air Fixed Conditioners	0	0	4682	6109	15486	26277
13	Light Commercial AC Variable Speed	13584	2494	13066	7150	109	36403
14	Submersible Pump Set	203231	246396	252703	96265	65259	863854
15	Openwell Submersible Pump Set	183461	70774	30782	45357	12731	343105
16	Microwave Oven	0	0	2794	3448	0	6242
17	Washing Machine	11039017	31944	394051	4784	0	11469796
18	Computer	0	0	0	0	0	0
19	Domestic Gas Stove	0	0	0	103184	298583	401767
20	Monoset Pump	24048	1900	32349	11524	1177	70998
21	Chillers	2	25	104	25	0	156
	Totals	**27965753**	**3648442**	**151161849**	**248952842**	**117902408**	**549631294**

Table VI: State-wise data on Share of Agriculture in State Electricity Consumption to Share in State GVA for FY 2022-23

State/UTs	% Share of Agriculture in State Electricity Consumption	% Share of Agriculture in State GVA
Madhya Pradesh	36.7	34.4
Rajasthan	35.3	27.4
Telangana	30.9	15.4
Karnataka	27.3	10.8
Maharashtra	22.4	11.0
Punjab	22.3	23.0
Haryana	17.4	16.7
Uttar Pradesh	16.3	22.4
Gujarat	14.9	13.5
Chhattisgarh	14.8	15.7
Andhra Pradesh	13.2	30.7
Tamil Nadu	12.8	11.1
Bihar	12.2	20.2
Tripura	4.8	25.6
Jammu and Kashmir	3.7	15.5
Uttarakhand	2.9	7.8
West Bengal	2.6	18.8
Puducherry	2.0	4.0
Kerala	1.5	8.5
Himachal Pradesh	0.8	13.5
Odisha	0.8	14.9
Goa	0.7	5.7
Manipur	0.7	18.0
Assam	0.6	15.9
Andaman and Nicobar Islands	0.5	11.1
Jharkhand	0.4	11.5
Mizoram	0.2	15.3
Delhi	0.1	0.3
Chandigarh	0.1	0.5
Arunachal Pradesh	0.0	23.6
Meghalaya	0.0	16.3
Nagaland	0.0	23.7
Sikkim	0.0	6.4

* Ladakh, Sikkim, Nagaland, Mizoram, Lakshadweep, Daman & Dui and D & N Haveli not included due to lack of data

Table VII: List of Appliances Covered Under the S&L Programme (As on Nov. 2024)

S. No.	Appliance	Category
1	Frost Free Refrigerator	Mandatory
2	Tubular Fluorescent Lamps (TFL)	Mandatory
3	Room Air Conditioner (Fixed Speed)	Mandatory
4	Direct Cool Refrigerator	Mandatory
5	Distribution Transformer	Mandatory
6	Colour TV	Mandatory
7	Stationary Storage type Electric Water Heater	Mandatory
8	Room Air Conditioners (Cassette, Floor Standing Tower,Ceiling, Corner AC)	Mandatory
9	LED Lamps	Mandatory
10	Room Air Conditioner (Variable Speed)	Mandatory
11	Light Commercial AC	Mandatory
12	Ceiling Fans	Mandatory
13	Deep freezer	Mandatory
14	Ultra High Definition (UHD) Colour Television	Mandatory
15	Washing Machine (Semi/Top load/Front load)	Mandatory
16	Chillers	Mandatory
17	Pump Sets	Voluntary
18	Induction Motors	Voluntary
19	Computer (Notebook/Laptops)	Voluntary
20	Ballast (Electronic/Magnetic)	Voluntary
21	Solid State Inverter	Voluntary
22	Office Equipment	Voluntary
23	LPG-Stoves	Voluntary
24	Diesel Generator Sets	Voluntary
25	Diesel Engine Mono-set Pumps	Voluntary

S. No.	Appliance	Category
26	Microwave Oven	Voluntary
27	Solar Water heater	Voluntary
28	Air Compressor	Voluntary
29	High-Energy Lithium-Ion Traction Battery Packs and Systems	Voluntary
30	Tires	Voluntary
31	Induction Hob	Voluntary
32	Side by Side / Multi Door Refrigerator	Voluntary
33	Pedestal Fan	Voluntary
34	Table/ Wall Fan	Voluntary
35	Solar Photovoltaic	Voluntary
36	Packaged Boiler	Voluntary
37	Commercial Beverage Coolers	Voluntary
38	Grid Connected Solar Inverter	Voluntary
39	Refrigerant Compressor	Voluntary

The detailed data on appliances production and energy savings incurred under S&L programme of BEE can be accessed from UDI Portal: https://udit.beeindia.gov.in/standards-labeling/#1563005183370-4b3f749f-06a9ef52-cb54d587-ed5e

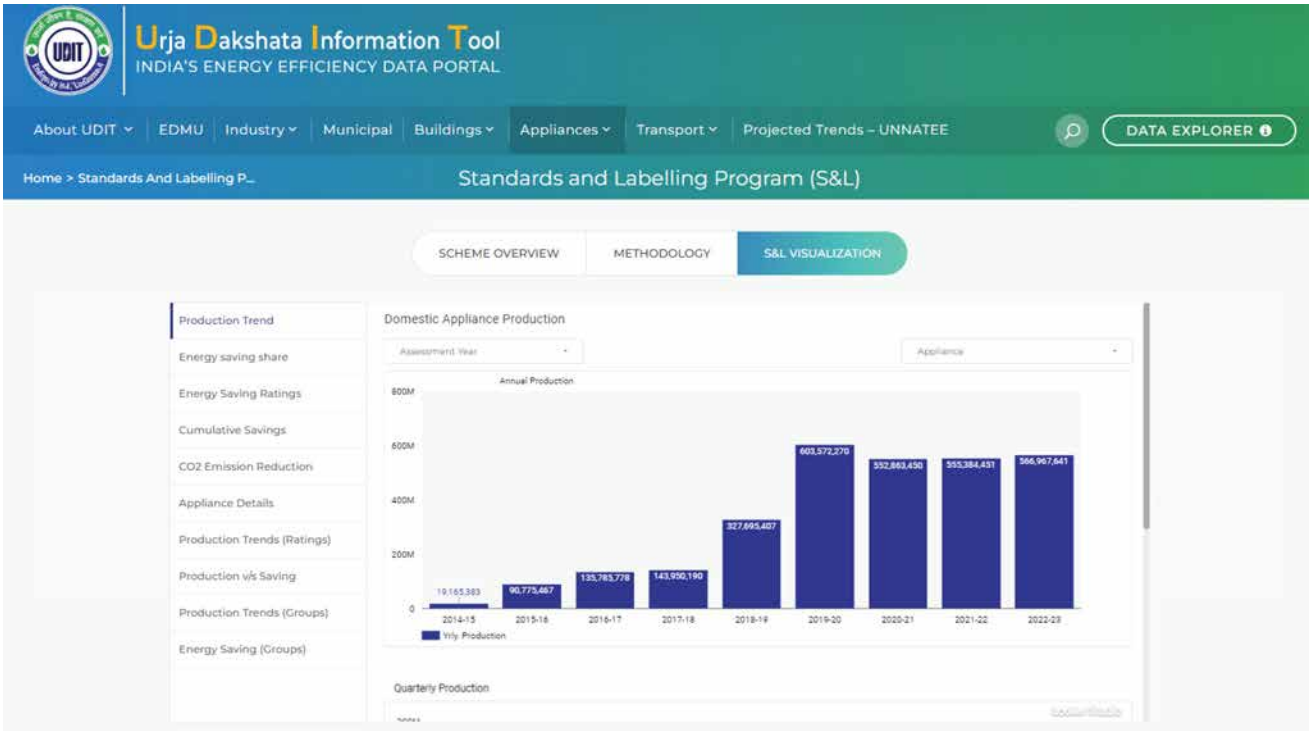


Table VIII: Notified Threshold Limit for PAT Industries (in toe)

Sr. No.	Sectors under PAT	Threshold Limit (toe)
1	Aluminium	7500
2	Cement	30000
3	Cement Grinding Unit	10000
4	Chlor Alkali	12000
5	Commercial Buildings (Hotels)	500
6	DISCOM	All Licensed
7	Fertilizer	30000
8	Iron and Steel	20000
9	Petrochemical	100000
10	Petroleum Refinery	90000
11	Pulp and Paper	7500
12	Railways	70000
13	Textile	3000
14	Thermal Power Plant	30000

Table IX: Notified Threshold Limit for Sectors to be Covered Under PAT Scheme (in toe)

Sr. No.	Sectors under PAT	Threshold Limit (toe)
1	Sugar	10000
2	Chemical	3000
3	Ceramic	5000
4	Glass	10000
5	Zinc	20000
6	Copper	10000
7	Port Trust	500
8	Dairy	2500
9	Automobile Assembly Units	3000
10	Tyre manufacturer	7000
11	Forging	1500
12	Foundry	5000
13	Refractories	3000

Table X: Conversion Factors

Fuel Type	Unit	Conversion Factor
Coal Production	Toe/Metric tonnes	0.40
Coal Import	Toe/Metric tonnes	0.53
Coal Export	Toe/Metric tonnes	0.67
Coal Final Consumption	Toe/Metric tonnes	0.51
Lignite Production	Toe/Metric tonnes	0.23
Lignite Import	Toe/Metric tonnes	0.22
Lignite Final Consumption	Toe/Metric tonnes	0.23
Crude Oil	Toe/Metric tonnes	1.02
Liquefied petroleum Gas	Toe/Metric tonnes	1.13
Naphtha	Toe/Metric tonnes	1.08
Kerosene	Toe/Metric tonnes	1.05
Diesel (HSD+LDO)	Toe/Metric tonnes	1.04
Fuel Oil	Toe/Metric tonnes	0.99
Lubricants	Toe/Metric tonnes	1.00
Bitumen	Toe/Metric tonnes	0.93
Low Sulphur Heavy Stock	Toe/Metric tonnes	0.96
Petrol	Toe/Metric tonnes	1.07
Aviation Turbine Fuel	Toe/Metric tonnes	1.07
Petroleum Coke	Toe/Metric tonnes	0.76
Other Petroleum Products	Toe/Metric tonnes	0.96
Natural Gas	Toe/MSCM	0.92
Electricity	Toe/kWh	0.09

Source: (MoSPI, 2024)

Table XI: Data Reporting Format Under PAT Scheme (Form 1)

"Form 1 [See rule 3]				
Details of information regarding total energy consumed and specific energy consumption per unit of production				
A.	**General Details**	**Description**		
1	Name of the Unit			
2	Year of Establishment Registration No (As provided by BEE)			
3	Sector and Sub-Sector in which the Designated Consumer falls	Sector	Sub-Sector	
4. (i)	complete address of Designated Consumer's Unit location (including Chief Executive's name and designation) with mobile, telephone, fax numbers and e-mail address.			
(ii)	Registered Office address with telephone, fax numbers, and e-mail address			
(iii)	Energy Manager's Name, designation, EM/EA Registration No., Address, Mobile, Telephone, Fax numbers and e-mail address			
B.	**Production details**			
5	**Manufacturing Industries specified as Designated Consumers**			
	Products	**Unit**	**Previous Financial Year (20..-20..)**	**Current Financial Year (20..-20..)**
		(1)	(2)	(3)
(i)	Product 1	tonne		
(ii)	Product 2	tonne		
(iii)	Product 3	tonne		

(iv)	Product (Please add extra rows in case of additional products)	tonne		
(v)	Total Equivalent Product	tonne		
C	**Energy Consumption Details of Manufacturing Industries specified as Designated Consumers**			
		(1)	(2)	(3)
6. (i)	Total Electricity Purchased from Grid/Other Source	Million kWh		
(ii)	Total Electricity Generated	Million kWh		
(iii)	Total Electricity Exported	Million kWh		
(iv)	Total Electrical Energy Consumption	Million kWh		
(v)	Total Solid Fuel Consumption	Million kcal		
(vi)	Total Liquid Fuel Consumption	Million kcal		
(vii)	Total Gaseous Fuel Consumption	Million kcal		
(viii)	Total Thermal Energy Consumption	Million kcal		
(ix)	Total Energy Consumption (Thermal + Electrical)	TOE		
(x)	Total Normalized Energy Consumption (Thermal + Electrical)	TOE		
D	**Specific Energy Consumption Details**			
7.(i)	Specific Energy Consumption(Without Normalization)	TOE/tonne		
(ii)	Specific Energy Consumption (Normalized)	TOE/tonne		
E	**Power Plants specified as Designated Consumers**			
8. (i)	Total Capacity	MW		
(ii)	Unit Configuration	No. of units with their capacity		
(iii)	Annual Gross Generation	Million kWh		
(iv)	Annual Plant Load Factor (PLF)	%		

(v)	Station Gross Design Heat Rate	kcal/kWh		
(vi)	Station Gross Operative Heat Rate	kcal/kWh		
(vii)	Auxiliary Power Consumption	%		
(viii)	Operative Net Heat Rate	kcal/kWh		
(ix)	Operative Net Heat Rate (Normalized)	kcal/kWh		
F	**Sector specific details**			
9.	Name of the Sector	Sub-Sector	Pro- forma in which the details shall be furnished	
(a)	Aluminum	Refinery/Smelter	Sa_1	
	Cold Rolling Sheet		Sa_2	
(b)	Cement	Cement	Sb	
(c)	Chlor-Alkali	Chlor-Alkali	Sc	
(d)	Fertilizer	Fertilizer	Sd	
(e)	Iron and Steel	Integrated Steel	Se_1	
	Sponge Iron		Se_2	
(f)	Pulp and Paper	Pulp and Paper	Sf	
(g)	Textile	Composite	Sg_1	
	Fiber		Sg_2	
	Spinning		Sg_3	
	Processing		Sg_4	
(h)	Thermal Power Plant	Thermal Power Plant	Sh	

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NOTES

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