सत्यमेव जयते
Ministry of Power

Impact of Energy Efficiency Measures

For The Year 2022-23

Bureau of Energy Efficiency

Imprint

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Preface

Over the past decades, India has witnessed a significant surge in energy consumption. As the nation grapples with this escalating demand, the imperative for energy efficiency becomes increasingly evident. Recognizing the crucial role of energy optimization, India took a proactive step with the inception of the Energy Conservation Act in 2001, marking a pivotal moment in its commitment to energy efficient practices.

This commitment is underscored by the establishment of the Bureau of Energy Efficiency (BEE), a key institution dedicated to advancing energy efficiency initiatives. Subsequently, India fortified its resolve by launching the National Mission for Enhanced Energy Efficiency (NMEEE), emphasizing a strategic focus on conserving energy resources.

While the implementation of energy conservation schemes is crucial, the assessment of their real-world impact becomes paramount. Evaluating the effectiveness of these initiatives is essential to inform future interventions and ensure a sustainable, low-carbon transformation. Periodic impact assessments can provide valuable insights into the success and areas for improvement in India's energy efficiency endeavors.

Bolstering these efforts are various national and state-level organizations, working in tandem with BEE, each introducing their own schemes. These initiatives span across key energy-consuming sectors, including Industry, Commercial, Residential, Transport, Agriculture, and Municipal domains. Through comprehensive cross-cutting mechanisms, these endeavors aim to realize substantial energy savings, contributing to India's ongoing journey towards a more sustainable and efficient energy landscape.

With respect to the related energy efficiency schemes, the Government has directed BEE to **conduct a study comparing the actual energy consumption in a particular year with the estimated energy consumption, had the current energy efficiency measures not been undertaken i.e., counterfactual.**

In compliance to this direction, BEE hired the services of an expert agency to conduct this study for the FY 2022-23. The overall objective of this study was to assess the impact of all the energy efficiency schemes/programmes in India in terms of total energy saved and reduction in the amount of CO_2 emissions in 2022-23. The study estimates energy efficiency achievements based on the impact of the schemes/programmes since FY 2018-19.

The objective of this study is to assess the overall impact of all the energy efficiency schemes at the national as well as state level for the FY 2022-23 and compare it with a situation where the same were not implemented. This study focused on the following schemes/programmes, viz. Perform, Achieve and Trade Scheme, Standards & Labeling Programme, UJALA Programme, ECBC – Commercial Buildings Programme, BEE Star rated buildings, Building Energy efficiency Programme, Corporate Average Fuel Economy (CAFE), FAME Scheme, BEE – SME Programme, GEF – UNIDO – BEE Programme, GEF – World Bank Programme, Agriculture Demand Side Management Programme, and Municipal Demand Side Management Programme.

The findings of the report reflect that the adoption of energy efficiency schemes/programs has led to the overall energy savings of 50.75 Million Tonnes of oil Equivalent for the year 2022-23. This study has estimated that various energy efficiency measures have led to the overall thermal energy savings in the order of 24.44 Million Tonnes of oil Equivalent, while overall electricity savings are to the tune of 306.55 Billion Units in the year 2022-23

Overall, these energy savings translated into monetary savings worth INR 191,810 crores per annum. The equivalent reduction in CO_2 emissions is around 306.02 Million Tonnes annually.

December 2023
New Delhi

Abhay Bakre
Director General, BEE

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Abbreviations

AC	Air Conditioner
BEE	Bureau of Energy Efficiency
BEEP	Building Energy Efficiency Programme
BU	Billion Units
CEA	Central Electricity Authority
CO2	Carbon Dioxide
COP	Coefficient of Performance
CSTL	Cooling Season Total Load
CTV	Color Television
DCR	Direct Cooling Refrigerator
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited
FFR	Frost Free Refrigerator
FY	Financial Year
GEF	Global Environment Facility
GWh	Giga Watt Hour
ISSER	Indian Seasonal Energy Efficiency Rating
kg	Kilogram
kW	Kilo Watt
kWh	Kilo Watt Hour
LED	Light Emitting Diode
LPG	Liquified Petroleum Gas
Mtoe	Million Tonne Of Oil Equivalent
MU	Million Units
MW	Mega Watt
No	Number
Q	Quarter
RAC	Room Air Conditioner
RE	Renewable Energy
S&L	Standard and Labeling
S&L	Standards & Labeling
SDA	State Designated Agency
SEC	Specific Energy Consumption
TFL	Tubular Florescent Lamp
TWh	Tera watt hour
TOE	Tonne Of Oil Equivalent
UNIDO	United Nations Industrial Development Organization
UNNATEE	Unlock National Energy Efficiency Potential
UT	Union Territories
VLT	Visible Light Transmittance
W	Watt
WBP	Whole Building Performance
Yr	Year

Executive Summary

Energy is among the most critical components of infrastructure, crucial for the economic growth and welfare of nations. The existence and development of adequate energy and power infrastructure is essential for the sustained growth of the Indian economy.

India's energy sector is one of the most diversified in the world. Sources of power generation range from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power to viable non-conventional sources such as wind, solar, and agricultural and domestic waste. The total Primary Energy Supply added up to 767.17 million Tonne of Oil equivalent (TOE) (P)[1] in the FY 2022-23. The two major contributors to the total energy supply in the country were Coal which accounted for 55.96% of the total and Crude Oil which accounted for 32.82% of the total energy supply (P).

Energy demand and consumption in the country has increased rapidly and is expected to rise further in the years to come. The total energy consumption in India has grown from about 332.93 million tons of oil equivalent (TOE) in 2012 to about 543.58 million TOE (P)[1] in the FY 2022-23.

Energy efficiency across all sectors of the economy is essential to enable decoupling of energy supply growth from economic growth, while ensuring that energy service demands are met.

India has remained progressive and one of the front runners in achieving its energy efficiency potential, through innovative programmes such as the Perform Achieve and Trade (PAT) scheme, Standards & Labeling (S&L), Unnat Jyoti by Affordable LEDs for All (UJALA) scheme, Energy Conservation Building Code (ECBC), Electric Vehicle mission, Smart metering, etc.

At the country level, there is still an immense potential to be tapped from the large-scale implementation of energy efficiency interventions in the various demand sectors like industry, agriculture, transport, municipal, domestic & commercial lighting and appliances, and MSMEs. This should help to limit the energy imports and perpetual headlong rush towards new production capacities which still require huge investments and significant financing.

The Bureau of Energy Efficiency (BEE) has actively undertaken numerous initiatives aimed at conceptualizing and executing energy efficiency programs. Additionally, complementary efforts by other agencies have further contributed to a tangible reduction in India's energy intensity, as evidenced by the discernible downward trajectory depicted in the accompanying figure.

[1] The values are estimated based on Energy Statistics 2023, MoSPI. Final values will be published in the 2024 version of Energy Statistics.

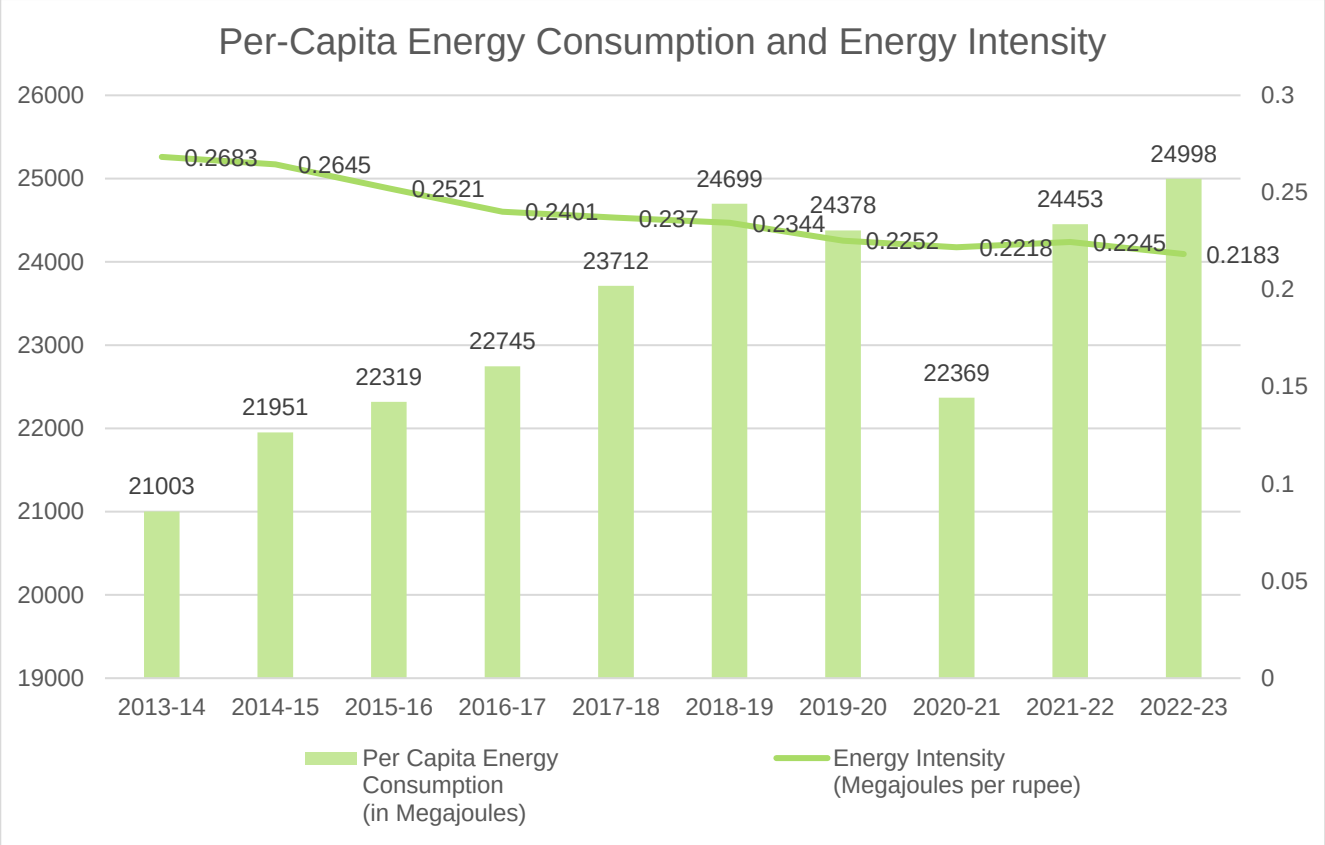


Figure 1: Energy intensity and Per capita Consumption trend

India's energy intensity decreased from 0.2683 Mega joules per rupee in 2013-14 to 0.2183 (P) Mega Joules in the FY 2022-23, which is a significant improvement of 18.65%. Similarly, Per-capita Energy Consumption increased from 21,003 Mega joules in 2013-14 to 24,998 Mega joules in the FY 2022-23. This decline is also attributed to the deployment of energy efficiency programmes among other factors.

Several omnibus schemes at the national, state and sectoral levels are in operation to achieve the goal of energy efficiency in India. Major energy-consuming sectors and prominent schemes in these sectors are presented in the figure below:

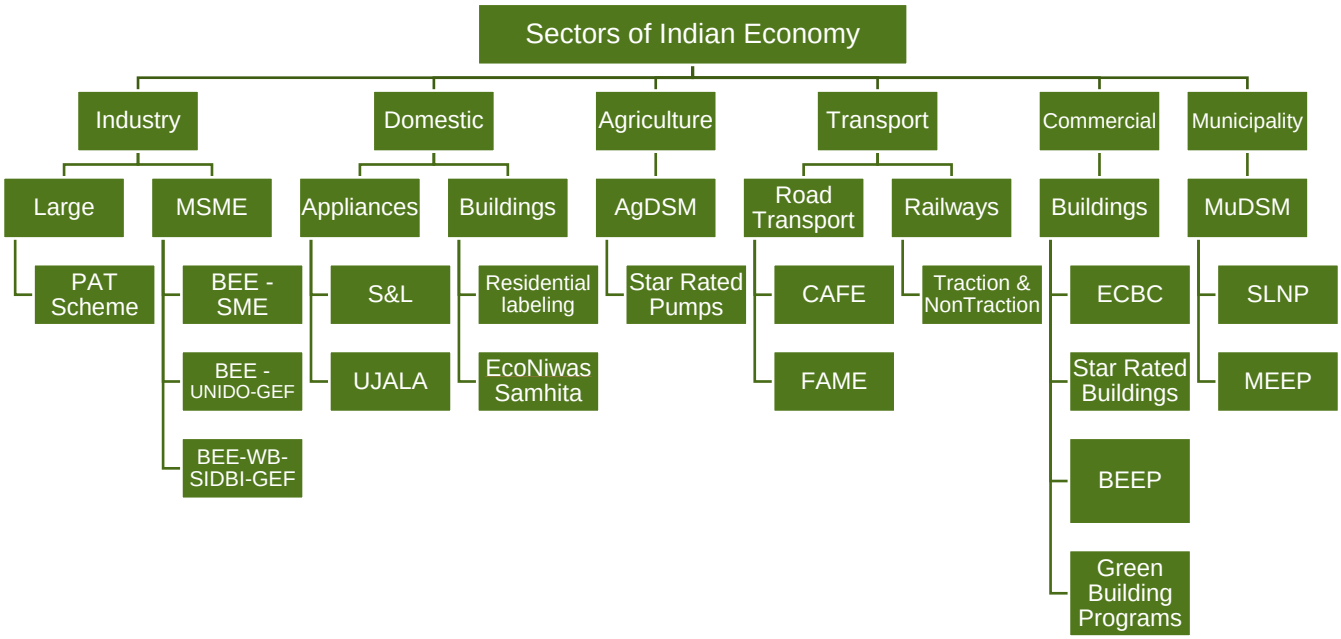


Figure 2: Energy Efficiency Schemes in India

Rationale and Objective

To assess the impact of various energy efficiency schemes/programmes, the Bureau of Energy Efficiency conducts an annual study. It estimates the impact by comparing the actual energy consumption with the estimated energy consumption had the current energy efficiency measures not been undertaken i.e., counterfactual.

The overall objective of the study was to assess the impact of all the energy efficiency schemes/ programmes in India in terms of total energy saved and reduction in CO_2 emissions during FY 2022-23. To assess the impact, the agency has carried out the following tasks:

- Review of all the national level schemes for energy efficiency
- Data collection, verification, and analysis

The agency had detailed consultations with all departments/agencies/bodies involved in implementing energy-saving measures across the country as mentioned in figure 2.

Estimated Energy Savings for 2022-23

The adoption of energy efficiency schemes/programmes has led to the overall energy savings of 50.75 Mtoe, i.e., 6.61% of the total primary energy supply of the country for the year 2022-23.

A summary of savings from various schemes and interventions is presented in the table below:

Table 1: Summary of energy savings (2022-23)[2]

Program/ Scheme	Sector	Electricity Savings (BU)	Thermal Savings (MTOE)	Total Energy Savings (MTOE)	GHG Reduction (MtCO2)	Monetary Savings (INR Crore)
PAT- V	Large Industry	0.008	0.6802	0.6809	2.68	1256.66
PAT- IV		0.009	0.7501	0.7508	2.96	1385.75
PAT- III		0.62	1.59	1.59	5.59	3223.20
PAT- II		36.47	10.95	14.08	68.43	43078.10
PAT- I		3.01	8.41	8.67	31.00	9500.00
PRSF	MSME	0.02	-	0.0019	0.02	14.17
4E		0.28	0.00089	0.0246	0.23	175.15
BEE-GEF-EESL		0.0015	0.0018	0.0019	0.009	4.49
BEE-UNIDO-SME		0.00	0.00	0.0057	0.038	36.72
FLCTD	Large/MSME	0.00009	0.000657	0.0007	0.002	1.22
ECBC	Commercial Buildings	0.1609	-	0.0138	0.1303	25.46
BEE Star Rating		0.2492	-	0.0214	0.2019	39.43
Green Building Rating Program (GRIHA)		0.0882	-	0.0076	0.0714	13.96
ENS	Residential Buildings	0.0048	-	0.00041	0.0034	0.76
S&L	Appliances	80.86	0.018	6.97	57.46	50894.84
UJALA	LED Lamps	176.19	-	15.15	125.09	70476
SLNP	Municipal	8.59	-	0.74	5.92	5688.00
FAME	Transport	-	0.14	0.14	0.53	1559.88
CAFÉ		-	1.89	1.89	5.69	4436.35
Total		**306.55**	**24.44**	**50.75**	**306.02**	**191810.16**

The findings of the report reflect that the adoption of energy efficiency schemes/programs has led to the overall **thermal energy savings in the order of 24.44 Mtoe** amounting to **INR 44,974 Crores** and a reduction of **88.37 Million tonne of CO_2 emission**. While overall electricity savings are to the tune of **306.55 BU annually**. These electricity savings resulted in cost savings worth **INR 192,820 Crores and a reduction of 217.65 Million tonne of CO2 emissions**.

[2]Savings of AgDSM, BEEP, Star rating building is primarily on account of the retrofitting of the energy efficient BEE star labeled appliances. As saving of the Appliances is accounted in S&L programme thus saving indicated under these heads are not included in total (to avoid double counting).
**Savings from LEDs under UJALA programme is considered here, LED industry has sold approximate 126 crore LEDs apart from UJALA till Jan 2020. Sales of these LEDs led to reduction of approximately 133 Mn tonne of CO_2.

Overall, these energy savings translated into monetary savings worth INR 191,810 crores in the year 2022-23. The equivalent reduction in CO_2 emissions is around 306.02 million Tonnes annually.

PAT scheme contributed to 50.73% of the total energy savings, while S&L and UJALA accounted for 43.67% of the total energy saving from all major interventions carried out during FY 22-23. The share of various schemes in the total Energy savings is presented in Figure 3.

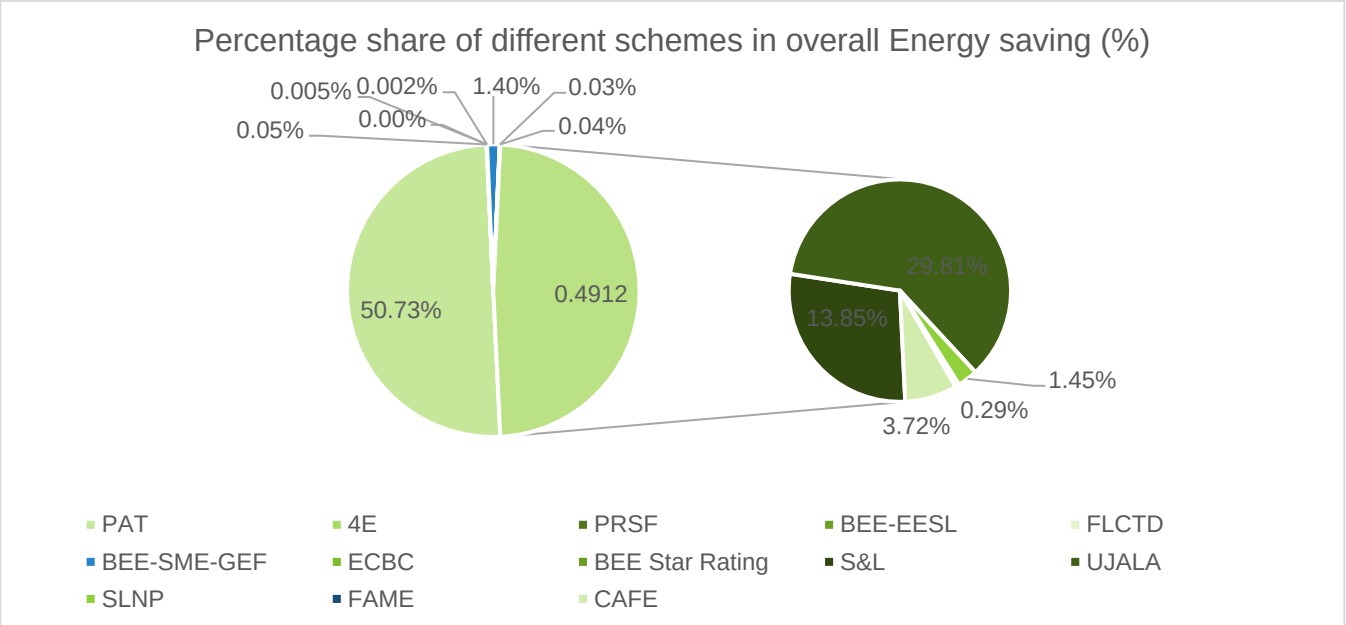


Figure 3: Total energy savings (Mtoe) by Scheme / Programme (2022-23)

Most of these schemes/programmes are essentially cross-sectoral, therefore these schemes successfully managed to save energy across all the demand sectors.

Implementation of energy efficiency interventions has led to the reduction of 39.23 Mtoe in the demand side energy consumption, amounting to 7.22% of the energy demand (543.585 Mtoe(P)) during the year 2022-23. The total energy savings achieved (including both Supply Side and Demand Side sectors of the economy) is of the order of 50.75 Mtoe. These energy savings amount to 6.61% of the total primary energy supply (767.17 Mtoe (P)) during FY 2022-23.

Thermal and Electrical Energy savings contribution from various economic sectors is presented in the table below:

Table 2: Sector-wise energy saving summary

Sector	Thermal Saving (Mtoe)	Electrical Saving (BU)	Total energy savings (Mtoe)	Emission reduction (Million Tonne of CO_2/year)	Estimated monetary savings (INR crore)
Industry[3]	22.38	40.41	25.81	110.95	58675.48
Domestic[4]	0.018	257.83	22.12	183.11	121370.84
Buildings[5]	-	0.503	0.043	0.357	79.61

[3] Industry Sector includes the savings from PAT (Excluding – DISCOM, Buildings, Railways) and MSMEs
[4] Domestic Sector includes the savings from S&L (except pump sets and DTs) and savings from UJALA programme
[5] Includes both Commercial & Residential buildings

Sector	Thermal Saving (Mtoe)	Electrical Saving (BU)	Total energy savings (Mtoe)	Emission reduction (Million Tonne of CO_2/year)	Estimated monetary savings (INR crore)
Transport (including Railways)	2.03	-	2.03	6.23	5996.23
Others (including Municipal)	-	8.59	0.74	5.92	5688.00
Total	**24.44**	**306.55**	**50.75**	**306.02**	**191810.16**

The industry sector has the highest contribution with a share of 50.73% of the total energy savings while the domestic sector has contributed 43.67% of the total savings achieved during FY 22-23.

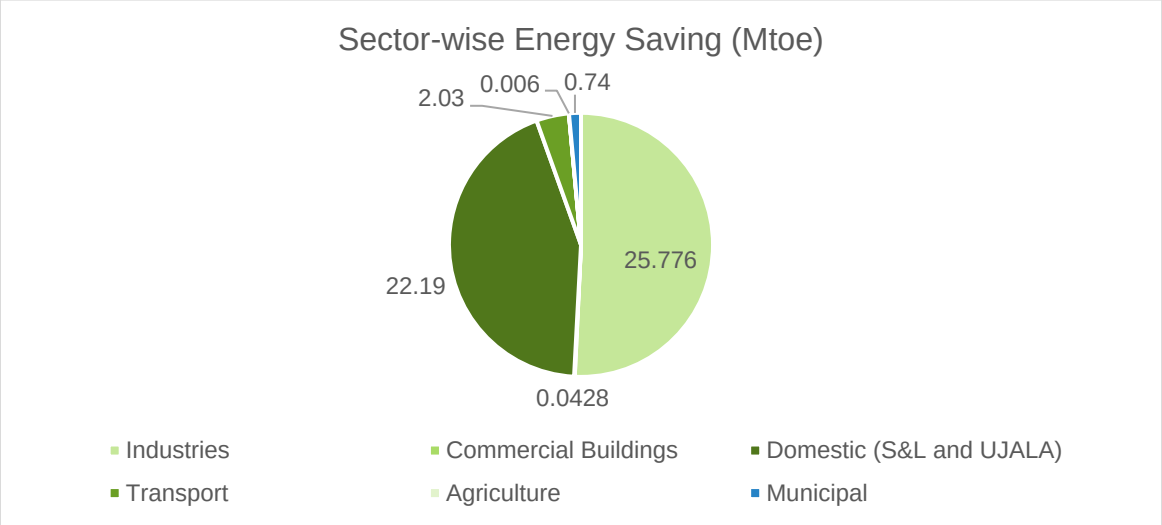


Figure 4: Total Energy Savings by Economic Sectors (2022-23)

Overall, these energy savings translated into monetary savings worth INR 191,810 crores and contributed to reducing 306.02 million Tonnes of CO_2 emission in the FY 2022-23. Emission reductions from the various schemes are presented in Figure 5:

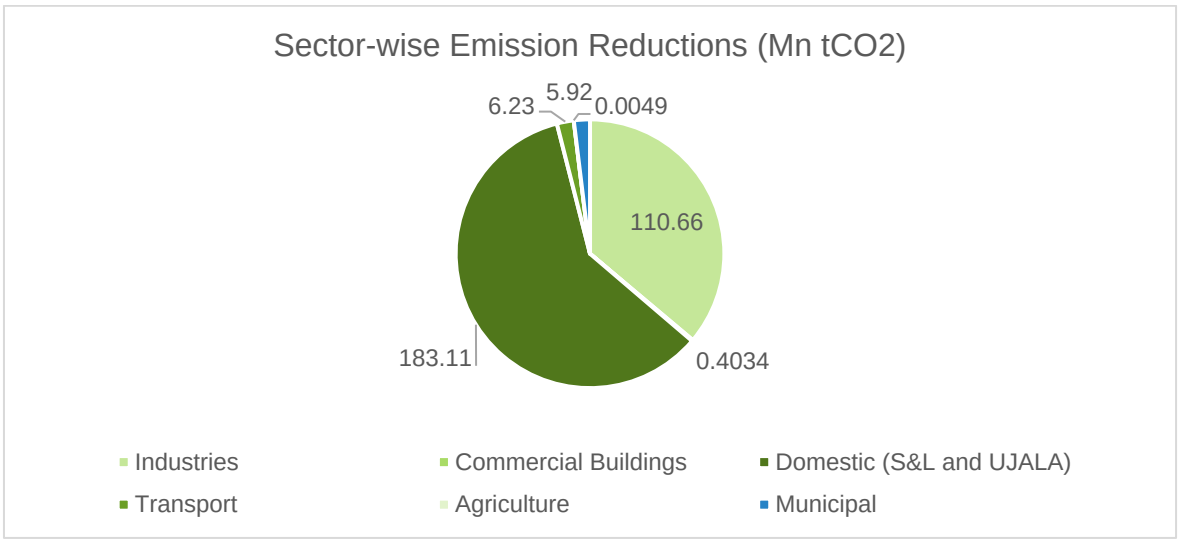


Figure 5: CO_2 Emission Reductions by Economic Sectors (2022-23)

Impact of various Energy Efficiency Interventions in India

Based on the energy savings data provided in the previous section, it is quite evident that all these schemes/programmes, were largely successful in generating a substantial amount of savings spanning across major energy-consuming sectors viz. Industry, Commercial, Residential, Transport, Agriculture, etc., and creating a culture of energy efficiency in India.

Over the years, the Bureau of Energy Efficiency and various other institutions have initiated multiple energy efficiency programs for the promotion and adoption of energy efficiency in India, by various sectors. The consolidated values of energy savings achieved for all these schemes during 2011-12 to 2022-23 across various sectors viz. Industry, building (domestic and commercial), municipal, agriculture, transport, and miscellaneous are calculated and the impact of various schemes is presented in Figure 6.

The role of energy efficiency remains crucial in complying with India's emission intensity reduction targets. Therefore, to capture the impact of all these interventions we have compared the energy savings achieved during the years by implementing EE technologies/ solutions with the total energy consumption of the country for the respective years:

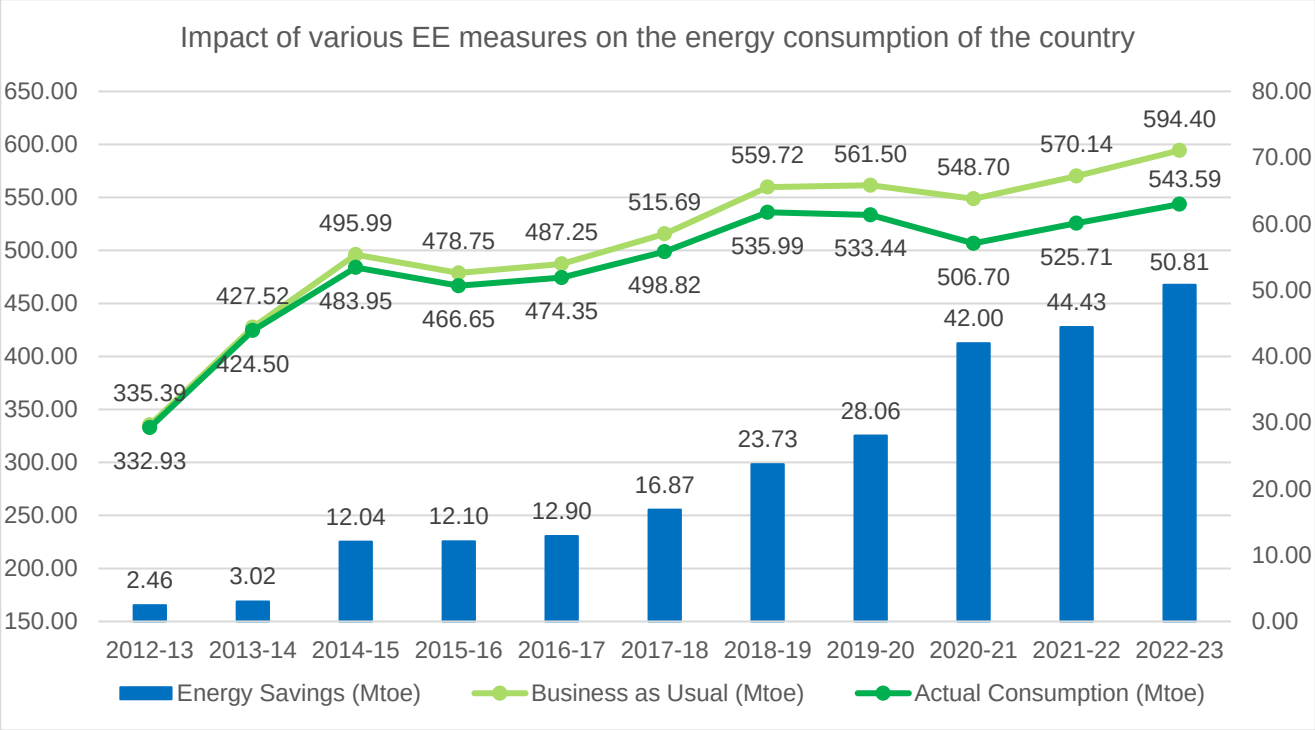


Figure 6: Impact of various EE measures (Mtoe)

Across all these years, these energy efficiency interventions have not only resulted in significant energy savings but have also been successful in building institutional capacity and creating strong awareness for energy efficiency in India.

Way forward

The role of energy in driving economic growth for companies is extensive, influencing manufacturing, production processes, logistics, and service delivery. Recognizing the need for reduced energy consumption, India, in its updated Nationally Determined Contributions (NDCs), pledges a 45% reduction in the emission intensity of its GDP by 2030 from 2005 levels. The country also aims to install 50% of power capacity from non-fossil sources and

achieve net zero emissions by 2070. With a population of 1.4 billion, India faces significant energy demand, although it has become a power surplus nation with an installed capacity exceeding 400 GW.

India is making strides in renewable energy, ranking as the world's third-largest producer, with over 40% of installed capacity from non-fossil fuels. Despite challenges and a reliance on coal, the government outlines an ambitious roadmap for secure, affordable, and sustainable energy access. The Bureau of Energy Efficiency (BEE) plays a crucial role, implementing initiatives like Standards and Labelling, the Energy Conservation Building Code (ECBC), and the Perform, Achieve, and Trade (PAT) scheme to reduce the country's energy intensity.

Recognizing the importance of comprehensive energy data, BEE has established the Energy Data Management Unit (EDMU) to compile and publish energy supply and consumption data across sectors. Collaborating with various stakeholders, EDMU aims to standardize definitions, methodologies, and calculations in line with international standards. This effort facilitates uniform reporting and enhances data dissemination for evidence-based policymaking, supporting India in meeting its environmental and developmental commitments.

Chapter 1: Introduction

1. *Introduction*

In the dynamic landscape of global economies, India stands as a compelling example of rapid advancement and growth. The country has experienced a remarkable surge in energy consumption, a phenomenon intricately linked to its swift economic expansion. The accessibility to affordable energy sources has played a pivotal role in fostering this heightened demand, further accentuated by the escalating industrialization across diverse sectors. As India endeavors to strengthen its economic foundations, the concurrent development of critical infrastructure projects and the diversification of energy-dependent end uses contribute significantly to the escalating demand for power. The multifaceted nature of this surge underscores the intricate interplay between economic development and the indispensable energy infrastructure required to sustain such progress.

The robust economic growth witnessed in India acts as a catalyst for increased energy consumption, serving as a fundamental driver shaping the nation's evolving energy landscape. The demand for energy is not confined solely to the burgeoning industrial sector; it is also a consequence of extensive efforts to enhance connectivity and promote infrastructure development throughout the country. The affordability of energy emerges as a key enabler in this scenario, facilitating access for a broader section of the population to essential energy resources. This confluence of factors paints a comprehensive picture of India's journey, where economic growth, infrastructure development, and energy consumption intersect, forming the crux of the nation's evolving energy narrative.

Looking ahead, India's trajectory on the global economic stage is poised for even more remarkable milestones. Projections from S&P Global Ratings indicate that by 2030, India is set to become the world's third-largest economy, with an anticipated 7 percent GDP growth in the fiscal year 2026-27[6]. Furthermore, the country is positioned to claim the title of the fastest-growing major economy in the next three years. However, this ambitious ascent comes with its challenges, prominently marked by the inevitable surge in energy demand and consumption. As India navigates its way towards economic supremacy, a critical exploration of the intricate relationship between its evolving energy landscape and economic progress becomes imperative.

In 2022-23, the total final Energy Consumption (End Use) in India was 5,43,585 kTOE (P)[7]. The industrial sector was the largest consumer of energy in the country with this sector itself using more than half, i.e., 50.59% of the total final energy consumption. The consumption of the residential, agriculture, commercial & public sectors, No-specified(others) and non-energy purpose represented 38.53% of the total final consumption in the country, whereas transport sector accounted for 10.88% of Total Final Consumption.

The total final energy consumption by the major sectors of the Indian economy is depicted in the figure below:

[6] Source: https://www.indiatoday.in/business/story/india-worlds-third-largest-economy-2030-7-percent-gdp-growth-forecast-2026-28-sp-2472135-2023-12-05?onetap=true

[7] The values are estimated based on Energy Statistics 2023, MoSPI. Final values will be published in the 2024 version of Energy Statistics

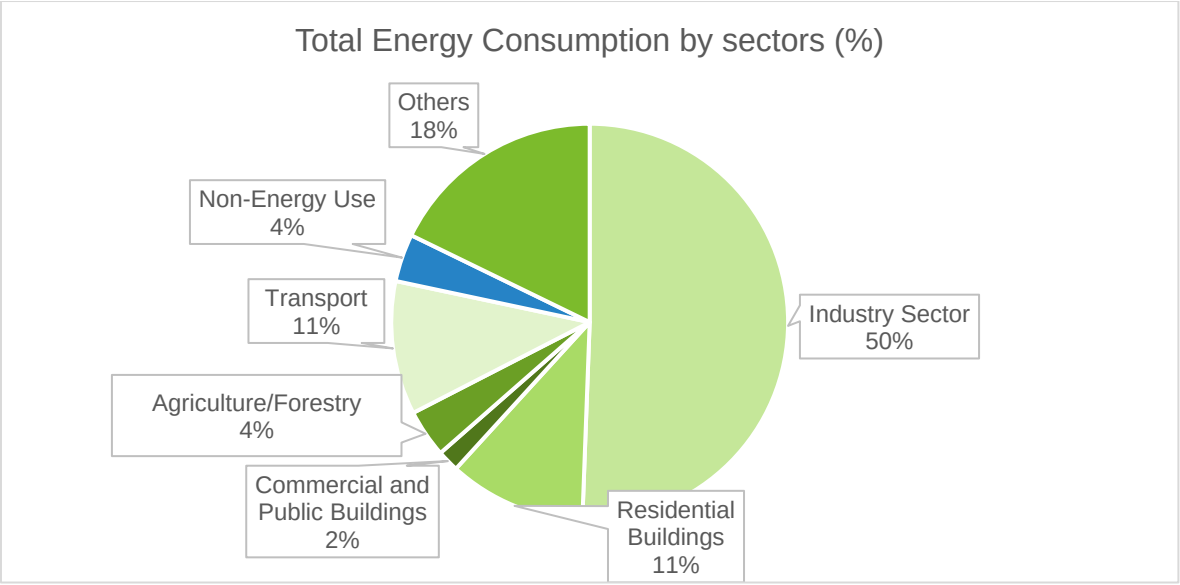


Figure 7: Total final energy consumption by major sectors in India Economy

Today, the diverse challenges facing the energy security today cannot be addressed by a single government, industry, company or other institution alone. In order to achieve its energy vision, several ministries and different energy sector stakeholders are working in tandem for building a strong foundation for the same.

The direction that national and state policies take, and the rigor and effectiveness with which they are implemented, plays a critical role in India's energy outlook. India had realized this importance of energy optimization long back, evident from the launch of the Energy Conservation Act in 2001 and its amendment in 2010. It had further directed its policies to focus specifically on energy efficiency by setting up the Bureau of Energy efficiency (BEE) and then initiating the National Mission for Enhanced Energy Efficiency (NMEEE), all aided by consistent improvements in the quality of Indian energy data.

Bureau of Energy Efficiency coordinates policies and programs on efficient use of energy and its conservation with the involvement of various stakeholders as well as formulates, manages and implements energy conservation programs such as Perform, Achieve and Trade (PAT) scheme, ECBC & ENS for commercial & residential buildings sector, Standards & Labeling programme for appliances, and conducive policies for clean transport (EVs) etc.

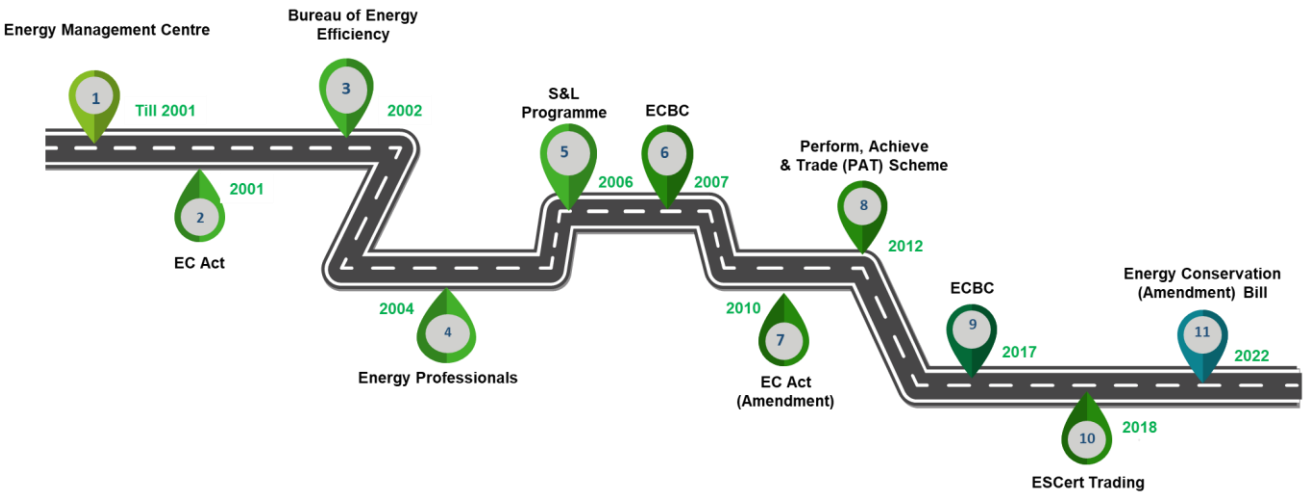
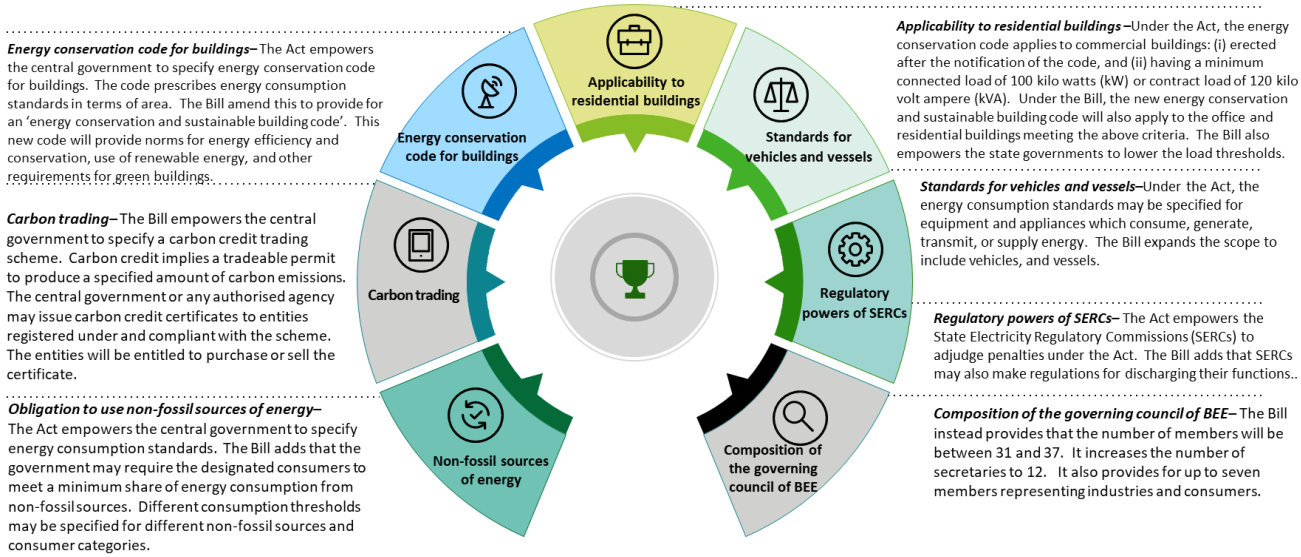


Figure 8: Chronograph of EE policies and programs in India

The Energy Conservation (Amendment) Bill, 2022 was introduced in Lok Sabha on August 3, 2022. The Bill seeks to amend the Energy Conservation Act, 2001. The Act promotes energy efficiency and conservation. It provides for the regulation of energy consumption by equipment, appliances, buildings, and industries. Key proposals under the Bill are:



The Parliament passed the Energy Conservation (Amendment) Bill, 2022 and it came into effect from 1st January, 2023. This includes provisions to "Specify the carbon credit trading scheme". Design of carbon trading scheme is to be prescribed through Rules after consideration of all relevant aspects, including transition of existing schemes of tradable certificates to single national framework. Any registered entity, in accordance with these Rules, shall be entitled to purchase or sell the carbon credit certificate.

In essence, the integration of carbon markets into the broader strategy for reducing energy consumption provides a market-driven mechanism for incentivizing and rewarding sustainable practices. It transforms the environmental cost of carbon emissions into an economic opportunity for positive change, fostering a collective effort to address climate challenges while simultaneously driving advancements in energy efficiency.

As part of the Standards & Labeling (S&L) Program, the Bureau of Energy Efficiency (BEE) has mandated the transition for four appliances (ceiling fans, LCAC (Large Capacity Air Conditioners), deep freezers, and UHD (Ultra High Definition) TVs) from voluntary to mandatory, effective from 1st July 2022.

Bureau of Energy Efficiency has developed a Mobile Application to facilitate in-vehicle navigation to the nearest public EV charger, a website to disseminate information on various central and state-level initiatives to promote e-mobility in the country, and a web-portal to enable CPOs to register their charging details securely into the National Online Database.

The Hon'ble President of India launched the 'EV Yatra' Web Portal and Mobile App to facilitate e-vehicle navigation and promote e-mobility in the country on 14th December 2022 in NECA event. The Mobile application titled "EV Yatra" has been designed and developed to facilitate in-vehicle navigation to the nearest public EV charger. This Mobile application can be easily downloaded on both iPhone and Android smartphones from Google play store and Apple Store and installed conveniently.

1.1. Objective of the Study

Along with BEE, there are other organizations at the national and state level, who are also supporting in achieving the goal of energy efficiency in India. These activities are spanning across major energy consuming sectors in India, viz. Industry, Transport, Agriculture, Commercial, Residential, etc., along with cross cutting mechanisms for realization of energy savings. All such schemes to promote energy conservation and energy efficiency are presented in Table 3, along with their status in FY 2022-23.

Table 3: Status of major EE schemes and programmes

Sector/ Sub-sector	Schemes/ Programs	Status as on FY 2022-23
Industry-Large Industry	Perform, Achieve and Trade (PAT) Scheme	• PAT Cycle-I (2012-15) comprised of 478 DCs from 8 energy intensive sectors. • PAT Cycle-II was launched in 2015 and added three more sectors (Refinery, Railways & DISCOM). Under PAT-II, 542 DCs out of total 621 DCs were analyzed for M&V. • PAT Cycle-III added 116 more DCs, out of these M&V of 95 DCs have been completed. • PAT Cycle – IV commenced with effect from April 2018. A total of 109 DCs with a total reduction target of 0.6998 MTOE were notified under PAT cycle – IV. • PAT cycle – V had commenced with effect from April 2019. Under PAT cycle – V, 110 DCs from the existing sectors of PAT were notified. PAT cycle – V aims to achieve total energy savings of 0.5130 MTOE. • PAT cycle – VI had commenced with effect from 1st April 2020. Under PAT Cycle – VI, 135 DCs from six sectors were notified. With implementation of PAT cycle – VI, it is expected to achieve a total energy savings of 1.277 MTOE. • PAT cycle – VII was notified in October 2021 for the period 2022-23 to 2024-25 wherein 509 DCs have been notified. • The PAT scheme has covered 1196 units from 13 sectors for participation till 31st March 2023.
Industry-MSME	PRSF Program	• Total 6 MSME clusters (Hoshiyarpur, Faridabad, Mandi, Gobindgarh, Pune and Ropar) covering sector as Foundry, Forging & Heat Treatment, Re-rolling, pharma and chemical are part of the programme.
	BEE-GEF-UNIDO Programme	• BEE-UNIDO program is operational in 23 MSME clusters including - Hand tools, Ceramics, Dairy, Foundry, Brass. • 599 small scale energy efficient projects implemented in the clusters as on 31st March 2023 • A widening of Energy and Resource Mapping activities have been initiated in fifteen (15) SME clusters of three (3) sectors i.e., namely Textile, Food Processing and Leather to conduct the detailed survey on the

Sector/ Sub-sector	Schemes/ Programs	Status as on FY 2022-23
		consumption of energy and its flow within the MSME facilities, technological status, operating practices, knowledge perception etc. • The project has able to implement around 33 EE/ RE projects with energy savings of 213 toe and reduced CO_2 emissions of 1390 tones and achieved co-financing investment from MSME's INR 8.73 crores
	GEF – EESL – BEE Programme	• 740 surveys, 78 detailed Energy Audits and more than 70 technology specific baseline studies have been completed. • More than 100 awareness / consultation / training workshops in 10 clusters for faster adoption of the technologies
Domestic- Lighting & appliances	Standards & Labeling (S&L)	• Total 34 appliances in this programme covered as on 31st March 2023. • 14 appliances under Mandatory regime. • 20 appliances under voluntary regime. • Ceiling fans, LCAC, Deep Freezers, UHD TVs have been mandatory w.e.f 1st July 2022. • As on 31st March 2023, 1431 brands and 20013 models are registered under S&L Program.
	UJALA	• 37 Crore LED bulbs were distributed till 31st March 2023. • 73 lakhs LED tube-lights and 25.92 EE fans were also distributed under UJALA programme till March 2023.
Domestic- Buildings	Eco Niwas Samhita	• As on 31st March 2023, Over 1.55 million sqm of the residential built-up area has been compliant with ENS part 1. Around 148 training and capacity building programs have been conducted which trained around 10000 stakeholders including Government and private sectors.
	Residential Labeling	• Labeling program takes forward EcoNiwas Samhita. • Estimated energy saving potential through labeling program is around 388 BU by year 2030.
Commercial - Buildings	ECBC– Commercial Building	• As on 31st March 2023, technical assistance has been provided to 465 buildings by the Building cells in all states. Over 575 training and capacity-building programs have been organized to train over 25000 various stakeholders including the government and private sector.
	BEE – Star Rating Programme	• Offices, Hospitals, Shopping malls, and BPOs are part of this program. • 80 existing commercial buildings across India have adopted BEE Star ratings as of 31st March 2022.
Agriculture- Appliances	AgDSM- (Star Rated Pumps)	• As on 31st March 2023, 79,975 agricultural pumps have been installed.

Sector/ Sub-sector	Schemes/ Programs	Status as on FY 2022-23
(Star Rated Pumps)		
Municipality - Lighting & Appliances	MuDSM- (SLNP)	• During the financial year 2022-23, total 8 lakh LED Street Lights have been installed which had led to cumulative achievement as on 31st March 2023 is 1.26 Crore.
Transport- Road Transport	Corporate Average Fuel Economy (CAFE)	• In 2015, the GoI established Corporate Average Fuel Economy (CAFÉ) Norms for passenger cars. • In August 2017, CAFÉ Norms were established for Heavy Duty Vehicles (HDV) and in 2019 Norms were established for Light Commercial Vehicles (LCV).
	Faster Adoption & Manufacturing of Electric Vehicles (FAME)	• FAME I was launched in the year 2015 to promote hybrid and electric vehicle technologies in India • In the First Phase of the FAME Scheme about 2.8 lakh hybrid and electric vehicles are supported by way of demand incentive amounting to Rs 358Crore (Approx.) • Saving of 97 million liters of fuel and reduction of about 242 million Kg of CO2 as on 25th January, 2022. • Upgradation of Public EV charging infrastructure for faster adoption of EV. • FAME II was launched in 2019. As on 31st March 2023, 54 OEMs under Phase-II of FAME Scheme for availing benefit of demand incentives. • As on 31st March 2022 sale of Electric vehicles 220117 for availing benefit of demand incentives. • Under Phase II, the department of Heavy Industries (DHI) has already sanctioned 2,877 charging stations in 68 cities across 25 states/ UT's in the year 2022-23. • Further, the Ministry has sanctioned 1576 charging stations in 9 Expressways and 16 Highways and issued LOA to selected entities accordingly.
Transport- Railways	PAT and Non-PAT EE Initiatives	• Under PAT Cycle II, 16 Zonal Railways and 6 production units were included. • Indian railways have taken several steps such as - *Mission Electrification, HOG (Head-on-Generation) Trains, 3-phase regenerative locomotives etc.* - to reduce the energy consumption in the traction segment.

Though it is difficult to estimate the impact of energy savings from the indirect effect of some of the programs and schemes, the energy savings resulting directly from all programs needs to be measured and verified to ascertain whether the programs being implemented on the ground have the desired impact or not. In this regard, annual impact assessment of all the schemes related to energy efficiency becomes more important than ever.

Towards this, BEE has hired the agency to undertake a comprehensive review of national and state level schemes initiated for the adoption of energy efficiency in 2022-23 across all the demand sectors. The coverage of national level schemes under the study is not only limited

to BEE but also extends to energy efficiency initiatives by other organizations such as EESL, SIDBI, ICAT, SDAs etc.

1.2. Scope of Work

This study aims to assess the impact of all the energy efficiency programmes in India, in terms of total energy saved and reduction in the amount of CO_2 emissions in 2022-23. In order to assess the impact, following tasks were carried out under the study:

- Review of all National level schemes pertaining to energy efficiency
- Stakeholder consultation, data collection and verification
- Data Analysis and report submission

As a part of this assignment, several stakeholders were consulted who were either directly or indirectly associated with various energy efficiency measures. These meetings were conducted to get their inputs for the specific schemes and programs that fall under their ambit, as well as gain valuable insights on the developments that have happened during the last year on the energy efficiency front. The list of stakeholders that were consulted is presented in Table 4 below:

Table 4: List of major Stakeholders

Stakeholder	Scheme/ Programme
BEE	PAT, S&L, ECBC, Star Rated Buildings, BEE SME Program, Residential labeling, Eco Niwas Samhita
EESL	SLNP, UJALA, BEEP, AgDSM, National EV Mission
TERI	GRIHA Rating System
CII	IGBC Rating System
GBCI	LEED Programme
DHI	FAME
ICAT	CAFÉ Norms
SIDBI	Partial Risk Sharing Facility (PRSF) Programme
UNIDO	BEE-UNIDO-GEF Programme
MoMSME	EESL -UNIDO -GEF 5
CEA	Electricity generation data
Ministry of Railways	EE initiatives in Traction and Non-traction system

In order to calculate the impact, certain assumptions have been taken in consultation with BEE and respective stakeholders. A list of assumptions is presented in Table 5.

Table 5 : Conversions and Assumptions

Conversions / Units / Assumptions
1 toe = 11,630 kWh
1 Mtoe = 1 Million tonne of oil equivalent
1 $MtCO_2$ = 1 Million tonne of carbon dioxide
1 BU = 1 Billion Unit =10^9 kWh = 1TWh

Conversions / Units / Assumptions
1 kWh saving = 0.71 kg of carbon dioxide emission reduction[8]
Cost/toe[9] = INR 18,402
Cost/kWh[10] = INR 6.29
Net energy (Total) consumption in 2022-23 = 543.58 Mtoe (P)
Net energy supply in 2022-23 = 767.17 Mtoe (P)
Electricity (Total) consumption in 2022-23= 1227 TWh
Emission factor for LPG[11] – 63.1 tonne of CO_2/ TJ

Note: With the rise in renewable energy (RE) generation, the grid emission factor has decreased to 0.71 tCO2/MWh during the fiscal year 2022-23.

As implementation of all the schemes are mostly independent of each other, each individual scheme has been discussed in separate sections. Chapters 2, 3, 4, 5, 6, 7, 8 and 9 discuss about all the sector specific energy efficiency schemes/programmes. These chapters provide overview of the schemes/ programmes and their impact due to energy savings in FY 2022-23. Chapter 10 covers various initiatives undertaken in states by SDAs and other agencies. Finally, chapter 11 concludes along with the way forward.

[8] https://cea.nic.in/wp-content/uploads/baseline/2023/01/Approved_report_emission__2021_22.pdf

[9] https://beeindia.gov.in/sites/default/files/press_releases/Ministry%20of%20Power%20notifies%20price%20of%20one%20metric%20tonne%20of%20oil%20equivalent%20applicable%20for%20Designated%20Consumer%20of%20Second%20Cycle%20of%20Perform%2C%20Achieve%20and%20Trade%20%28PAT%29%20scheme..pdf

[10] https://pfcindia.com/DocumentRepository/ckfinder/files/Operations/Performance_Reports_of_State_Power_Utilities/Report%20on%20Performance%20of%20Power%20Utilities%20-%202021-22%20%20updated%20up%20to%20May%202023.pdf

2. *Industries*

The industrial sector plays a pivotal role in the Indian economy, making a substantial contribution to the total gross value added in the country. Industry accounts for 31% of India's GDP and employs over 12.1 crore people. In the year 2022-23, the industrial sector has grown by 6.7%[12]. Manufacturing is emerging as an integral pillar in the country's economic growth, thanks to the performance of key sectors like automotive, engineering, cement, textiles, steel, chemicals, pharmaceuticals, and consumer durables. The manufacturing sector of India has the potential to reach US$ 1 trillion by 2025.[13]

Notably, the manufacturing segment within this sector stands out as a key player, holding the position of the largest consumer of commercial energy in India. As this sector generates more than a quarter of India's GDP, it simultaneously consumes about half of the available commercial energy resources. The significance of the manufacturing industry lies not only in its economic contribution but also in its substantial energy requirements.

The energy intensity of the manufacturing sector in India is a noteworthy aspect. This intensity stems from the multifaceted energy demands associated with the entire production process. From the extraction of natural resources to the conversion of these resources into raw materials, and finally, the manufacturing of finished products, each stage requires a considerable amount of energy. Consequently, the industrial sector can be broadly categorized into two main segments: energy-intensive industries and light industries. Examples of energy-intensive industries include iron and steel, chemicals, petroleum refining, cement, aluminium, and pulp and paper. On the other hand, light industries encompass activities such as food processing, textiles, wood products, printing and publishing, and metal processing. It's worth highlighting that a significant majority of the energy consumed within the industrial sector is attributed to these energy-intensive industries.

In essence, the industrial sector's role in the Indian economy is multifaceted, encompassing economic growth, employment generation, and energy consumption. The energy-intensive

[12] Source: https://prsindia.org/files/policy/policy_committee_reports/Economic%20Survey%20Summary%202022-23.pdf
[13] Source: IBEF

nature of manufacturing underscores the need for sustainable practices and efficient energy management strategies within this crucial sector.

The major drivers for industrial energy demand are the increased demand for materials in buildings, transportation, capital goods and infrastructure. In the FY 2022-23, the total final Energy Consumption by the industrial sector was 5,43,585 ktoe (P). The industrial sector was also the largest consumer of energy in the country with this sector itself using more than half, i.e., 50.59% of the total final energy consumption.[14]

As depicted in the figure below, the most energy intensive industries within the industry sector were iron and steel, which accounted for 15.29% of the industrial energy use followed by Chemicals and petrochemicals 5.36 % and construction 2.09%.[14]

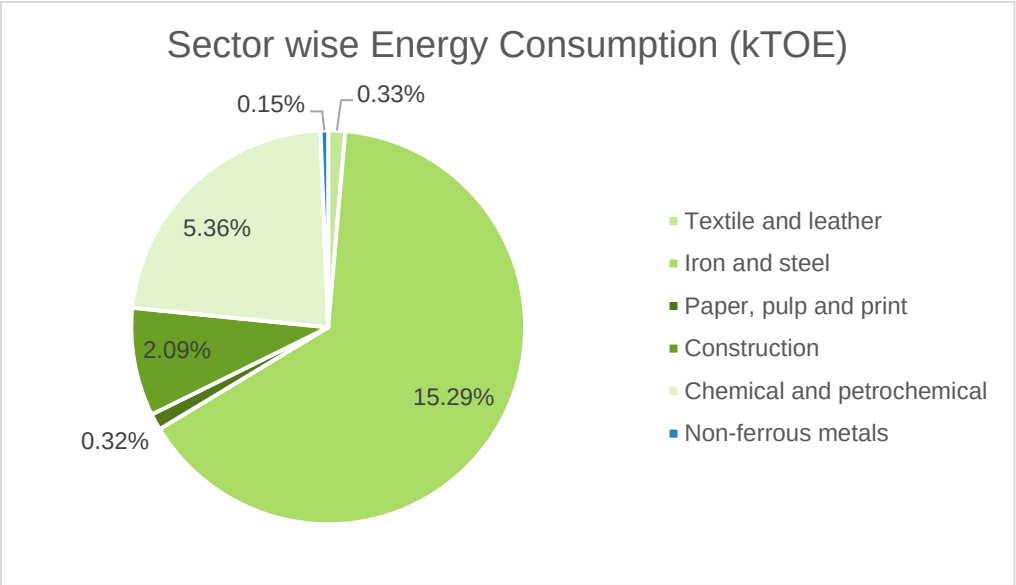


Figure 9:Energy Consumption by various industrial sectors in the FY 2022-23

Our Hon'ble Prime Minister, Shri Narendra Modi, announced India's aim of achieving net zero emissions by 2070 at COP 27 in Glasgow. Within one year, India has submitted its Long-Term Low Emissions Growth Strategy indicating low carbon transition pathways in key economic sectors. Responding to the call for increased ambition in our 2030 climate targets, India updated its Nationally Determined Contributions in August 2022. We have embarked on far-reaching new initiatives in renewable energy, e-mobility, ethanol blended fuels, and green hydrogen as an alternate energy source.

Low carbon development transitions in the sector should not impact energy security, energy access and employment. The focus will be on improving energy efficiency by the Perform, Achieve and Trade (PAT) scheme, National Hydrogen Mission, high level of electrification in all relevant processes and activities, enhancing material efficiency and recycling leading to expansion of circular economy, and exploring options for hard-to-abate sectors, such as steel, cement, aluminium and others.

Needless to say, Industrial consumers will also be the front-enders when it comes to sharing the targets, either through regulations, or in context of global pressure and even voluntarily. The rising quantum of energy consumed by the industrial consumers signifies the immense potential for energy conservation across industrial sector.

[14] The values are estimated based on Energy Statistics 2023, MoSPI. Final values will be published in the 2024 version of Energy Statistics

The Bureau of Energy Efficiency (BEE) in India has established comprehensive policies aimed at promoting energy efficiency (EE) across various sectors. Among these sectors, the industrial segment has become a key focus for BEE, as enhancing energy efficiency within industries plays a pivotal role in addressing the escalating issues of energy consumption and associated carbon emissions. To address these concerns and promote sustainable development, the Government of India introduced the National Action Plan on Climate Change (NAPCC) in 2008, outlining a path toward low-carbon and highly resilient development.

In recent years, the drive for energy efficiency in the industrial sector has gained significant traction, with specific policy initiatives such as the Perform, Achieve and Trade (PAT) scheme. Perform Achieve and Trade (PAT) scheme, one of the flagship programmes of Bureau of Energy Efficiency is aimed at improving energy efficiency in energy intensive industries. The programme is a major contributor towards reduction in GHG gas emissions and energy savings in the large industry sector.

To further expedite the transition toward energy efficiency in industrial sectors, BEE has developed "User Manuals" tailored for different stakeholders participating in the PAT scheme. These manuals are expected to serve as valuable resources, providing essential guidance for the effective and efficient implementation of the scheme.

Recognizing the need to align with commitments made under the Nationally Determined Contributions (NDCs), activities with climate benefits are being consolidated and aligned with NDC goals. Consequently, the National Mission for Enhanced Energy Efficiency (NMEEE) has undergone a revision, evolving into the "Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE)." This broader version of the mission encompasses all current and potential areas of energy efficiency across various sectors.

ROSHANEE serves as a strategic framework to strengthen NMEEE, conducting a thorough review of existing approaches and planning a new portfolio of strategies aimed at reinforcing energy efficiency nationwide until 2030. As part of ROSHANEE, a Specific Financing Facility (SFC) proposal has been approved with a budget of Rs. 167 Crores, encompassing the PAT scheme and other activities related to energy efficiency financing. This comprehensive approach reflects a commitment to addressing energy efficiency challenges holistically, contributing to India's sustainable and resilient development goals.

2.1. Perform, Achieve and Trade (PAT) framework

Enhancing energy efficiency in industries in order to reduce carbon emissions and to combat against the threats of climate change is a priority concern for India. The Perform Achieve and Trade (PAT) scheme was formulated to achieve the objective of improving energy efficiency in energy intensive industries of India. PAT scheme is one of the key initiatives under the National Mission for Enhanced Energy Efficiency (NMEEE) which is one of the eight national missions under National Action Plan on Climate Change (NAPCC). The PAT scheme shares a substantial part of the mitigation responsibility envisaged under the Nationally Determined Contributions (NDCs) committed to the United Nations Framework Convention on Climate Change (UNFCCC).

PAT is a regulatory instrument to reduce specific energy consumption in energy intensive industries, with an associated market-based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.

It has been observed in the recent years that, attempts are being made by energy intensive industries to become more and more efficient through implementation of energy efficiency

projects. In order to provide more encouragement to these industries and further accelerate the process of reduction in carbon emissions, PAT scheme has been launched by the Government of India. The energy intensive industries including the thermal power plants are the major players in this entire scheme of PAT. PAT is a mechanism designed to achieve the emissions reduction in energy intensive industries and revolves around the concept of reduction in Specific Energy Consumption (SEC). It refers to the calculation of SEC in the baseline year and projected SEC in the target year covering different forms of net energy going into the boundary of the designated consumers' plant and the products leaving it over a particular cycle.

As of now Ministry of Power (MoP), based on the recommendations of Bureau of Energy Efficiency (BEE) notified industrial units and other establishments having annual energy consumption more than the threshold in thirteen industrial sectors viz. Aluminum, Cement, Chlor- Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power Plant, Textile, Railways, Refineries, DISCOMs, Petrochemicals and Commercial buildings (hotels) as Designated Consumers (DCs).

The target reduction for each DC is based on the prevailing levels of energy efficiency, so that energy efficient units will have low target of percentage reduction, as compared to less energy efficient units which will have higher targets. Each DC is given a mandatory target of SEC reduction with a time period of three years from the date of notification by the Central Government.

A robust Monitoring and Verification (M&V) process is one of the key features of the PAT Scheme. M&V of DCs who have been notified under PAT Scheme is a process to verify the SEC and other related parameters through verifiable means in the baseline year and in the assessment year by empaneled accredited energy auditing firms. BEE empanels accredited energy auditors (AEAs) especially for conducting and M&V of the DCs.

DCs which are able to achieve SEC level that are lower than their targets can receive Energy Savings Certificates (ESCerts) for their excess savings. On the other hand, the DCs which fail to achieve the given targets either through their own actions or through purchase of ESCerts are liable to financial penalty under the Energy Conservation Act, 2001.

The ESCerts are to be traded at two power exchanges that is Indian Energy Exchange (IEX), Hindustan Power Exchange (HPX) and Power Exchange India Limited (PXIL) or bought by other units under PAT who can use them to meet their compliance requirements.

Some of the broad steps involved in commissioning and operationalizing typical PAT cycles in industries / industry sectors are presented in Figure 10:

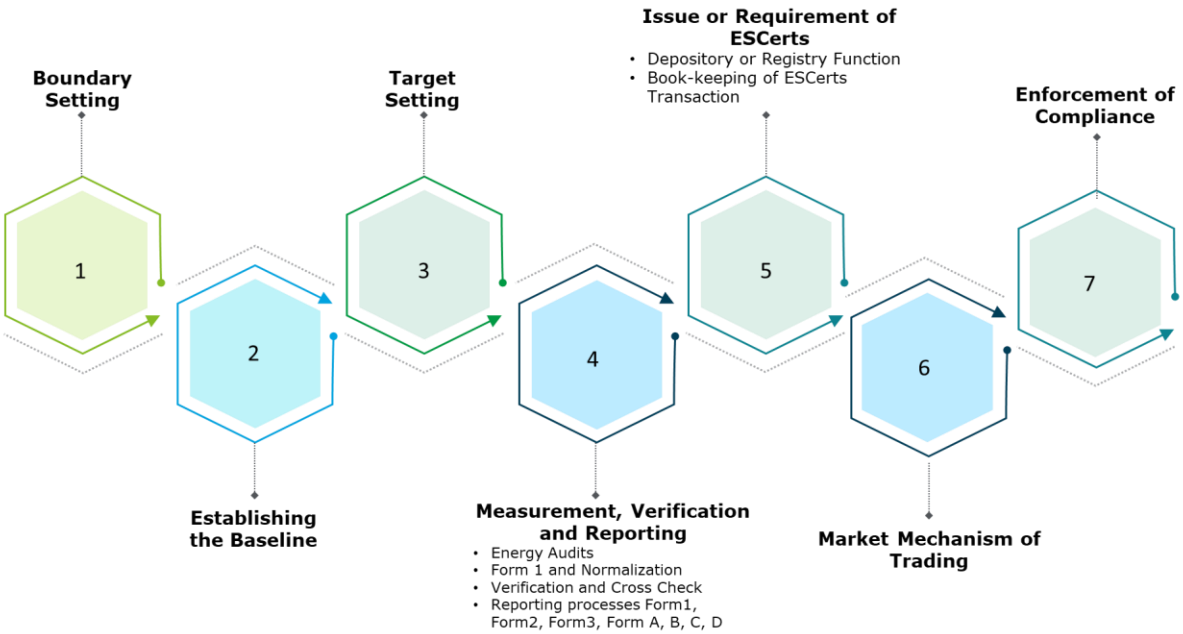


Figure 10: Design of the PAT framework

Salient features of PAT Scheme:

1. PAT scheme is a blend of regulatory mechanism embedded with market component as the Designated Consumer upon complying to mandatory SEC reduction targets, their excess energy saving is incentivized to enable trading in a market.
2. The SEC reduction targets are unit specific so that units are competing against their own benchmark.
3. The national/sectoral energy saving targets are assigned based on their level of energy consumption.
4. The saving targets are relatively assigned based on their level of efficiencies, i.e. unit which is more efficient gets lesser target compared to the one that is relatively inefficient recognizing the fact that the already efficient one would have lesser room for further improvement in efficiency.
5. This employs a robust M&V procedure where achievements of each DC are verified with utmost detail through an independent third party agency and thereafter again the reports get scrutinized at various State and Central Government levels before arriving at conclusion of their performance.

Table 6: PAT Stakeholders and responsibilities

Stakeholders	***Responsibility***
Ministry of Power (MoP)	Policy Maker & Administrator
Bureau of Energy Efficiency (BEE)	Nodal Agency
Designated consumer (DC)	Implementer
State Designated Agency (SDA)	State Administrator
State Electricity Regulatory Commission (SERC)	Adjudicator
Empaneled Accredited Energy Auditors	Verifier
CERC, Grid India	Trading Regulator, Registry
Power exchange – IEX, PXIL, HPX	Trading Platform

2.1.1. PAT Overview:

PAT cycle – I comprised of 478 industrial units from 8 sectors (Table 2) viz. Aluminum, Cement, Chlor- Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power Plant and Textile. PAT Cycle I was completed on 31st March, 2015. The energy savings achieved in PAT Cycle –I is 8.67 Mtoe which was excess of 30 percent against the target of 6.686 Mtoe. This energy saving also translates into avoiding about 31 million tonne of CO2 emission.

Considering the success of the PAT Cycle I, PAT Cycle II was launched in 2016 with addition of three sectors, namely, Petroleum Refineries, DISCOMs and Railways. With this widening of sectors and deepening among existing sectors, 173 DC were added during PAT Cycle II, taking the total number of DCs to 621 across 11 target sectors.

Table 7: PAT Sector Overview:

Sector	Threshold Energy Consumption for the DC (TOE)	No. of DCs	
		Cycle I	Cycle II
Thermal Power Plant	30,000	144	154
Iron and Steel	20,000	67	71
Cement			
a) Integrated Cement Unit	30,000	85	111
b) Cement Grinding Unit	10,000		
Fertilizer	30,000	29	37
Aluminium	7,500	10	12
Pulp and Paper	20,000	31	29
Textile	3,000	90	99
Chlor-Alkali	12,000	22	24
Petroleum Refineries	90,000	-	18
Petrochemical units having gas crackers or naphtha crackers or both	1,00,000	-	-
Railways			
a) All Zonal Railways (Traction)	70,000	-	16

b) Workshops	750	-	6
Commercial Buildings			
a) Hotels	500	-	-
b) Airports	500	-	-
DISCOMs	All licensed distribution companies BY SERC/JERC	-	44
	Total	**478**	**621**

Since 2017, PAT Cycles are notified on rolling basis. PAT Cycle III is launched in 2017 for 116 newly identified DCs within the existing 6 target sectors.

PAT cycle –IV was notified in March 2018. A total of 109 DCs with a total reduction target of 0.6998 MTOE was notified under PAT cycle -IV. The DCs notified under PAT cycle -IV are from 8 sectors consisting of 6 existing sectors and two new sectors. The new sectors are Petrochemicals and Buildings.

PAT cycle –V (2019-2020 to 2022-23): PAT cycle –V had commenced with effect from 1st April 2019. Under PAT cycle –V, 110 DCs from the existing sectors of PAT i.e., Aluminum, Cement, Chlor-Alkali, Commercial Buildings (Hotels), Iron & Steel, Pulp & Paper, Textile and Thermal Power Plant were notified.

PAT cycle –VI (2020-21 to 2022-23) PAT Cycle-VI has commenced with effect from 1st April 2020. Under PAT Cycle-VI, 135 DCs from six sectors, i.e., Cement, Commercial buildings (hotels), Iron and Steel, Petroleum Refinery, Pulp and Paper and Textiles, have been notified. With implementation of PAT cycle –VI, it is expected to achieve a total energy savings of 1.277 MTOE.

Today, PAT framework has come a long way in its seventh cycle, covering 13 Sectors and 1196 DCs. PAT Cycle-VII has commenced with effect from 28th Oct 2021 for the period 2022-23 to 2024-25. Under PAT Cycle-VII, 707 DCs from sectors, i.e. Locomotive, Coach, Wheel, A.Zonal Railways, Cement, Commercial buildings (hotels), Iron and Steel, Petroleum Refinery, Pulp and Paper and Textiles, have been notified. PAT cycle – VII was notified for FY 2022-25 with overall energy saving target of 8.485 MTOE.

Details are presented in the *Table 8*:

Table 8: PAT details till Cycle VII

Sector / No. of DCs	PAT Cycle I (Apr'12)	PAT Cycle II (Apr'16)	PAT Cycle-III (Apr'17)	PAT Cycle-IV (Apr'18)	PAT Cycle- V (Apr'19)	PAT Cycle- VI (Apr'20)	PAT Cycle-VII (Apr'22)	Total Notified DCs till VII A
Aluminium	10	12	1	-	1	-	12	14
Cement	85	111	14	1	12	37	120	175
Chlor- Alkali	22	24	-	2	2	-	24	28
Fertilizer	29	37	-	-	-	-	0	37
Iron & Steel	67	71	29	35	23	5	134	204
Paper & Pulp	31	29	1	2	8	2	24	48
Textile	90	99	34	7	16	7	120	168
Thermal Power Plant	144	154	37	17	17	-	152	239
Refinery	-	18	-	-	-	20	0	20
Railways	-	22	-	-	-	-	26	26
DISCOMs	-	44	-	-	-	-	95	96
Petrochemical	-	-	-	8	-	-	0	8
Buildings	-	-	-	37	31	64	0	133
Total	**478**	**621**	**116**	**109**	**110**	**135**	**707**	**1196**

The PAT cycles (till Cycle VII) has covered 1196 units from 13 sectors for participation till March 2023. The state wise distribution of these DCs is showcased in the figure below:

Figure 11: State-wise No. of DCs till PAT Cycle VII

2.1.2. PAT Cycle I

PAT Cycle I (2012-15) which was operationalized in April 2012, included 478 units, known as "Designated Consumers" (DCs), from eight energy-intensive sectors viz. Aluminium, Cement, Chlor – Alkali, Fertilizer, Iron & Steel, Pulp & Paper, Thermal Power Plant and Textile were included. The annual energy consumption of these DCs in eight sectors was around 164 million TOE.

These 478 DCs were provided individual targets for reduction in Specific Energy Consumption (SEC), arrived at by a detailed and methodical process in close consultation with industry bodies, so as to collectively achieve savings of 6.686 Million Tonne of Oil Equivalent (Mtoe). The Table 9 showcases the sector wise targets provided to DCs covered under PAT cycle I:

Table 9: Energy Reduction Target for DCs covered under PAT Cycle -1

Sector	No. of DCs	Energy Reduction Target for PAT Cycle -1 (Million toe)
Aluminium	10	0.456
Cement	85	0.815
Chlor-Alkali	22	0.054
Fertilizer	29	0.478
Iron & Steel	67	1.486
Pulp & Paper	31	0.119
Textile	90	0.066
Thermal Power Plant	144	3.211
Total	**478**	**6.68**

The outcomes of M&V are reflected in issuance of Energy Saving Certificates (ESCerts) to overachieving DCs, together with notification for obligation of ESCerts to those DCs who have underachieved their SEC reduction targets.

With the completion of the PAT Cycle – I in 2015, the reported overall achievement was 8.67 Mtoe, exceeding the target for cycle -I by almost 30%. These energy savings of 8.67 Mtoe is equivalent to saving of about 20 million tonnes of coal and avoided emissions of about 31 million tonnes of CO2. Summary of sector wise savings are presented in the Table 10:

Table 10: Summary of energy saving and emission reduction PAT Cycle I

S.No	Sector	Number of DC	Energy savings Achieved (Mtoe)	CO2 Emissions (Mn tonne of CO2 /year)
1	Aluminium	10	0.73	3.10
2	Cement	85	1.48	4.34
3	Chlor-Alkali	22	0.09	0.62
4	Fertilizer	29	0.78	0.93
5	Iron & Steel	67	2.10	6.51
6	Pulp & Paper	31	0.29	1.24
7	Textile	90	0.13	0.62
8	Thermal Power Plant	144	3.06	13.64
	Total	**478**	**8.67**	**31.00**

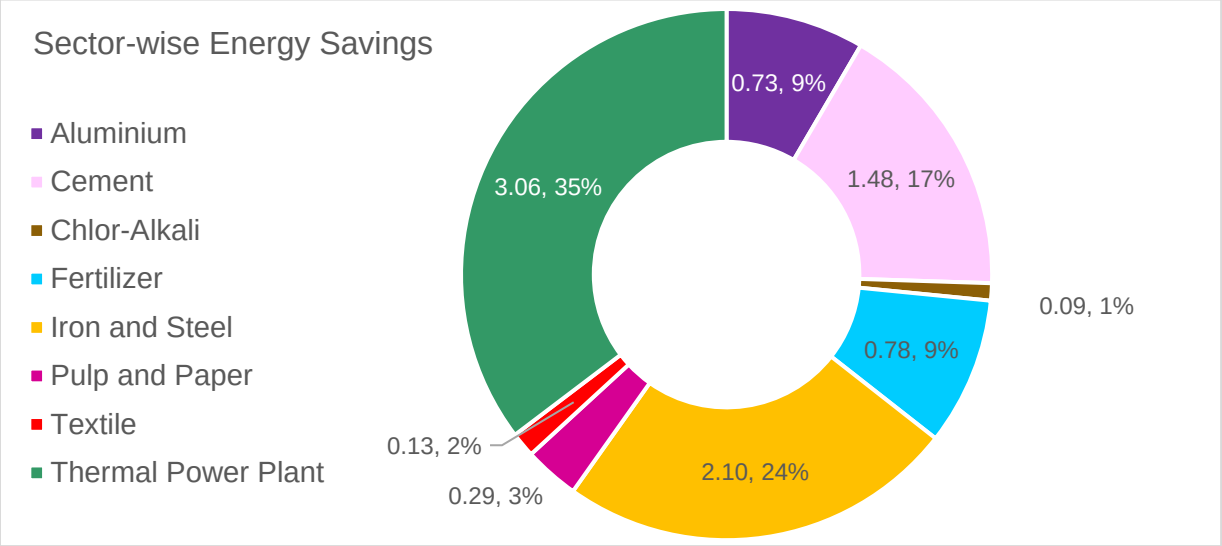


Figure 12: PAT Cycle I – Sector-wise Energy Savings

Energy Savings- Target Vs Achieved

Perform Achieve and Trade in its first cycle was designed to reduce the specific energy consumption (SEC) in energy intensive sectors under which 478 DCs from 8 sectors viz. Aluminum, Cement, Chlor- Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power Plant and Textile have been included. PAT cycle I has achieved an energy saving of 8.67 Mtoe against the targeted energy saving of 6.68 Mtoe which is about 30% over achievement.

Most of the sectors overachieved the assigned targets. However, thermal power plants were not able to meet the reduction targets which were set for them. The % Achievement over the energy saving targets of this sector is highlighted in red in the *Table 11*

Table 11: Energy savings and achievement of PAT targets by sector

Sector	Reduction Target from the DCs analyzed (Mtoe)	Energy Savings Achieved (Mtoe)	% Achievement Over the Energy Saving Targets
Aluminium	0.456	0.73	60.09%
Cement	0.815	1.48	81.60%
Chlor-Alkali	0.054	0.09	66.67%
Fertilizer	0.478	0.78	63.18%
Iron & Steel	1.486	2.10	41.32%
Pulp & Paper	0.119	0.29	143.70%
Textile	0.066	0.13	96.97%
Thermal Power Plant	3.211	3.06	(4.70%)
Grand Total	**6.68**	**8.67**	29.79%

The figure below showcases the energy targets and energy savings achieved by the DCs covered under PAT Cycle-1:

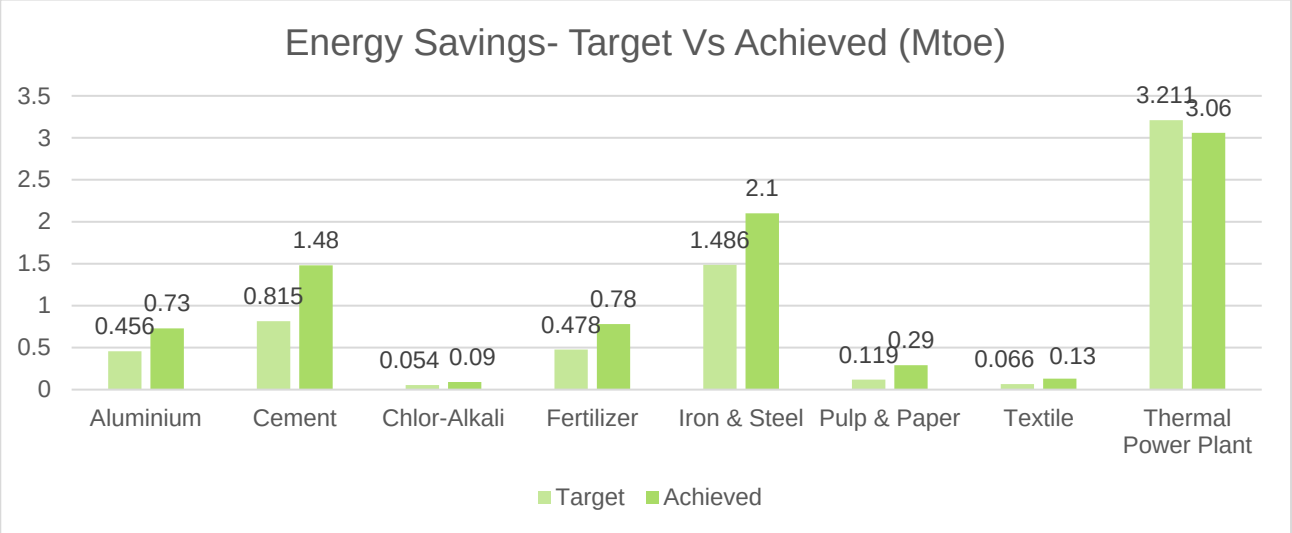


Figure 13: Energy Savings - Target Vs Achieved

Note: PAT Cycle-I concluded in March 2015. Nevertheless, considering the longevity of the energy-efficient technologies and equipment implemented, with a lifespan surpassing 10-15 years, the accumulated energy savings derived from the adoption of these measures during PAT Cycle-I are factored into the computation of the overall energy savings for the FY 2022-23.

2.1.3. PAT Cycle –II (2016-17 to 2018-19)

In order to include new sectors and to identify new DCs under PAT Scheme, "Deepening study" –identifying new DCs in existing sectors and "Widening study" –including new sectors of PAT, was respectively carried out before the commencement of the second cycle.

PAT Cycle II was notified with effect from 1st April, 2016 and was completed on 31st March 2019. Under this cycle, SEC reduction targets were notified to 621 DCs from 11 energy intensive sectors (eight sectors and three new sectors namely Refineries, Railways and DISCOMs). Summary of target savings and DCs are presented in the Table 12.

Table 12: PAT Cycle II- Base year data and target savings:

S No	Sector	Number of DC	Energy savings targets (Mtoe)
1	Aluminium	12	0.466
2	Cement	111	1.117
3	Chlor-Alkali	24	0.102
4	Fertilizer	37	0.447
5	Iron and Steel	71	2.283
6	Pulp and Paper	29	0.146
7	Textile	99	0.088
8	Thermal Power Plant	154	3.134
9	Petroleum Refinery	18	1.098
10	Railways	22	0.077
	Total	**577**	**8.958**
11	DISCOM	44	4.675
	Total	**621**	**13.633**

2.1.3.1. Impact of PAT Cycle II:

The impact under the PAT scheme for this report was calculated based on the data of 548 DCs. The total energy savings for PAT cycle II totals to 14.08 Mtoe (based on baseline year production data of FY 2014-15). The share of energy saved by each sector is presented in Table 13 below:

Table 13: PAT Cycle II Energy Savings Achieved

Sectors		Energy Savings Achieved (Mtoe)	% Share of Savings (Sector-wise)	% Share of Savings (Demand & Supply wise)
PAT Sector (Demand Side)	PAT Sector (Supply Side)			
Aluminium		1.226	8.7%	48.24%
Cement		1.559	11.1%	
Chlor-Alkali		0.133	0.9%	
Fertilizer		0.383	2.7%	
Iron and Steel		2.845	20.2%	
Pulp and Paper		0.315	2.2%	
Textile		0.135	1.0%	
Railways		0.196	1.4%	
	Thermal Power Plant	3.435	24.4%	51.76%
	Petroleum Refinery	1.43	10.2%	
	DISCOM	2.423	17.2%	
Grand Total		14.08	100%	

The sectors mentioned in Table 13 is further divided as demand side sectors and supply side sectors with respect to energy. The Thermal Power Plants, Refineries and DISCOMs, apart from being consumers under PAT, are primarily a part of the energy generation and energy supply value chain. Hence energy efficiency measures in these sectors are classfied as supply side energy efficiency.

Energy Savings- Target Vs Achieved

Data in below Table 13 shows that PAT II has overachieved its energy saving targets by almost more than 16.08%. Most of the sectors achieved the assigned targets with Aluminium, Pulp & Paper and Railways sector achieving more than twice of their assigned targets. However, sectors like Fertilizer and DISCOM were not able to meet the reduction targets which were set for them. The % Achievement over the energy saving targets of these 2 sectors are highlighted in red within the brackets in the *Table 14*

Table 14: Energy savings and achievement of PAT targets by sector

Sector	Number of PAT DCs analyzed for M&V	Reduction Target from the DCs analyzed (Mtoe)	Energy Savings Achieved (Mtoe)	% Achievement Over the Energy Saving Targets
Aluminium	12	0.46	1.226	167%
Cement	99	1.05	1.559	48%
Chlor-Alkali	24	0.1	0.133	33%
Fertilizer	36	0.44	0.383	(13%)
Iron and Steel	67	2.27	2.845	25%
Pulp and Paper	24	0.12	0.315	163%
Textile	85	0.08	0.135	69%
Thermal Power Plant	22	2.85	3.435	21%
Petroleum Refinery	118	0.96	1.430	49%
Railways	18	0.08	0.196	145%
DISCOM	43	3.73	2.423	(35%)
Grand Total	548	12.13	14.08	16%

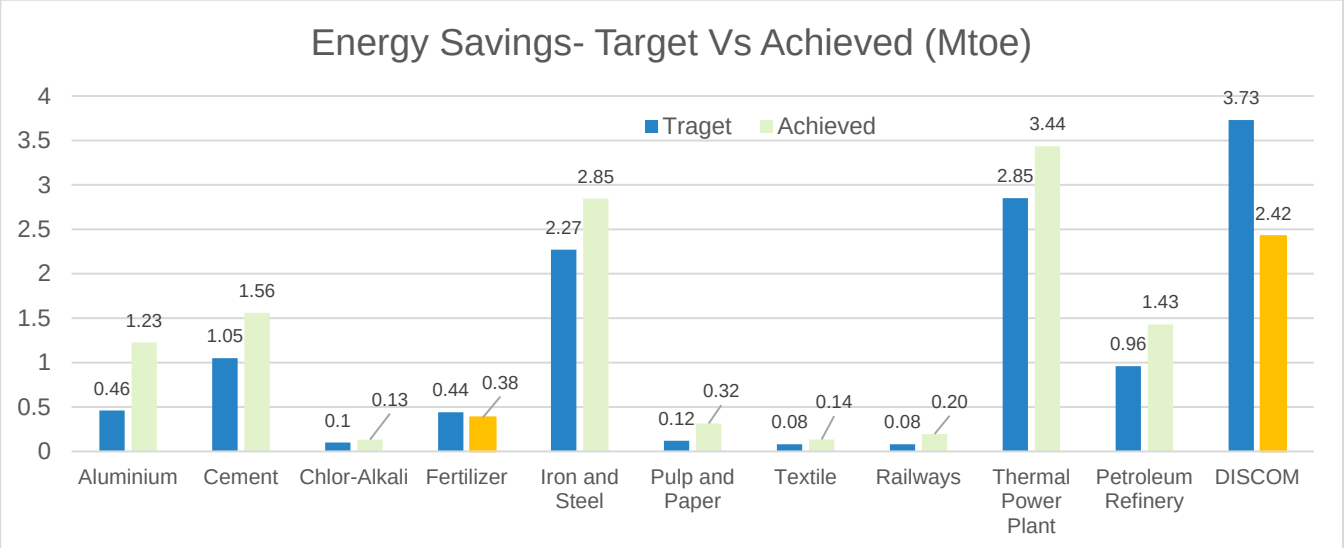


Figure 14: Energy Savings - Target Vs Achieved

2.1.3.1.1. Estimation of reduction in CO_2 emission

Overall, the thermal energy savings of 10.945 Mtoe and electrical savings of 36.466 BU under PAT Cycle II has resulted in emissions reduction of 68.43 MtCO2. Emission reduction due to PAT Cycle II is presented in Table 15.

Table 15: Share (Value) of reduction in CO2 emission by each sector per year

Sector	Total DCs	Evaluated DCs	Total Emission Reduction (Million tCO2/year)	% Share
Aluminium	12	12	4.20	6.14%
Cement	111	99	5.45	7.96%
Chlor-Alkali	24	24	0.55	0.80%
DISCOM	44	43	25.44	37.18%
Fertilizer	37	36	1.18	1.72%
Iron and Steel	71	67	11.85	17.32%
Petroleum Refinery	18	18	5.19	7.58%
Pulp and Paper	29	24	1.35	1.97%
Railways	22	22	1.00	1.46%
Textile	99	85	0.66	0.96%
Thermal Power Plant	154	118	11.57	16.91%
Grand Total	**621**	**548**	**68.43**	**100%**

Summary:

Under the PAT scheme, overall summary of energy (thermal & electrical) savings, and corresponding reduction in CO2 emissions is presented in Table 16:

Table 16:PAT Cycle II emission and energy saving summary

Parameters	Values
No. M&V Analyzed PAT DCs	548
Total Energy Savings achieved per year under PAT II	14.08 Mtoe
Overall reduction in CO2 emissions per year	68.43 MtCO2
Energy (thermal) saved at consumption side per year	6.217 Mtoe
Energy (thermal) saved at supply side per year	4.728 Mtoe
Energy (electrical) saved at consumption side per year	6.694 BU
Energy (electrical) saved at supply side per year	29.772 BU

Note: PAT Cycle II was completed on 31st March 2019. Nevertheless, considering the longevity of the energy-efficient technologies and equipment implemented, with a lifespan surpassing 10-15 years, the accumulated energy savings derived from the adoption of these measures during PAT Cycle-II are factored into the computation of the overall energy savings for the fiscal year 2022-23.

2.1.4. PAT Cycle –III (2017-18 to 2019-20):

The Parliamentary Standing Committee on Energy, Executive Committee on Climate Change under Prime Minister's Office (PMO) and Group of Secretaries recommended to include DCs annually for accelerated coverage of DCs under PAT. Consequently, PAT scheme is being implemented on a rolling cycle basis where new DCs/sectors will be included every year. In view of this PAT cycle –III has started from 1st April 2017.

The duration of PAT Cycle III is from 2017-18 to 2019-20 with 116 new DCs. These DCs are from 6 sectors viz. Thermal Power plant, Cement, Aluminium, Pulp and Paper, Iron and Steel and Textile. The energy consumption of these DCs is 35 Mtoe. These 116 Designated Consumers from six sectors have been given target to reduce 1.06 Mtoe, details of the target energy saving for 116 DC is presented in Table 17.

Table 17: PAT Cycle III- Energy savings targets:

S No	Sector	PAT-III (as per base year 2015-16)		
		Number of DC	Energy Consumption (Mtoe)	Energy savings targets (Mtoe)
1	Thermal Power Plant	37	23.86	0.406
2	Iron & Steel	29	7.65	0.457
3	Cement	14	1.74	0.094
4	Aluminium	1	1.02	0.061
5	Paper & Pulp	1	0.06	0.003
6	Textile	34	0.67	0.040
	Total	116	35.0	1.06

2.1.4.1. Methodology adopted to calculate the savings

Monitoring & Verification of the units under PAT cycle III is being carried out and production data of the baseline year (2015-16) has been taken into consideration for calculating the Energy Savings.

2.1.4.2. Impact of PAT Cycle III

M&V Data for 95 DCs under PAT cycle III was analyzed and as per preliminary assessment it has been estimated that this will result into energy savings of 1.594 Mtoe (based on baseline year production data of FY 2015-16). The share of energy saved by each sector is presented in the Table 18:

Table 18: PAT Cycle III Energy Savings Achieved

PAT Sectors	Number of DCs Notified in PAT	Energy Savings Achieved (Mtoe)	% Share of Savings (Sector-wise)
Aluminium	1	0.089	5.58%
Cement	14	0.156	9.79%
Iron and Steel	29	0.572	35.88%
Pulp and Paper	1	0.005	0.31%
Textile	34	0.048	3.01%
Thermal Power Plant	37	0.724	45.42%
Total	**116**	**1.594**	**100%**

The analysed data of demand side sectors demonstrates the total energy savings of 0.870 Mtoe while the total energy savings for the supply side sectors amounts to 0.724 Mtoe for FY 2019-20.

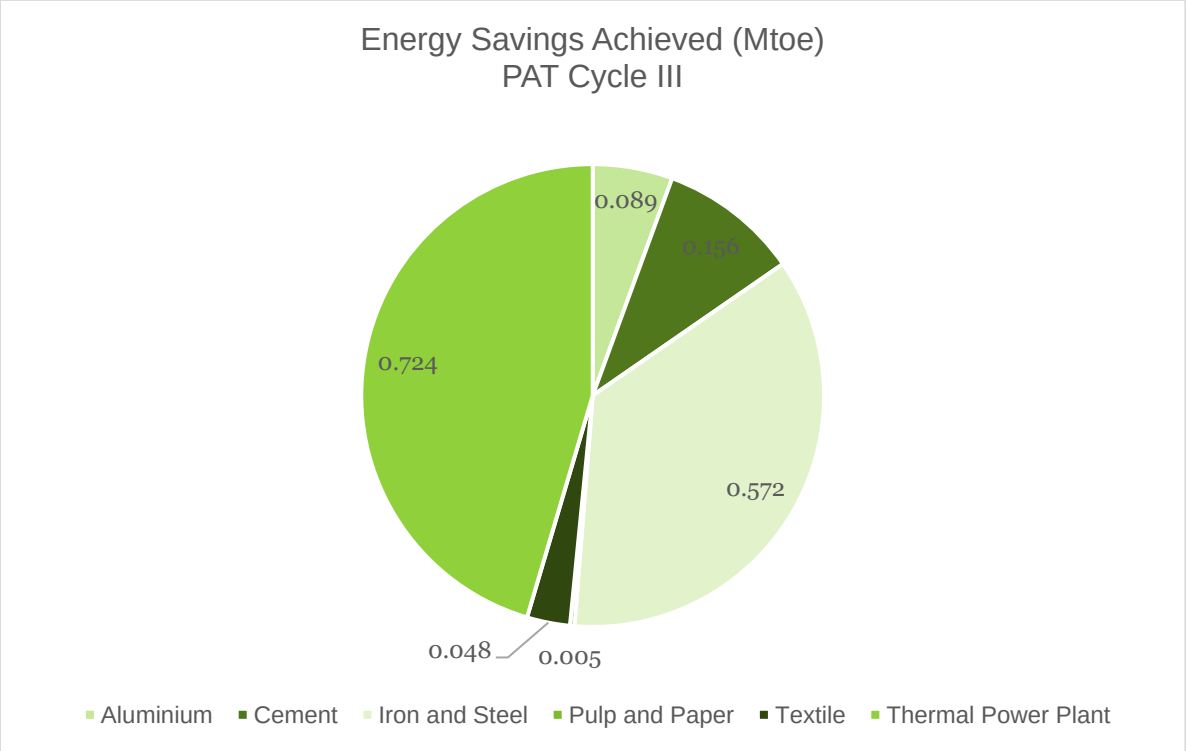


Figure 15: PAT Cycle III Energy Savings Achieved

The DCs, in each sector, under PAT Cycle III has overachieved its energy saving targets. The total target given to these sectors and the energy savings achieved under PAT Cycle III is showcased in the figure below:

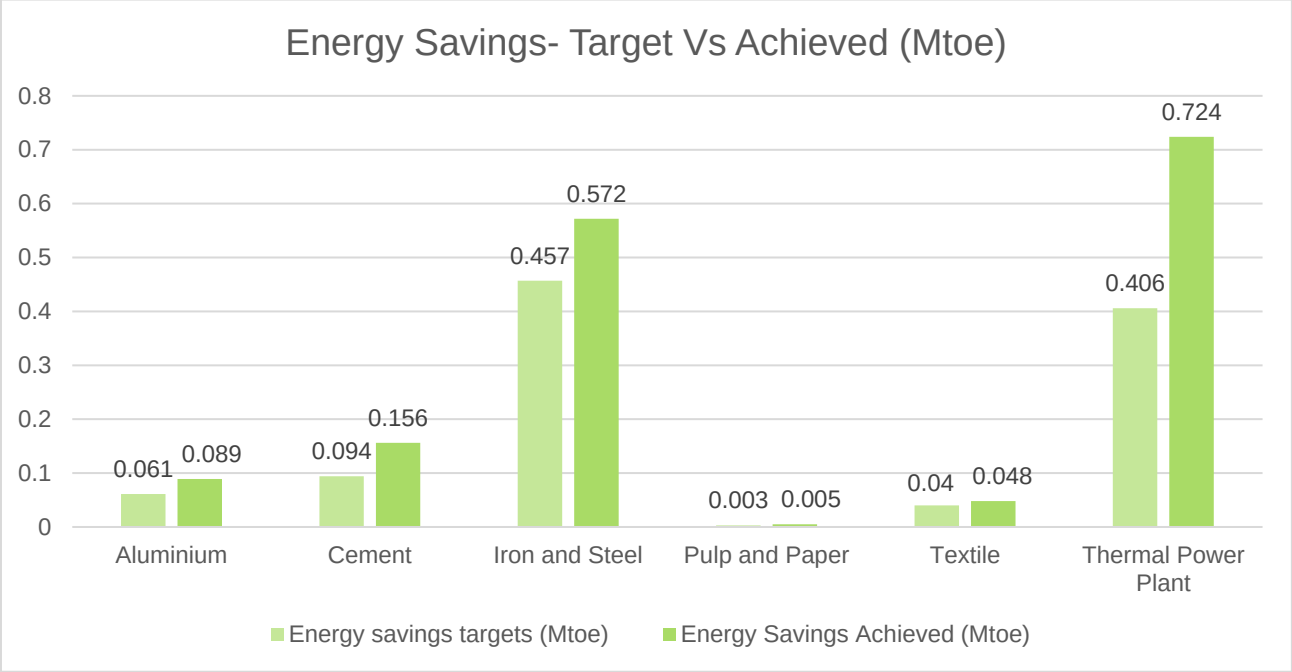


Figure 16: PAT Cycle III Energy Savings - Target Vs Achieved

2.1.4.2.1. Estimation of Fuel- wise energy savings:

In order to calculate the fuel-wise energy savings, a list and percentage of fuel consumed in each PAT sector is calculated. Using these values fuel mix for each PAT sector estimation of thermal and electrical savings is calculated, details are presented in the Table 19

Table 19: Demand and supply side Energy saving (Thermal and electrical) per year

PAT Sector	No. of PAT DCs	Thermal Energy Savings (Mtoe)	Electrical Energy Savings (BU)
Aluminium	1	0.088	0.002
Cement	13	0.136	0.237
Iron and Steel	21	0.555	0.203
Pulp and Paper	1	0.005	0.0
Textile	28	0.033	0.175
Thermal Power Plant	31	0.724	0.0
Grand Total	**95**	**1.541**	**0.617**

The analysed data of sector under the consumption side demonstrates the total thermal **energy savings of 0.870 Mtoe and electrical energy savings of 0.617 BU**. While the sector under the **supply side demonstrates the total thermal energy savings of 0.724 Mtoe**.

2.1.4.2.2. Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO2 emission, Fuel-mix for each PAT sector is considered. Subsequently, we make certain assumptions regarding calorific values, fuel density, and CO2 conversion factors. These assumptions serve as essential parameters for assessing the reduction in emissions. Overall, energy savings of 1.594 Mtoe and 0.617 BU under PAT Cycle III has resulted in reduction of 5.591 MtCO2. CO_2 emission reductions due to PAT Cycle III is presented in Table 20.

Table 20: Share (Value) of reduction in CO2 emission by each sector per year

Sector	No. of DCs	Emission Reduction ($MtCO_2$/year)	% Share in Total reduction
Aluminium	1	0.345	6.17%
Cement	13	0.339	6.06%
Iron and Steel	21	1.691	30.25%
Pulp and Paper	1	0.015	0.27%
Textile	28	0.261	4.67%
Thermal Power Plant	31	2.94	52.58%
Total	**95**	**5.591**	**100%**

Summary:

Under the PAT scheme III, overall summary of energy (thermal & electrical) savings, and corresponding reduction in CO2 emissions is presented in Table 21.

Table 21:PAT Cycle III emission and energy saving per year summary

Parameters	Values
No. of M&V Analyzed PAT DCs	95
Total Energy Savings achieved per year under PAT III	1.594 Mtoe
Overall reduction in CO2 emissions per year	5.591 MtCO2
Energy (thermal) saved per year at consumption side	0.870 Mtoe
Energy (thermal) saved per year at supply side	0.724 Mtoe
Energy (electrical) saved per year at consumption side	0.617 BU
Energy (electrical) saved per year at supply side	0 BU

Note: PAT Cycle –III was completed on 31st March 2020. Nevertheless, considering the longevity of the energy-efficient technologies and equipment implemented, with a lifespan surpassing 10-15 years, the accumulated energy savings derived from the adoption of these measures during PAT Cycle-III are factored into the computation of the overall energy savings for the fiscal year 2022-23.

2.1.5. PAT Cycle –IV (2018-19 to 2021-22):

Baseline Year: 2016-17 & Assessment Year: 2022-23

PAT cycle –IV was notified on 28th March-2018. A total of 109 DCs with a total reduction target of 0.701 MTOE was notified under PAT cycle -IV. The DCs notified under PAT cycle -IV are from 8 sectors consisting of 6 existing sectors and two new sectors. The new sectors are Petrochemicals and Buildings. The assessment year of these DCs was April –July 2021 which was affected by the outbreak of the Pandemic due to COVID19 and thus was extended to April –July 2022 vide notification S.O. 3510

The details of the target energy saving for 109 DC is presented in the Table 22 below.

Table 22: PAT Cycle IV- Energy savings targets:

S No	Sector	PAT-IV (as per base year 2016-17)		
		Number of DC	Energy Consumption (Mtoe)	Energy savings targets (Mtoe)
1	**Cement**	1	0.07	0.004
2	**Chlor Alkali**	2	0.05	0.003
3	**Iron & Steel**	35	3.33	0.193
4	**Paper & Pulp**	2	0.16	0.010
5	**Textile**	7	0.34	0.020
6	**Thermal Power Plant**	17	10.75	0.237
7	**Petrochemical**	8	3.82	0.230
8	**Commercial Buildings (Hotels)**	37	0.06	0.004
	Total	**109**	**18.60**	**0.701**

2.1.5.1. Methodology adopted to calculate the savings

Monitoring & Verification of the units under PAT cycle IV is being carried out and production data of the baseline year (2016-17) has been taken into consideration for calculating the Energy Savings. Following set of equations prepared in order to find the energy savings:

i. Step I: Obtain the Specific Energy Consumption (SEC) for the base year 2016-17 = $SEC_{2016\text{-}17}$

ii. Step II: Obtain the Estimated SEC target for the year 2022-23= SEC_{target}

iii. Step III: $SEC_{2016\text{-}17}$ - SEC_{target} (Improvement in Energy Efficiency)

iv. Step IV: In order to calculate the Energy Savings (ES) in Mtoe, the results of Step 3 to be multiplied by the total production of respective DCs for the year 2016-17.

Therefore formula = $ES_{Plant\ 1}$= ($SEC_{2016\text{-}17}$ - SEC_{target}) x $Production_{2016\text{-}17}$

v. Step V: $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4}$ +----------+ $ES_{Plant\ N}$

2.1.5.2. Impact of PAT Cycle IV

M&V Data for 90 DCs under PAT cycle IV was analyzed and as per preliminary assessment it has been estimated that this will result into energy savings of 0.7508 Mtoe (based on baseline year production data of FY 2016-17). Among all the sectors included in PAT cycle IV, the textile industry fell short of meeting its prescribed reduction targets. Despite being assigned a target of 0.020 Mtoe, the textile sector achieved 0.003 Mtoe, failing to attain the set objective for the sector.

The share of energy saved by each sector is presented in the Table 23:

Table 23: PAT Cycle IV Energy Savings Achieved

PAT Sector (Demand Side)	PAT Sector (Supply Side)	Number of DCs Notified in PAT	Number of PAT DCs analyzed for M&V	Energy Savings Achieved (Mtoe)*	% Share of Savings (Sector-wise)	% Share of Savings (Demand & Supply wise)
Cement		1	1	0.002	**0.27%**	50.17%
Chlor Alkali		2	2	0.001	**0.12%**	
Iron & Steel		35	31	0.357	**47.54%**	
Paper & Pulp		2	2	0.001	**0.15%**	
Textile		7	5	0.003	**0.42%**	
Petrochemical		8	0	0.000	**0.00%**	
Commercial Buildings (Hotels)		37	34	0.019	**2.51%**	
	Thermal Power Plant	17	15	0.374	**49.83%**	49.83%
Grand Total		**109**	**90**	**0.7508**	**100%**	

The sectors mentioned in Table 23 is further divided as demand side sectors and supply side sectors with respect to energy. The analysed data of demand side sectors demonstrates the total energy savings of 0.377 Mtoe while the total energy savings for the supply side sectors amounts to 0.374 Mtoe for FY 2022-23.

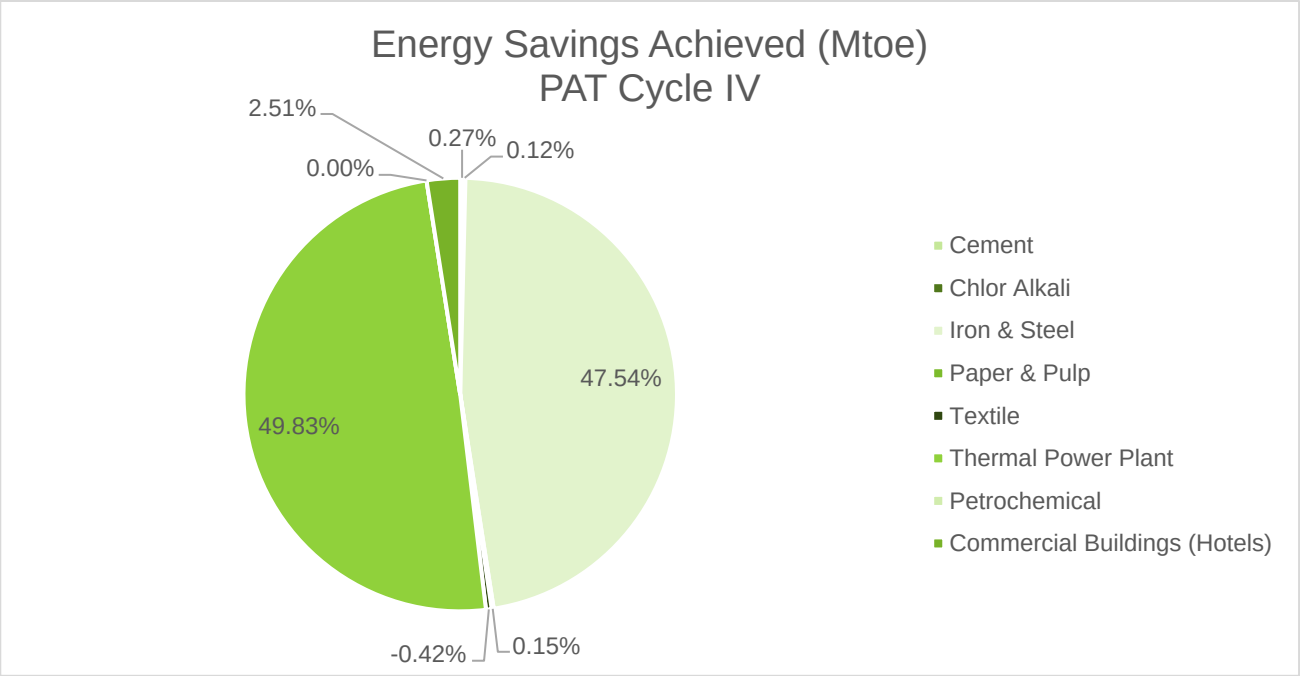


Figure 17: PAT Cycle IV Energy Savings Achieved

Out of the 109 Designated Consumers (DCs) spanning across 8 diverse sectors, the Monitoring and Verification (M&V) process has been successfully conducted for 90 DCs by the culmination of March 31, 2022. Remarkably, three specific sectors—namely, Iron & Steel, Thermal Power Plants and Commercial buildings (Hotels)—participating in the Perform, Achieve, and Trade (PAT) Cycle IV have surpassed their designated energy-saving targets.

This noteworthy achievement underscores the efficacy of energy-saving endeavors within these sectors, contributing significantly to the overall success of PAT Cycle IV.

The total target given to these sectors and the energy savings achieved under PAT Cycle IV is showcased in the figure below:

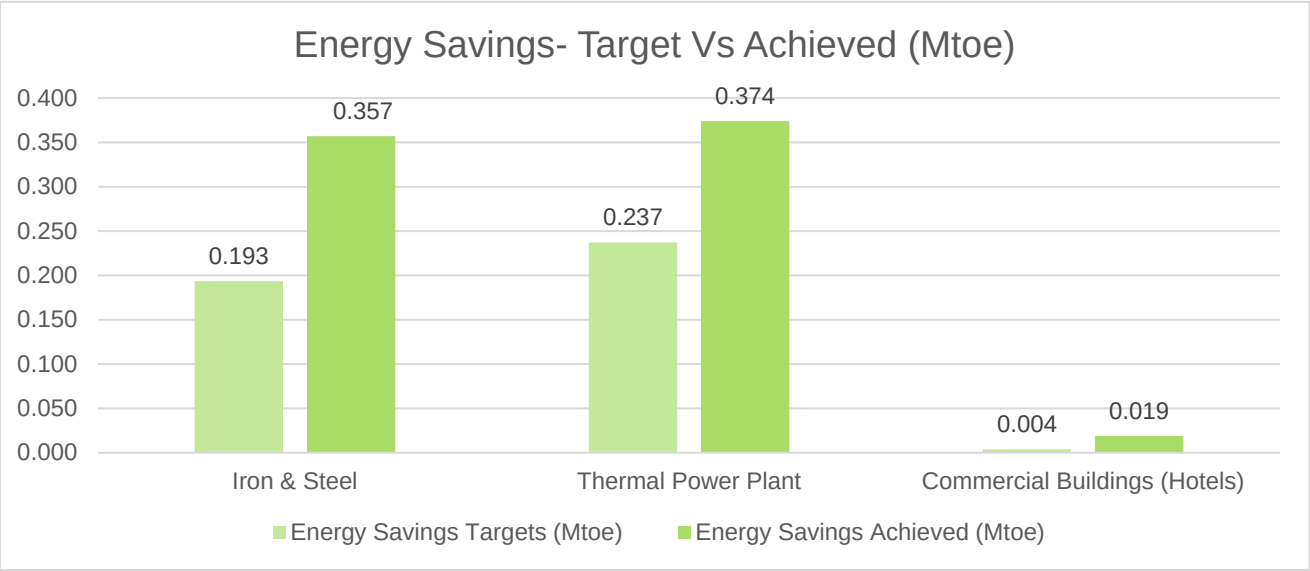


Figure 18: PAT Cycle IV Energy Savings - Target Vs Achieved

2.1.5.2.1. Estimation of Fuel- wise energy savings:

In order to calculate the fuel-wise energy savings, a list and percentage of fuel consumed in each PAT sector is calculated. Using these values fuel mix for each PAT sector we estimated the thermal and electrical savings of each sector which is presented in the table below. After conducting the initial assessment of the DCs under PAT cycle V, it is evident that the textile sector fell short of attaining the energy savings targets outlined in PAT cycle V for the sector. Consequently, the corresponding data is highlighted within brackets and presented in red text in the table below:

Table 24: Demand and supply side Energy saving (Thermal and electrical) per year

PAT Sector (Demand Side)	PAT Sector (Supply Side)	No. of PAT DCs	Thermal Energy Savings (Mtoe)*	Electrical Energy Savings (MU)
Cement		1	0.02	0.024
Chlor Alkali		2	0.001	0.011
Iron & Steel		31	0.357	4.141
Paper & Pulp		2	0.001	0.014
Textile		5	(0.003)	(0.037)
	Thermal Power Plant	15	0.374	4.34
Petrochemical		0	0.000	0.00
Commercial Buildings (Hotels)		34	0.019	0.218
Grand Total		**90**	**0.750**	**8.709**

*Note: Based on initial assessment

The analysed data of sector under the consumption side demonstrates the total thermal **energy savings of 0.376 Mtoe and electrical energy savings of 4.37 MU**. While the sector under the **supply side demonstrates the total thermal energy savings of 0.374 Mtoe and electrical energy savings of 4.34 MU**.

2.1.5.2.2. Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO2 emission, Fuel-mix for each PAT sector is considered and based on the calorific values, density of respective fuels and CO2 conversion factors are used for evaluation of the emission reduction. **Overall, energy savings of 0.7508 Mtoe and 8.71 MU under PAT Cycle IV has resulted in reduction of 2.962 MtCO2**. CO_2 emission reductions due to PAT Cycle IV is presented in the Table 25.

Table 25: Share (Value) of reduction in CO2 emission by each sector per year

Sector	No. of DCs	Emission Reduction ($MtCO_2$/year)	% Share in Total reduction
Cement	1	0.008	0.28%
Chlor Alkali	2	0.003	0.12%
Iron & Steel	31	1.414	47.75%
Paper & Pulp	2	0.005	0.16%
Textile	5	0.013	0.42%
Thermal Power Plant	15	0.064	2.16%
Petrochemical	0	0.000	0.00%
Commercial Buildings (Hotels)	34	1.480	49.97%
Total	**90**	**2.962**	**100%**

Summary:

Under the PAT cycle IV, overall summary of energy (thermal & electrical) savings, and corresponding reduction in CO2 emissions is presented in the Table 26.

Table 26:PAT Cycle IV emission and energy saving per year summary

Parameters	Values
No. of M&V Analyzed PAT DCs	90
Total Energy Savings achieved per year under PAT IV	0.7508 Mtoe
Overall reduction in CO2 emissions per year	2.962 MtCO2
Energy (thermal) saved per year at consumption side	0.376 Mtoe
Energy (thermal) saved per year at supply side	0.374 Mtoe
Energy (electrical) saved per year at consumption side	4.370 MU
Energy (electrical) saved per year at supply side	4.339 MU

2.1.6. PAT Cycle –V (2019-20 to 2021-22):

Baseline Year: 2017-18 & Assessment Year: 2022-23

The initiation of PAT Cycle V took effect on April 1, 2019, marking the commencement of a new cycle in the Perform, Achieve, and Trade (PAT) program. This cycle encompasses a total of 110 Designated Consumers (DCs) drawn from the existing sectors covered by PAT, including Aluminum, Cement, Chlor-Alkali, Commercial Buildings (Hotels), Iron & Steel, Pulp & Paper, Textile, and Thermal Power Plant. These sectors collectively contribute to a significant portion of the industrial landscape and are critical targets for energy efficiency improvement.

The estimated energy consumption of these 110 DCs is quantified at 15.244 Million Tonnes of Oil Equivalent (MTOE). Within the framework of PAT Cycle V, an ambitious target has been set to achieve a total energy savings of 0.5130 MTOE. These 110 Designated Consumers from existing eight sectors have been given target to reduce 15.25 Mtoe, details of the target energy saving for 110 DC is presented in the Table 27.

Table 27: PAT Cycle V- Energy savings targets:

		PAT-V		
S No	**Sector**	**Number of DC**	**Energy Consumption (Mtoe)**	**Energy savings targets (Mtoe)**
1	**Aluminum**	1	1.24	0.074
2	**Cement**	12	1.60	0.087
3	**Chlor-Alkali**	2	0.03	0.002
4	**Iron & Steel**	23	2.83	0.169
5	**Pulp and Paper**	8	0.28	0.017
6	**Textile**	16	0.23	0.014
7	**Thermal Power Plant**	17	9.02	0.150
8	**Building**	31	0.02	0.001
	Total	**110**	**15.25**	**0.513**

2.1.6.1. Methodology adopted to calculate the savings

Monitoring & Verification of the units under PAT cycle V is being carried out and production data of the baseline year (2017-18) has been taken into consideration for calculating the Energy Savings. Following set of equations prepared in order to find the energy savings:

i. Step I: Obtain the Specific Energy Consumption (SEC) for the base year 2017-18 = $SEC_{2017\text{-}18}$

ii. Step II: Obtain the Estimated SEC target for the year 2021-22= SEC_{target}

iii. Step III: $SEC_{2017\text{-}18}$ - SEC_{target} (Improvement in Energy Efficiency)

iv. Step IV: In order to calculate the Energy Savings (ES) in Mtoe, the results of Step 3 to be multiplied by the total production of respective DCs for the year 2017-18.

Therefore formula = $ES_{Plant\ 1}$= ($SEC_{2017\text{-}18}$ - SEC_{target}) x $Production_{2017\text{-}18}$

v. Step V: ΣES = $ES_{Plant\ 1}$ + $ES_{Plant\ 2}$+ $ES_{Plant\ 3}$ + $ES_{Plant\ 4}$ +----------+ $ES_{Plant\ N}$

2.1.6.2. Impact of PAT Cycle V

M&V Data for 91 DCs under PAT cycle V was analyzed and as per preliminary assessment it has been estimated that this will result into energy savings of 0.681 Mtoe (based on baseline year production data of FY 2017-18). The share of energy saved by each sector is presented in the Table 28

Table 28: PAT Cycle V Energy Savings Achieved

PAT Sector (Demand Side)	PAT Sector (Supply Side)	Number of DCs Notified in PAT	Number of PAT DCs analyzed for M&V	Energy Savings Achieved (Mtoe)*	% Share of Savings (Sector-wise)	% Share of Savings (Demand & Supply wise)
Aluminum		1	1	0.089	13.00%	80.53%
Cement		12	12	0.153	22.49%	
Chlor-Alkali		2	2	0.003	0.45%	
Iron & Steel		23	16	0.263	38.67%	
Pulp and Paper		8	6	0.023	3.38%	
Textile		16	11	0.012	1.72%	
Commercial Buildings (Hotels)		31	28	0.006	0.82%	
	Thermal Power Plant	17	15	0.133	19.47%	19.47%
Grand Total		**110**	**91**	**0.681**	**100%**	

*Note: Based on initial assessment

The sectors mentioned in Table 28 is further divided as demand side sectors and supply side sectors with respect to energy. The analysed data of demand side sectors demonstrates the total energy savings of 0.548 Mtoe while the total energy savings for the supply side sectors amounts to 0.133 Mtoe for FY 2022-23.

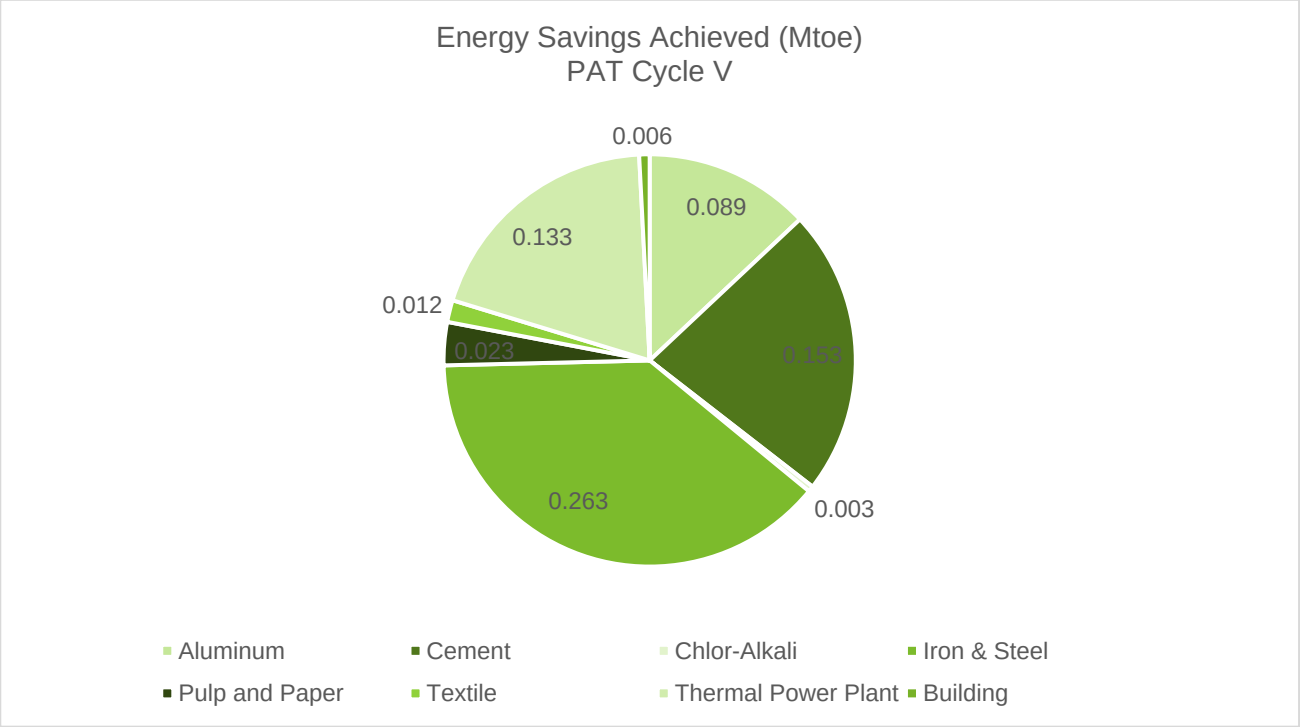


Figure 19: PAT Cycle III Energy Savings Achieved

Out of the total 110 Designated Consumers (DC) spanning across eight sectors, Monitoring and Verification (M&V) processes have been successfully conducted for 91 DCs as of 31st March 2023. Up to the present date, notable achievements have been observed in six sectors, specifically Aluminum, Cement, Chlor-Alkali, Iron & Steel, Pulp and Paper, as well as commercial buildings, all falling under the ambit of Perform, Achieve, and Trade (PAT) Cycle V. These sectors have surpassed their stipulated energy-saving targets, showcasing commendable progress in meeting and even exceeding the set benchmarks for enhanced energy efficiency. The total target given to these sectors and the energy savings achieved under PAT Cycle V is showcased in the figure below:

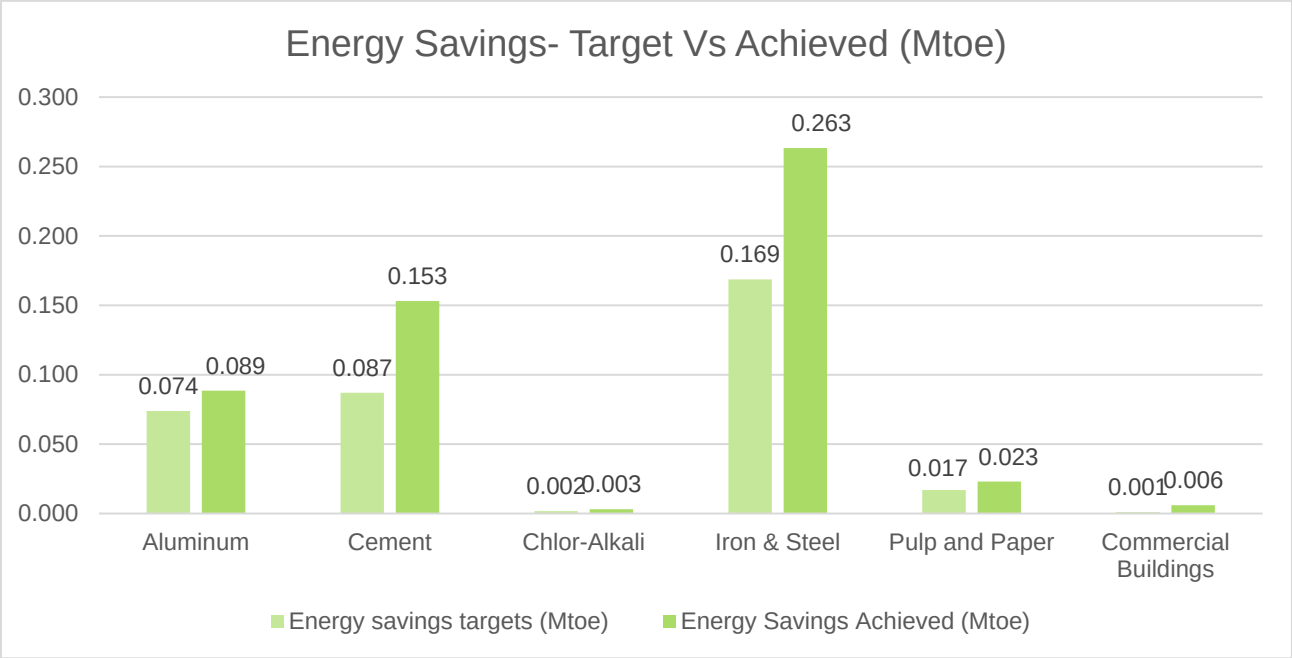


Figure 20: PAT Cycle V Energy Savings - Target Vs Achieved

2.1.6.2.1. Estimation of Fuel- wise energy savings:

In order to calculate the fuel-wise energy savings, a list and percentage of fuel consumed in each PAT sector is calculated. Using these values fuel mix for each PAT sector is identified and is used for estimation of thermal and electrical saving, details are presented in the Table 29

Table 29: Demand and supply side Energy saving (Thermal and electrical) per year

PAT Sector (Demand Side)	PAT Sector (Supply Side)	No. of PAT DCs	Thermal Energy Savings (Mtoe)	Electrical Energy Savings (MU)
Aluminum		1	0.088	1.03
Cement		12	0.153	1.78
Chlor-Alkali		2	0.003	0.04
Iron & Steel		16	0.263	3.05
Pulp and Paper		6	0.023	0.27
Textile		11	0.012	0.14
	Thermal Power Plant	15	0.132	1.54
Commercial Buildings		28	0.006	0.06
Grand Total		**91**	**0.680**	**7.90**

*Note: Based on initial assessment

The analysed data of sector under the consumption side demonstrates the total thermal **energy savings of 0.548 Mtoe and electrical energy savings of 6.361 MU**. While the sector under the **supply side demonstrates the total thermal energy savings of 0.132 Mtoe and electrical energy savings of 1.54 MU**.

2.1.6.2.2. Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO2 emission, Fuel-mix for each PAT sector is considered and based on calorific values, density of respective fuels and CO2 conversion factors were used for evaluation of the emission reduction. **Overall, energy savings of 0.681 Mtoe and 7.90 MU under PAT Cycle V has resulted in reduction of 2.68 MtCO2**. CO_2 emission reductions due to PAT Cycle V is presented in the Table 30

Table 30: Share (Value) of reduction in CO2 emission by each sector per year

Sector	No. of DCs	Emission Reduction ($MtCO_2$/year)	% Share in Total reduction
Aluminum	1	0.35	13.10%
Cement	12	0.61	22.72%
Chlor-Alkali	2	0.01	0.46%
Iron & Steel	16	1.04	38.93%
Pulp and Paper	6	0.09	3.41%
Textile	11	0.05	1.72%
Thermal Power Plant	15	0.53	19.67%
Commercial Buildings	28	0.02	0.70%
Total	**91**	**2.68**	**100%**

Summary:

Under the PAT cycle V, overall summary of energy (thermal & electrical) savings, and corresponding reduction in CO2 emissions is presented in the Table 31.

Table 31:PAT Cycle V emission and energy saving per year summary

Parameters	Values
No. of M&V Analyzed PAT DCs	91
Total Energy Savings achieved per year under PAT V	0.6809 Mtoe
Overall reduction in CO2 emissions per year	2.677 MtCO2
Energy (thermal) saved per year at consumption side	0.5478 Mtoe
Energy (thermal) saved per year at supply side	0.1324 Mtoe
Energy (electrical) saved per year at consumption side	6.361 MU
Energy (electrical) saved per year at supply side	1.537 MU

2.1.7. Summary of PAT Cycle IV & V

Enhancements in large-scale industrial interventions during the PAT cycle IV and V Perform, Achieve, and Trade (PAT) cycles have resulted in substantial energy savings. Specifically, the combined impact of these interventions has yielded a noteworthy total saving of 1.4317 million tons of oil equivalent (Mtoe). This comprehensive achievement is attributed to the conservation of 1.4310 Mtoe in thermal energy and a further reduction of 16.608 billion units (BU) in electrical energy consumption, collectively contributing to the success of PAT cycles IV and V.

The Sector wise energy saving achieved under PAT cycle IV and V is presented in the Table 32 below:

Table 32: Total Energy saving Achieved per year from PAT cycle IV and V

PAT Cycle	Total Energy Savings Achieved per year		
	Thermal (Mtoe)	Electrical (MU)	Total (Mtoe)
PAT IV	0.7501	8.7095	0.7508
PAT V	0.6809	7.8982	0.6809
Total	**1.4310**	**16.6077**	**1.4317**

Deepening and Widening of PAT Scheme:

The feasibility study of various sectors has been conducted in which the scheme could be expanded with additional coverage to new sectors such as Sugar, Zinc, Copper, Glass, Dairy, Ceramic, Chemicals, Tyre, Automobile assembly unit, forging, Port trust, Foundry and Refractory.

Establishment of Excellence Centre (UTPRERAK):

An advanced Industrial Technology Demonstration Centre (AITDC) center called UTPRERAK at NPTI Badarpur is being setup to showcase the non-working models of energy efficiency technologies across the sectors such as Cement, Iron & Steel, Pulp & Paper, Textile, Chlor-Alkali. The center was inaugurated in June 2023.

Chapter 3: MSME Sector

3. *MSME Sector*

The Micro, Small, and Medium Enterprises (MSME) sector in India have evolved into a dynamic force in the economy, playing a crucial role in the nation's economic and social development over the past five decades. Serving as a significant source of employment and fostering entrepreneurship, the MSME sector stands as a vital component of inclusive industrial development, complementing large industries as ancillary units.

The Micro, Small and Medium enterprise (MSME) sector accounts for a large share of world economic activity. The MSME sector contributes immensely towards economic growth, job creation, poverty alleviation and inequality reduction. For developing economies like India, the MSME sector assumes even greater importance due to its close linkages with socio-economic aspects; contribution in fostering entrepreneurship and generating employment opportunities at comparatively lower capital costs.

MSME sector in India holds immense importance for the country's economic development, employment generation, promoting Entrepreneurship and exports as illustrated in the image below.

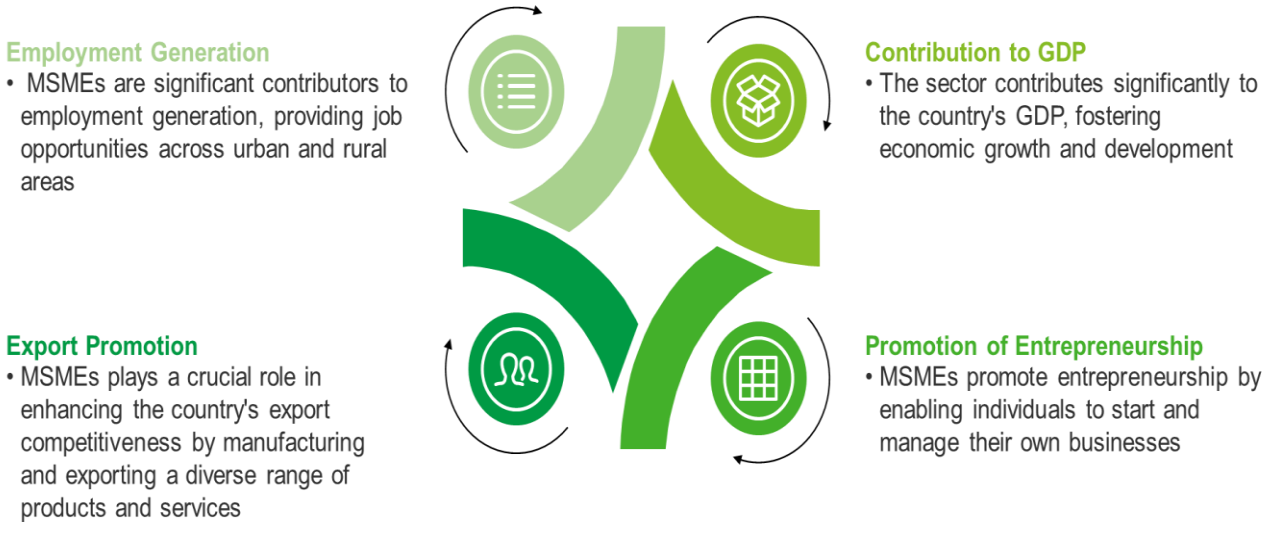


Figure 21: Importance of MSME Sector in India

The Indian MSME sector makes up approximately 33% of the nation's total GDP and is projected to add a value of US$ 1 trillion to India's overall exports by the year 2028. The country hosts a substantial registry of 7.9 million registered MSMEs and supports around 120 million jobs spanning various industries and regions[15]. In addition to its economic impact, the MSME segment actively participates in grassroots wealth creation, encompassing often overlooked and small-scale entrepreneurs, including women, marginal entrepreneurs, and local artisans.

The growth in the number of MSMEs is likely to result in an increased energy demand. As MSMEs expand their operations and production activities, their energy requirements, including electricity and other power sources, are expected to rise. This heightened demand for energy underscores the need for sustainable energy planning and resource management to ensure the continued development of the MSME sector while addressing the challenges associated with increased energy consumption. The energy demand of MSME in India is estimated to be 1026 million MWh[16] which is about 20-25% of the total industrial energy consumption[17]. Let us further understand about MSME sector and its relationship with the energy sector of the nation.

3.1.1. MSME Sector (as the backbone of the Indian industrial economy)

The Micro, Small, and Medium Enterprises (MSME) sector stands as the backbone of the Indian industrial economy, playing a pivotal role in driving economic growth, fostering entrepreneurship, and promoting inclusive development. With millions of enterprises, the MSME sector contributes significantly to India's Gross Domestic Product (GDP), serves as a major source of employment generation, and facilitates the industrialization of diverse sectors. Its importance is underscored by its substantial contribution to export earnings, provision of ancillary support to large industries, and geographical dispersion, addressing regional economic imbalances. Supported by government initiatives, the MSME sector remains a cornerstone in the foundation of India's industrial landscape.

As published by the Ministry of Micro, Small & Medium Enterprises Notification, 2020 the Micro, Small, and Medium Enterprises (MSME) are classified as below[18]:

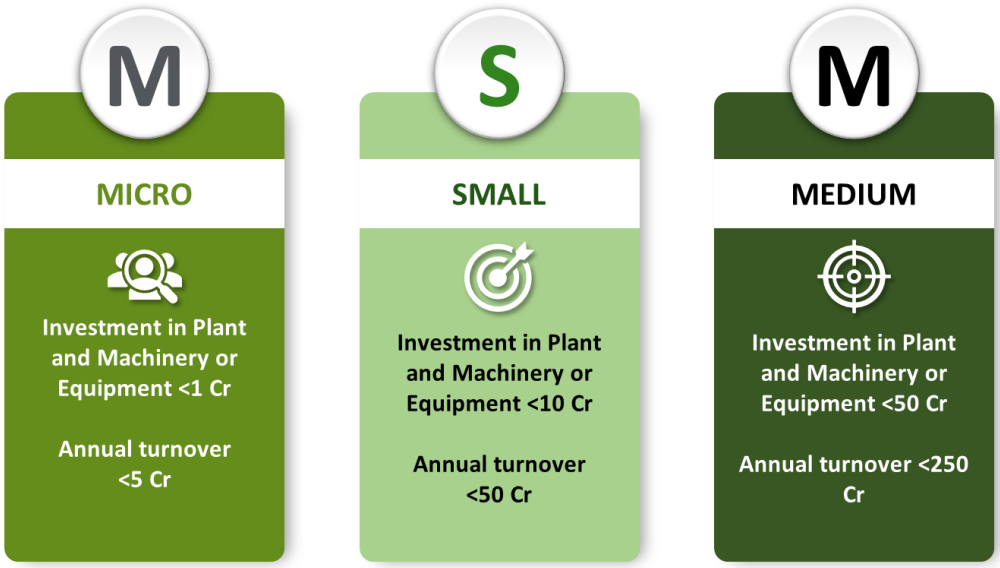
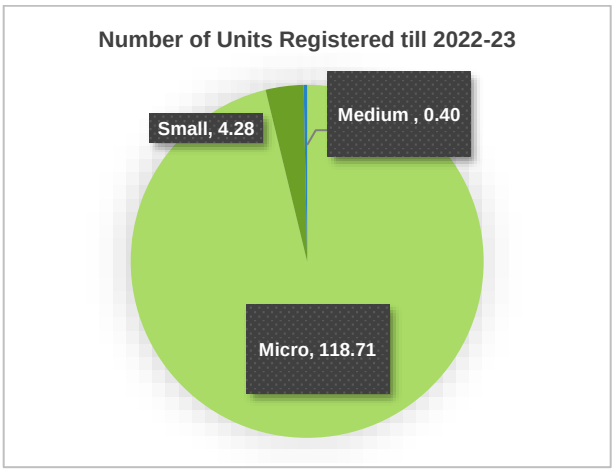


Figure 22: Definition of Micro, Small and Medium enterprises

[15] Budget 2023-24: MSMEs to drive growth? India: Business & Trade, January 2023
[16] Energy Efficiency and Sustainability in MSMEs in India, Green Letter 2023
[17] Unlocking National Energy Efficiency Potential (UNNATEE), Strategy Plan Towards Developing an Energy Efficient Nation (2017-2031)
[18] Ministry of Micro, Small & Medium Enterprises Notification, The Gazette of India, 1st June 2020.

Based on an estimate by the India Brand Equity Foundation, the MSME sector in India comprises 633.9 lakh enterprises, with micro-enterprises dominating the market share at over 99%, followed by small enterprises at 0.5%, and medium enterprises at 0.01%. According to the Ministry of MSME Annual Report 2022-23, out of the total estimated MSMEs (633.88 lakh), 51.25% (324.88 lakh) are situated in rural areas, while 48.75% (309 lakhs) are located in urban areas.



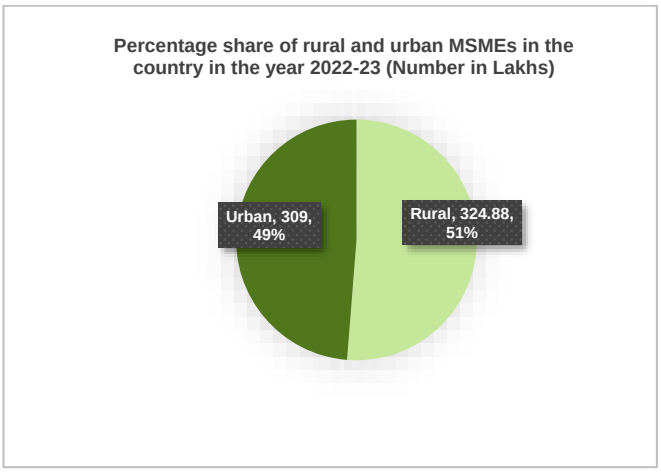


Figure 23: Number of MSMEs and distribution of enterprises in rural and urban areas 2022-23

The contribution of MSME Gross Value Added (GVA) to India's Gross Domestic Product (GDP) has exhibited a varying pattern in the past three years. In the fiscal year 2019-20, the share was recorded at 30.5%. However, there was a slight dip to 27.2% in 2020-21, followed by a rebound to 29.2% in 2022-23[19].

As per the Ministry of MSME's annual report for the fiscal year 2022-23, the Micro sector, encompassing an estimated 630.52 lakh enterprises, constitutes more than 99% of the total estimated number of MSMEs. Conversely, the small sector, with an estimated 3.31 lakh MSMEs, contributes 0.52% to the total, and the Medium sector, comprising 0.05 lakh estimated MSMEs, accounts for 0.01%. Among the overall estimated 633.88 MSMEs, 51.25% (324.88 lakh) are located in rural areas, while 48.75% (309 lakh) operate in urban areas.

As the economy advances, the MSME sector actively engages in the development and manufacture of a diverse array of products, ranging from everyday consumer goods to intricately crafted, high-precision finished products. It has positioned itself as a significant contributor to both the mass consumption goods and the production of essential items like auto components, plastic goods, electrical equipment, and pharmaceuticals.

The sector's growth not only addresses the demand for common-use products but also impacts industries requiring substantial energy consumption, including foundry, forging, textile, ceramics, refractory, glass, and dairy. Notably, various MSMEs in India form clusters with similar product offerings, though there is considerable diversity in technology and management practices within the sector. Stimulating growth in this sector is anticipated to yield a multiplier effect on overall economic development.

As per BEE's UNNATEE (Unlocking National Energy Efficiency Potential) report, industrial sector including MSMEs, will contribute an estimated 60% the of the energy savings. Energy consumption of the Indian MSME sector is estimated to increase to 500% in the next decade (by year 2031) and to realize the energy saving potential at MSMEs, an investment of ~12.3 Bn USD is required in next 14 years as per UNNATEE report.

[19] Underscoring contribution of MSME sector to economic growth of India, Times of India, August 2023

Within the MSME spectrum, there are dynamic and forward-thinking enterprises at one end, while at the other end, there are unregistered units and businesses employing outdated technologies and practices. The considerable diversity in technology and operational approaches leads to significant disparities in energy performance and greenhouse gas (GHG) emissions. In numerous energy-intensive sectors, where energy costs constitute a substantial proportion of operating expenses, the imperative arises for energy conservation and the implementation of energy-efficient measures. This underscores the essential need for energy-saving initiatives and the adoption of measures to enhance energy efficiency.

These clusters of MSMEs share various commonalities, including technology usage, production capacities, and operating practices. The utilization of conventional technologies and suboptimal operating methods presents a substantial opportunity for energy conservation through the upgrading of technology and the adoption of best operating practices (BOPs) in the production processes.

3.1.2. Programmatic interventions in the energy efficiency domain

India's MSME sector is a significant contributor to the economy. At the same time, the sector is a notably GHG emission intensive due to high use of fuels and informal nature which is difficult to regulate. MSMEs consumes about 25% of the total energy consumed by the industrial sector in India and out of the total energy consumed in MSME, 15% is electricity consumption and 85% is thermal energy consumption. As a significant contributor to the economy and emissions, India's MSMEs needs to transition into a low-carbon emitting sector in order to support achieving the country's NDCs and other global climate commitment.

At the core of enhancing the competitiveness of the MSME sector and curbing carbon emissions lies Energy Efficiency (EE). The crucial adoption of Energy Efficient Technologies (EET) and optimal operating practices in industrial processes plays a vital role in mitigating greenhouse gas (GHG) emissions and addressing climate change challenges. The MSME sector, with its substantial potential, stands as a key player in advancing energy efficiency and upgrading technologies to contribute significantly to sustainable practices.

Achieving an Energy Efficient India and pursuing a path of sustainable development necessitates the adoption of green and efficient manufacturing processes by the MSME sector. To underscore the potential for energy efficiency, the Indian government has implemented numerous policies, strategies, and programs dedicated to promoting energy efficiency on a national scale within the MSME sector. The various programs and schemes initiated by the Government of India and the Bureau of Energy Efficiency (BEE) serve as significant catalysts for driving energy conservation and fostering the uptake of energy efficiency practices among SMEs. While these interventions have shown some impact, there remains a considerable journey ahead before a majority of SMEs voluntarily embrace energy efficiency measures.

In its effort to expedite the adoption of energy efficiency in the MSME sector, the Bureau of Energy Efficiency (BEE) launched an SME program in 2009 with the aim of enhancing the energy performance of the MSME sector.

International organizations and agencies such as the World Bank, UNIDO, UNDP, JICA, and GIZ prioritize Energy Efficiency in the MSME sector, which is also a key agenda for various institutes and development programs. Additionally, certain commercial banks extend concessional energy efficiency loans to MSMEs under various Government schemes and bilateral lines of credit. The below image highlights few schemes off BEE's programmatic intervention for energy efficiency measures.

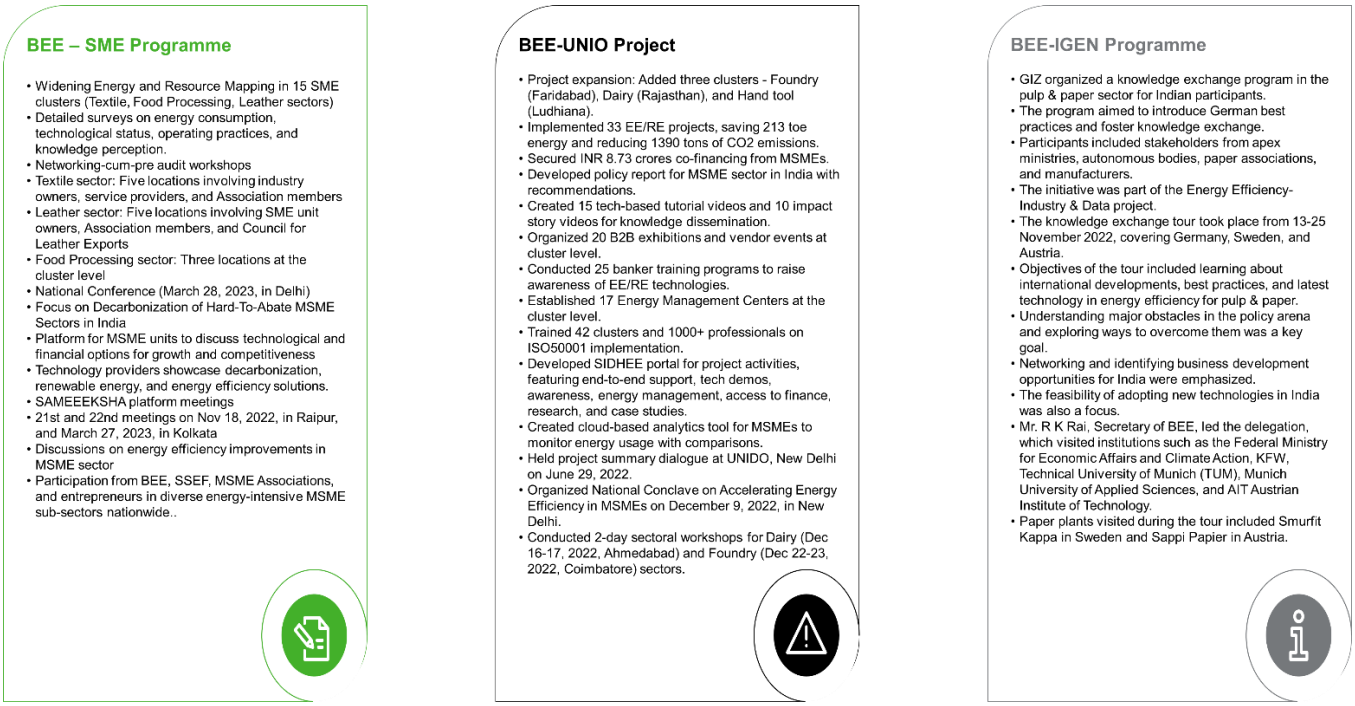


Figure 24: BEE Programmatic Interventions

The advancement of innovations and technological upgrades, such as Energy Efficient technologies like Waste Heat Recovery solutions, servo motors, induction furnaces, CNC machines, and VFD-installed plastics molding machines, along with efficient Permanent Magnet Motors for air compressors, is bolstering the growth of MSMEs. Moreover, the adoption of automation through data acquisition and analysis, Artificial Intelligence, Internet of Things (IoT), and Industry 4.0 is gaining prominence for enhancing efficiency, productivity, and cost-effectiveness.

Consistent implementation of technologies, policies, and financing schemes aimed at promoting and encouraging energy-saving measures would empower the MSME sector to become increasingly self-reliant and energy-efficient.

Energy Efficiency (EE) is the centre of improving the competitiveness of the MSME sector and reducing carbon emissions. Adoption of Energy Efficient Technologies (EET) and best operating practices in industrial process is of vital importance for mitigating greenhouse gases (GHG) emissions and tackling climate change. The sector holds immense potential in fostering energy efficiency and upgradation of technologies.

To make Energy Efficient India and follow a path of sustainable development, it is important that the MSME sector adopt the green and efficient manufacturing processes. Various programme/schemes of Govt. of India and BEE remain a key driving force of energy conservation/uptake of energy efficiency among the SMEs. While these programmatic interventions have made an impact, there is a long way to go before majority of SMEs voluntarily increase their uptake of energy efficiency interventions.

3.1 BEE – SME Programme

Objective of BEE-SME Programme

The objective of the scheme is to enhanced energy efficiency in India, accelerate adoption of energy efficiency measures and technologies to conserve energy in MSME sectors. It aims to empower MSMEs through supportive services, including knowledge sharing, capacity building, demonstrations of efficient technologies, and the provision of suitable financial mechanisms.

Observing the energy consumption in the MSME sector, the Bureau of Energy Efficiency recognized the necessity to create, showcase, and promote energy-efficient technologies at the cluster level. This is addressed through the "National Programme on Energy Efficiency and Technology Upgradation in SMEs" to tackle the diverse challenges encountered by MSMEs in India.

The scheme primarily addresses challenges such as the adoption of modern technologies, accessibility to finance for energy-efficient equipment and technologies, a scarcity of proven case studies, and the need for specific technical skills. The BEE-SME program has been engaging in activities to promote efficient energy consumption in MSMEs since 2009. Some of the initiatives undertaken to encourage efficient energy consumption in Indian MSMEs are outlined below.

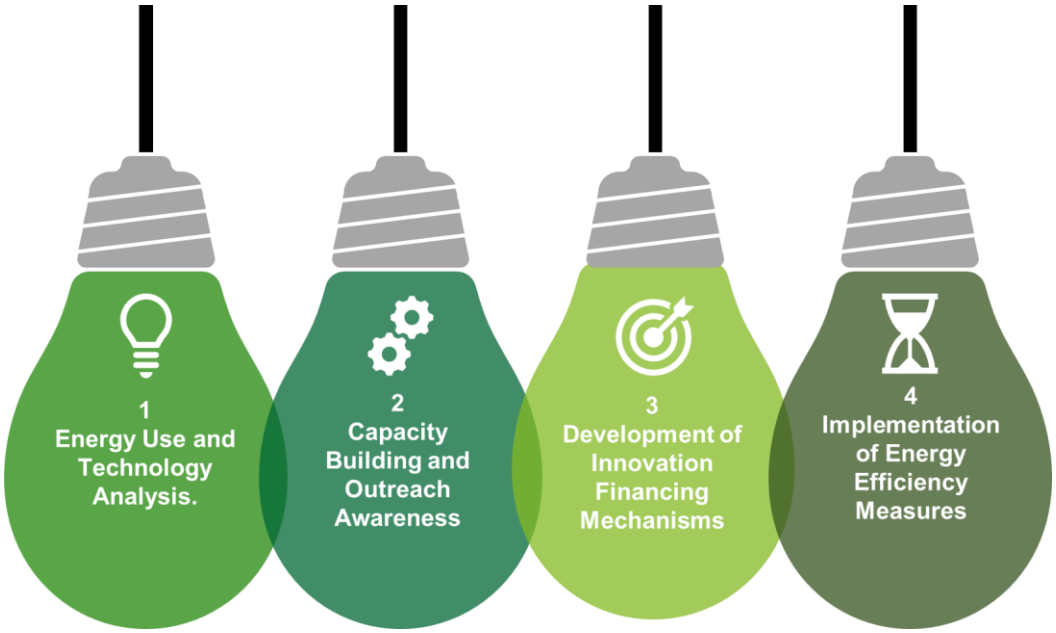
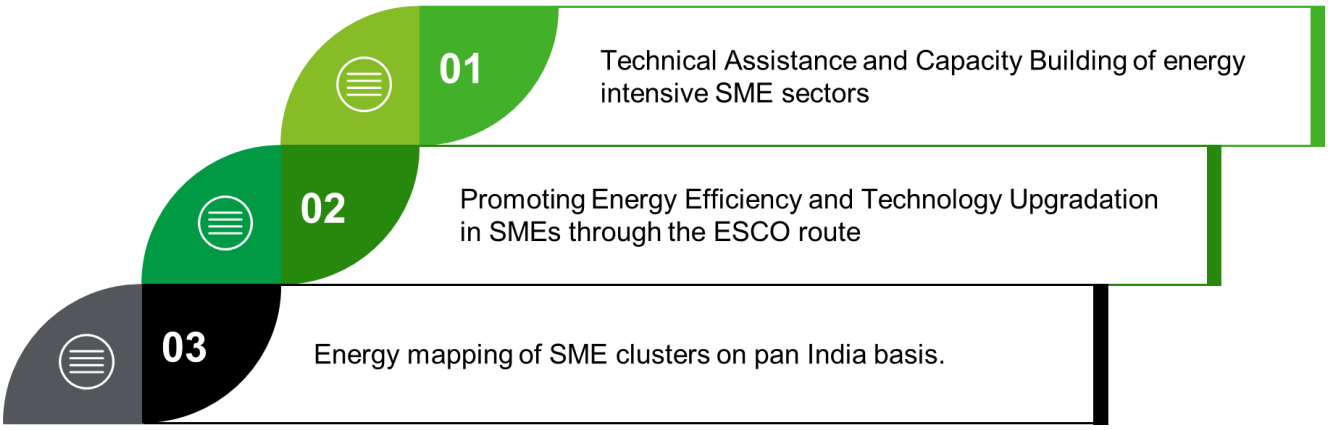


Figure 25: Activities to encourage Energy Efficiency in MSMEs

BEE – SME Programme during the year 2017 - 2023

In light of the Bureau's concerted efforts to enhance energy performance, the current state of awareness, perception, and responsiveness to energy efficiency programs in the MSME segment in India suggests that energy efficiency interventions in the SME sector have not yet become mainstream across the country.

While the energy-saving potential in this sector is substantial, a notable challenge faced by Indian MSME entrepreneurs includes risk aversion, cumbersome documentation, and a lack of awareness or motivation. The key activities currently being implemented are as follows:



Numerous Small and Medium Enterprises (SMEs), including foundries, brass, textiles, refractories, brick, ceramics, glass, utensils, rice mills, and khan sari manufacturing units, among others, are identified as having significant potential for energy savings. Many of these units are concentrated in clusters situated across various states in the country.

National Programme on Energy Efficiency and Technology Upgradation of MSMEs

To improve energy efficiency of MSMEs, significant efforts and progress has been made since 2007 which also include the bilateral partnerships exclusively for MSME sector. However, many gaps still remain in the ecosystem for providing EE services to MSMEs. Accordingly, to enhance the energy efficiency of this sector, and to bring together the various MSME stakeholders and enable them to revisit the achievements, what remains to be done, and to chart the course ahead, Bureau has taken several initiatives.

- Widening of Energy and Resource Mapping in 15 SME clusters across Textile, Food Processing, and Leather sectors and conducted detailed surveys on energy consumption, technological status, operating practices, and knowledge perception.
- Organized networking-cum-pre audit workshops in five locations for the Textile sector, involving stakeholders such as textile industry owners, service providers, and Association members. The goal is to conduct a detailed energy audit and develop sectoral benchmarks for sustainable growth.
- Conducted networking workshops in five locations for the Leather sector, involving stakeholders like SME unit owners, Association members, and Council for Leather Exports (CLE). The objective is to survey energy consumption and production profiles to establish roadmaps and policy recommendations.
- Held networking-cum-pre audit workshops for the Food Processing sector in three different locations at the cluster level.

- National Conference scheduled for March 28, 2023, in Delhi focuses on Decarbonization of Hard-To-Abate MSME Sectors in India, providing a platform for MSME units to discuss technological and financial options for long-term growth and competitiveness. Technology providers showcase decarbonization, renewable energy, and energy efficiency solutions.
- The 21st and 22nd meetings of SAMEEEKSHA platform occurred on November 18, 2022, in Raipur, and March 27, 2023, in Kolkata. Discussions centered on energy efficiency improvements in the MSME sector, with participation from BEE, SSEF, MSME Associations, and entrepreneurs representing diverse energy-intensive MSME sub-sectors nationwide.

3.2. "Promoting Energy Efficiency and Renewable Energy in selected MSME clusters of India" BEE - GEF - UNIDO Project

The project "Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India" has an objective to develop and promote market environment for introducing energy efficient technologies and enhancing the use of renewable energy technologies in process applications.

The United Nations Industrial Development Organization (UNIDO), in collaboration with the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India, is executing a Global Environment Facility (GEF) funded national project titled 'Promoting energy efficiency and renewable energy in selected MSME clusters in India'. The project aims to develop and promote a market environment for introducing energy efficiency (EE) and enhanced use of renewable energy (RE) technologies in process applications in selected energy intensive industrial clusters, comprising micro, small and medium enterprises (MSMEs). The project is supported by the Ministry of Micro, Small and Medium Enterprises (MoMSME) and Ministry of New and Renewable Energy (MNRE).

The programme "Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India" has major four components:

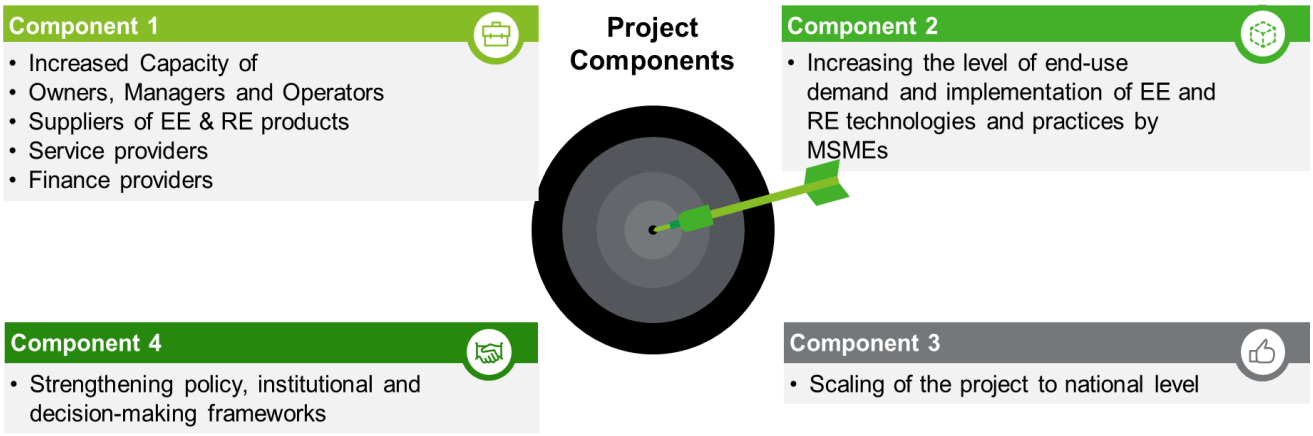
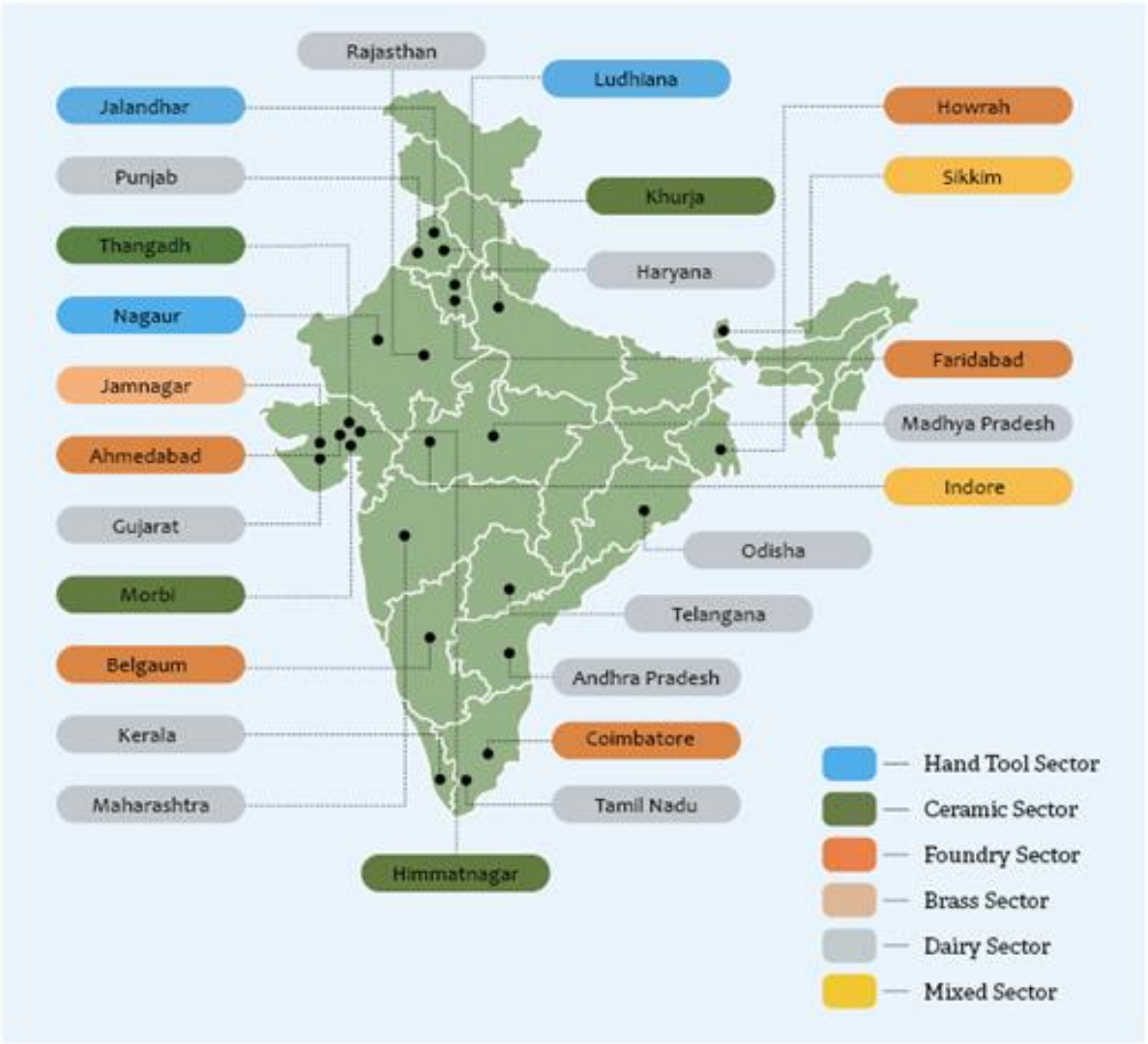


Figure 26: Project Components of BEE-GEF-UNIDO Project

The project was started in 12 MSME clusters across India in five sectors namely Brass (Jamnagar); Ceramics (Khurja, Thangadh and Morbi); Dairy (Gujarat, Sikkim and Kerala); Foundry (Belgaum, Coimbatore and Indore); Hand Tools (Jalandhar and Nagaur) in its first phase. The Project has scaled-up and expanded its activities to additional 14 new clusters to reach out to MSME's at national level.



Key achievements of this programme during FY 2022-23 are as below:

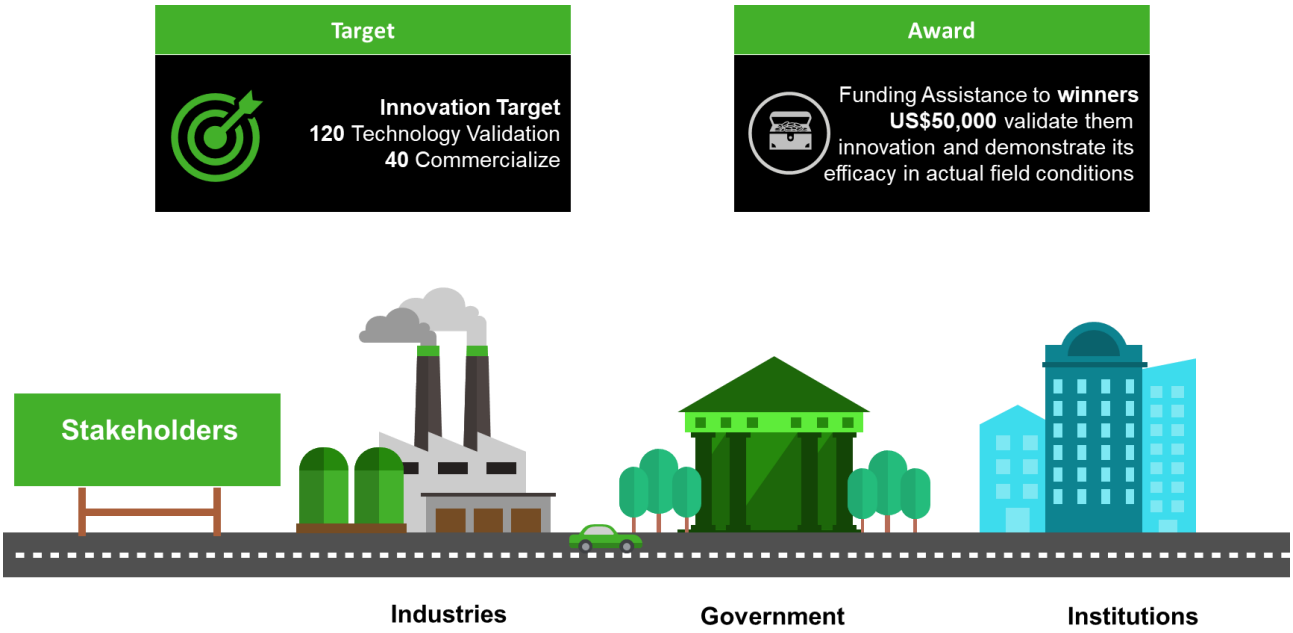
- Project expanded to include three more clusters: Foundry (Faridabad), Dairy (Rajasthan), and Hand tool (Ludhiana).
- Implemented approximately 33 EE/RE projects, resulting in energy savings of 213 toe and a reduction of 1390 tons of CO2 emissions.
- Secured co-financing investment of INR 8.73 crores from MSMEs.
- Developed a comprehensive report on the policy and regulatory framework for the MSME sector in India, providing recommendations for profitability, competitiveness, and broader policy goals.
- Created 15 technology-based multimedia tutorial videos and 10 impact story videos for knowledge dissemination in the clusters.
- Organized 20 B2B exhibitions and vendor interfacing events at the cluster level to showcase technologies.
- Conducted 25 banker training programs in selected clusters to raise awareness of EE/RE technologies and facilitate interactive sessions between bankers and MSMEs for financing opportunities.
- Established 17 new Energy Management Centers at the cluster level.
- Trained 42 clusters and over 1000 industry professionals on the implementation process of ISO50001, with a pilot demonstration in Ceramic, Dairy, and Hand tool sectors covering 15 units.
- Developed the SIDHEE portal for all project activities, featuring end-to-end support, technology demonstrations, awareness of energy efficiency and key performance indicators (KPIs), energy management system guidance, access to finance, research and tools, and case studies on energy-efficient practices.
- Created a cloud-based data analytics and benchmarking tool hosted on the Government's server at the National Informatics Centre for MSME units to monitor energy usage with inter and intra-cluster comparisons.
- Held a project summary dialogue on June 29, 2022, at UNIDO, New Delhi, attended by government officials, UNIDO officials, consultants, and MSME unit owners.
- Organized a National Conclave on Accelerating Energy Efficiency in Micro, Small, and Medium Enterprises on December 9, 2022, in New Delhi.
- Conducted 2-day sectoral workshops for the Dairy sector on December 16-17, 2022, in Ahmedabad, and for the Foundry sector on December 22-23, 2022, in Coimbatore.

3.3. "Facility for Low Carbon Technology Deployment"

Commencing in 2016, the Facility for Low Carbon Technology Deployment (FLCTD) project seeks to foster innovation in low carbon technology solutions, addressing prevalent technology gaps within Indian industrial and commercial sectors. Executed in collaboration with the Bureau of Energy Efficiency (BEE) and funded by the Global Environment Facility (GEF), this project is overseen by the United Nations Industrial Development Organization (UNIDO)[20].

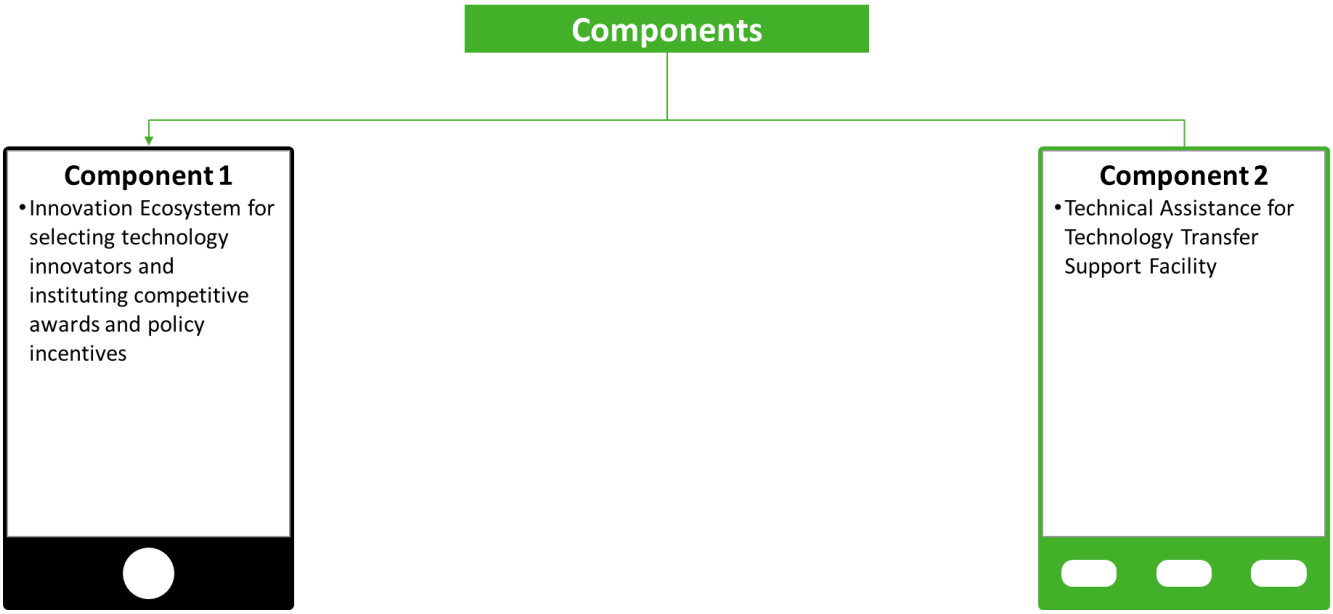
To facilitate the validation of innovative low carbon technology thereby assist in scale up, deployment and scaling up of low-carbon technologies in India promoting innovation of low carbon technology solutions that address the existing technology gaps in Indian industrial and commercial sectors

The target of the project is to get 120 innovative technology validation ideas and 40 commercialize innovations. The project provides financial assistance of up to US$50,000 to the winners to validate their innovation and demonstrate its efficacy (performance) in actual field conditions[21]



The project is alienated into two components, of which one focus on the innovation ecosystem for selecting, awarding and policy interventions, while the other focuses on technical assistance for implementation of technology transfer support facility.

[20] Source: https://www.low-carbon-innovation.org/the-project.html
[21] https://www.low-carbon-innovation.org/the-project.html



Component 1 – Development of an awards methodology to identify and select competitive technology for project support

Within this component, the project has established a mechanism to discern early-stage innovations that target technology gaps and exhibit the potential for energy savings and replication. The "Innovation Challenge" represents an open award competition that focuses on technology areas identified through diverse technical studies, consultations with industry experts, and collaboration with the Bureau of Energy Efficiency. This challenge encompasses six technology areas, including heat, resource efficiency, pumping, IoT, space, and energy storage, as detailed in the figure below.

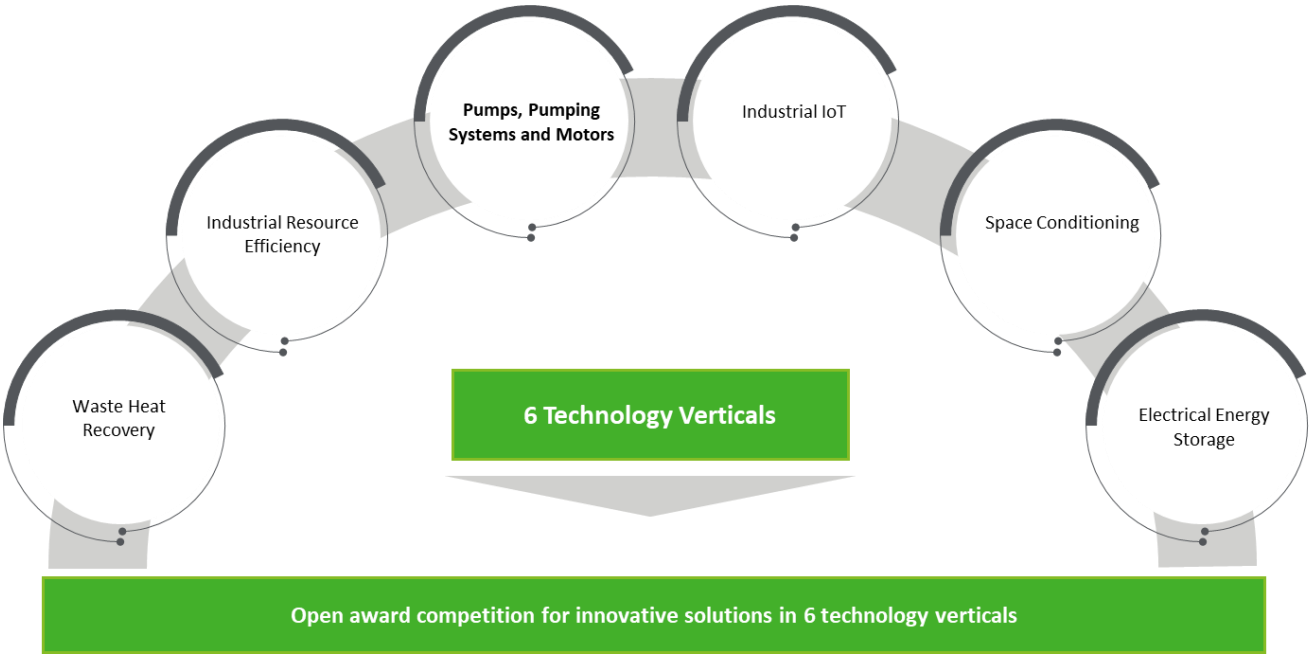


Figure 27: Open award competition for innovative solutions in 6 technology verticals

For each of the mentioned technology verticals, a panel of experts outlines the criteria for the Innovation Challenge and selects promising innovations that bridge technology gaps, possess the potential to decrease energy consumption, and are scalable. Winners are eligible for

financial assistance of up to **USD 50,000** to validate their innovation and demonstrate its effectiveness in field conditions – a crucial prerequisite for commercialization within the project.

The project additionally concentrates on fortifying the innovation ecosystem, involving knowledge-based institutions, government, industry, and other stakeholders in the innovation domain. In addition to identifying low carbon technology innovations, the project nurtures their development, deployment, and validation for commercialization through technology challenges. The entire project follows a seven-step process, as outlined in the figure below.

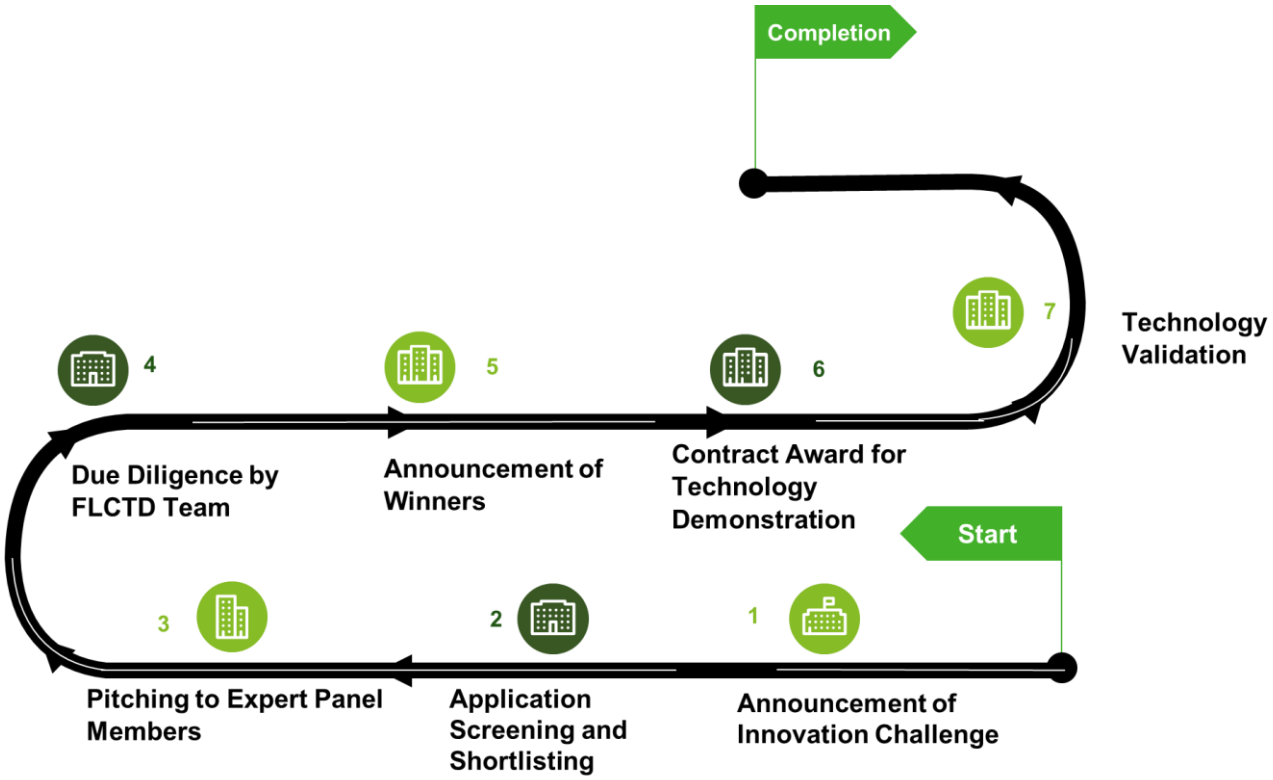


Figure 28: Innovation Challenge Cycle

Component 2 – Technical assistance for the Technology Transfer Support Facility

Under component 2 a specialized support framework for clean, low-carbon, and energy-efficient technologies is established to foster the development of an innovation ecosystem for providers of low-carbon and sustainable energy solutions in India. This initiative encompasses capacity-building activities, facilitated through consultations and workshops with international and national experts. The documentation and dissemination of the facility's activities are integral components of this effort. Additionally, the project team has made endeavors to gather and disseminate best practices in line with these objectives.

Initiated in 2019 as part of FLCTD, the Low Carbon Technology Accelerator Program was executed by Sangam Capital Advisors Pvt. Ltd. This program aims to offer training and mentoring assistance to startups in the early stages of crafting clean technology solutions who may not have progressed to the final round. Spanning a duration of four months, the program is conducted in collaboration with 'Start-up India,' providing industry professionals and aspiring innovators with practical guidance to enhance their business prospects[22].

[22] https://www.low-carbon-innovation.org/media/docs/compendium_april2022.pdf

Participation from Indian Technical Institutes/Universities, Research Institutes, Startups, Micro, Small & Medium Enterprises, Large Industries, Research and Development Units In Public Sector, Enterprises & Govt Labs are encouraged under the program[23].

The accelerator programme was developed based on the learning from the 2018 innovation challenge round in which it was found that many applicants with good innovations could not be shortlisted for the final round of the challenge as their applications lacked an understanding of the market, in terms of where the innovation would add value.

Key achievements of this program during FY 2022-2023 are as below:

Project Component 1: Innovation Ecosystem for selecting technology innovators

- Three winners of FLCTD innovation challenge – M/s ENCON Thermal Engineers, M/s CEEP, and M/s AFECO Heating Systems were received the Energy Efficiency Innovation Awards on 14th December, 2022 during the function of National Energy Conservation Awards 2022.
- *5th innovation challenge in all the six technology verticals were launched on 1st April, 2022 and closed* on 30th June 2022, where 205 valid applications from all six technology verticals were received. Based on recommendation of expert panel and after the due diligence of applicants, 18 innovations has been identified for conducting field demonstartion. The details as per different technology verticals is listed below:

Table 33: 5th innovation challenge in six technology verticals

S. No.	Name of the Vertical	Applications	Shortlisted	Final Presentation	Winners
1	*Waste Heat Recovery & Thermal Efficiency*	*24*	*8*	*6*	*2*
2	*Space Conditioning*	*17*	*7*	*6*	*2*
3	*Pumps, Pumping Systems and motors*	*19*	*9*	*5*	*1*
4	*Industrial Resource Efficiency & Circular Economy*	*48*	*13*	*10*	*4*
5	*Industrial IOT*	*24*	*12*	*8*	*2*
6	*Electrical Energy Storage*	*73*	*16*	*15*	*7*
	Total	***205***	***65***	***50***	***18***

- Details of the energy savings and reduction in CO_2 emissions for the technology demonstrations completed by the winners of 2019 and 2020 FLCTD Innovation challenge is included in the table below.
- Under FLCTD Accelerator program, training to 23 early-stage startup was provided. Launched in partnership with Startup India on 14th July 2022, the call for application received 246 response from startups. Starting 13th September 2022, the startups underwent rigorous training for the next 4 months. The accelerator concluded on 10th March 2023 with winner selection by an independent panel of investors. Certificates were distributed to 20 startups who graduated from the accelerator program.

[23] https://www.low-carbon-innovation.org/about-innovation-challenge.html

A summary of the energy savings and corresponding emission savings obtained by implementing the technologies through the FLCTD project in the FY 2022-23 is showcased in the table below:

Table 34: Energy Savings achieved under FLCTD Program in the FY 2022-23

S. No.	Technology Demonstrations completed	Innovation Challenge	Name of the Winner	Technology	Savings from single pilot demonstration		Savings from all pilot demonstrations			FLCTD support (contract Value)
					Annual Energy Savings (coal / diesel/ electricity)	Net annual CO_2 emissions avoided, tons of CO_2/annum	No. of pilot demonstration	Annual Energy Savings (coal / diesel / electricity)	Net annual CO_2 emissions avoided, tons of CO_2/annum	Monetary Savings (INR)
Waste Heat Recovery										
1	January 2023	2019	Aspiration Energy	High temperature heat pump for industrial process heating	18.48 kL of Diesel is saved in the canteen	34.421	1	18480 litres of diesel	34.421	36,00,000.00
2	June 2022	2019	CEEP	Heat recovery from cotton textile dye effluent	215.8 tons of coal per WHR system	253.09	2	431.6 tons of coal savings	506.18	36,00,000.00
3	September 2022	2020	AFECO Heating Systems	Electrical holding furnace for Aluminium	46.212 MWh for each Aluminium holding furnace installation	36.507	1	46.212 MWh	36.507	29,20,888.00
Pumps, Pumping systems, and motors										
4	April 2022	2019	Aquasub Engineering	Performance improvement of mixed flow centrifugal multistage pump	12.5 MWh per pump	9.8	10	125	98	35,25,000.00
5	September 2022	2019	Water Hand Limited	Pression irrigation algorithms and IoT unit.	157 kWh/crop cycle, 1566 kL of water / crop cycle	0.124	16	2.512	1.984	35,00,000.00
6	December 2022	2019	Sense It out intelligent solutions Private Limited	Sensor Based Intelligent Crop Centric Automation (SICCA)	108 kWh/crop cycle 1081 kL of water / crop cycle	0.085	6	0.648	0.51	33,62,000.00
7	January 2023	2019	Scientific and Industrial Testing and Research Centre (Si'Tarc)	Smart Submersible Pump with high-speed permanent magnet motor	Submersible pump - 5hp @ 2.0 MWh annual savings Submersible pump - 7.5hp @ 2.12 MWh annual savings	Submersible pump - 5hp - 1.5 tons of CO2/annum/pump Submersible pump - 7.5hp - 1.67 tons of CO2/annum/pump Submersible pump -	15	12.96 MWh of annual electrical savings	10.23	35,00,000.00

S. No.	Technology Demonstrations completed	Innovation Challenge	Name of the Winner	Technology	Savings from single pilot demonstration		No. of pilot demonstration	Savings from all pilot demonstrations		FLCTD support (contract Value)
					Annual Energy Savings (coal / diesel/ electricity)	Net annual CO_2 emissions avoided, tons of CO_2/annum		Annual Energy Savings (coal / diesel / electricity)	Net annual CO_2 emissions avoided, tons of CO_2/annum	Monetary Savings (INR)
				Submersible pump - 20hp@ 8.8 MWh annual savings		20hp - 6.9 tons of CO2/annum/pump				
Space Conditioning										
8	April 2022	2019	Inficold India Private Limited	200 Lt Solar milk-cooler to provide instant chilling at the point of collection	610 litres of Diesel per milk chiller	5.2	12	7320	62.4	33,58,913.00
9	July 2022	2019	Zedbee Technologies	ZedBee – Automated HVAC control in buildings	13.3 MWh of electrical savings	10.5	5	18.62	14.7	36,00,000.00
10	July 2022	2019	Tan90 Thermal solutions Private Limited	Fast Charge Phase Change Material (PCM) based transport containers - Portable Cold Storages for first and last mile transport of perishables	121 kWh of electrical energy per PCM	0.09	600	72.6 MWh of electrical energy	54	35,00,000.00
			Grand Total	19.09 kL/year of diesel, 215.8 tons/year of coal, 85.318 MWh/year electricity, 2647 kL of water/crop cycle		359.887	668		818.932	3,44,66,801

- **Component 2:** Contract issued to the DST – Centre for Policy Research (DST-CPR), Panjab University, Chandigarh for doing the study of technology transfer centre in the country in August 2022. Key tasks include -
  - Study design and research instruments in the form of an interview questionnaire, characterization matrix and best practice framework have been designed to include reference of innovation ecosystems of 5 developed countries.
  - A long list of more than 500 technology commercialization centers in academic R&D institutions has been compiled and 25 of these institutes have been shortlisted for in-person visits and interviews by DST-CPR. As on 31st March 2023, 21 visits have been completed.
  - Innovation ecosystem profiles of each of the 5 countries: Switzerland, USA, South Korea, Germany and Israel- is being prepared and will be used to compile the best practices for further analysis.

3.4. BEE-IGEN Programme

To encourage knowledge exchange and introduce to German best practices in the pulp & paper sector, GIZ organized knowledge transformation programme with Indian participants calling stakeholders from the apex ministries, autonomous bodies, paper associations and manufacturers.

This knowledge exchange tour under the Energy Efficiency- Industry & Data project was scheduled from **13-25 November 2022, covering countries Germany, Sweden & Austria.** The broad objectives of the knowledge exchange tour:

- Learn about international developments, best practice, and latest technology in the field of Energy Efficiency in the pulp & paper sector
- Get a better understanding of major obstacles and how to overcome them in the policy arena
- Networking and exploring business development opportunities for India
- Feasibility of adoption of new technologies in India

Mr. R K Rai, Secretary, BEE led the delegation from BEE. The delegates visited institutes like Federal Ministry for Economic Affairs and Climate Action, KFW, Technical university of Munich (TUM), Munich University of Applied Sciences, AIT Austrian Institute of Technology. Paper plants covered during the visit include Smurfit Kappa, Sweden & Sappi Papier, Austria.

3.5. "Partial Risk Sharing Facility for Energy Efficiency" – WB-SIDBI-GEF project

"Partial Risk Sharing Facility for Energy Efficiency" project was initiated by Government of India partnering with World Bank to promote an increased level of investments in energy efficient projects, particularly through energy service performance contracting delivered through energy service companies ("ESCOs").

Objective

To transform the energy efficiency (EE) market in India by promoting increased level of EE investments, particularly through energy service performance contracting (ESPC) delivered through Energy Service Companies (ESCOs).

The programme is implemented by Global Environment Facility("GEF") and the Clean Technology Fund ("CTF"). It is supporting the loans granted by various PFIs and by SIDBI as lender (in such capacity, “SIDBI as Lender”), who are empaneled with the PEA Division to either ESCOs or the Host who are implementing energy saving projects, by providing risk coverage for repayment of such loans.

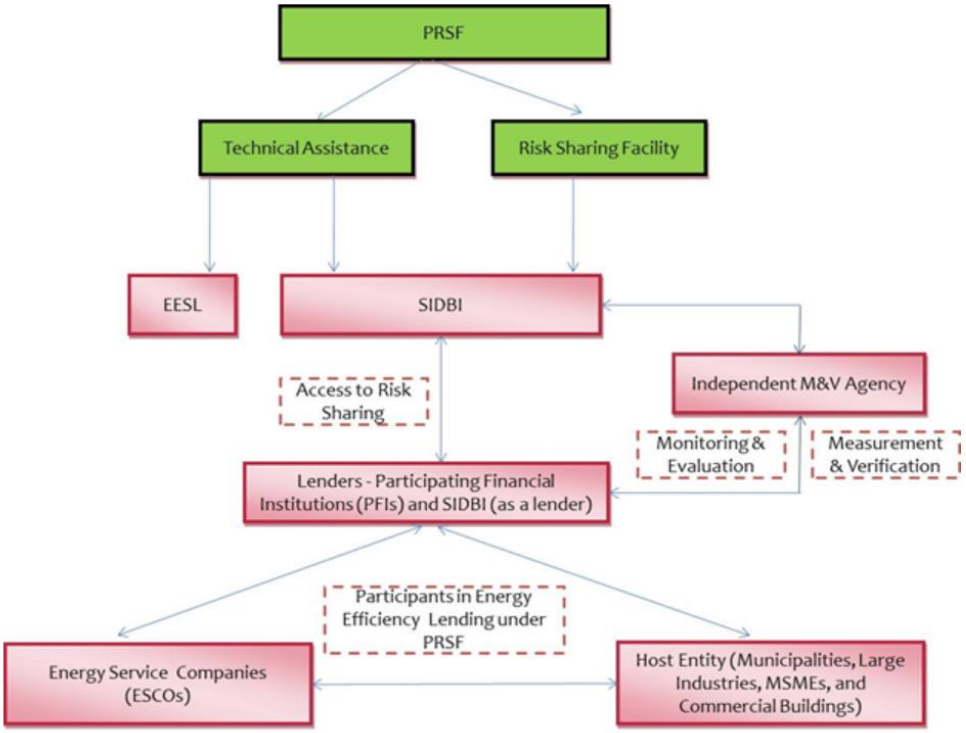


Figure 29: *Management Hierarchy of the PRSF programme*

The ESCOs are important drivers to achieve energy-efficiency potential and the business model they use, energy performance contracting, helps overcome several market barriers. Financing for the EE equipment/technology investment can either be provided by the ESCO from its internal funds or by the customer, or by a third-party funding (TPF), in which a financial institution allows a credit either to the ESCO or directly to Host entity where the energy savings project is being implemented; the loan may or may not be backed by a guarantee for the projected energy or cost savings given by the ESCO.

The above objective can be accomplished through:

The procedure to obtain a loan under the PRSF scheme for EE technology is showcased in the figure below:

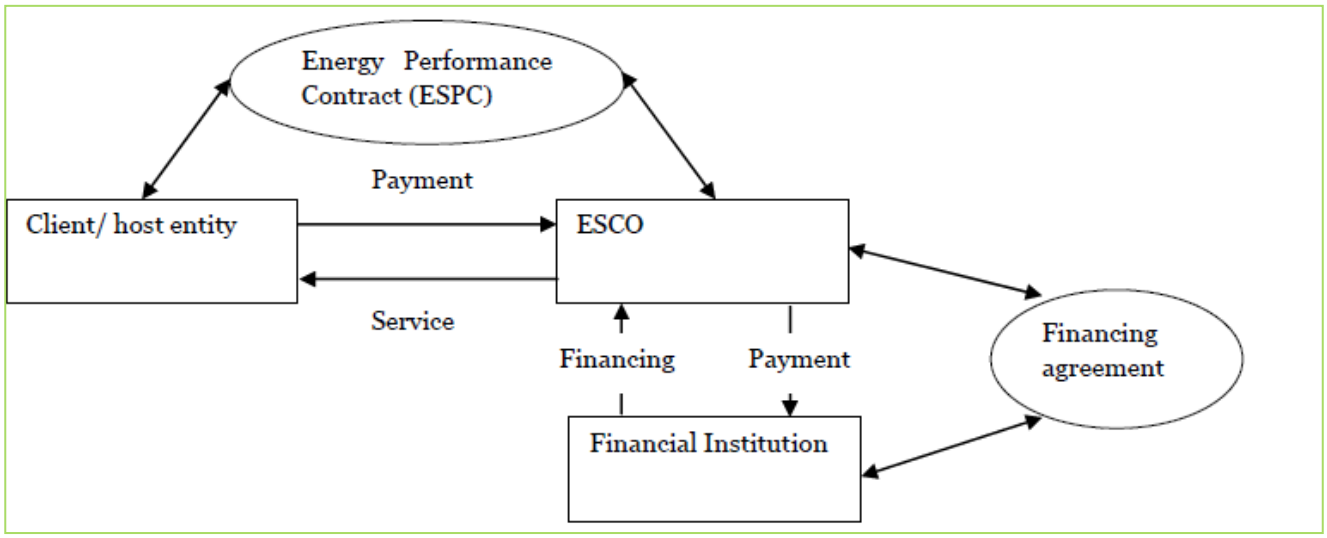


Figure 30: Functioning of PRSF Scheme

There are two main models for energy performance contracting: the "shared savings" model and the "guaranteed savings" model.

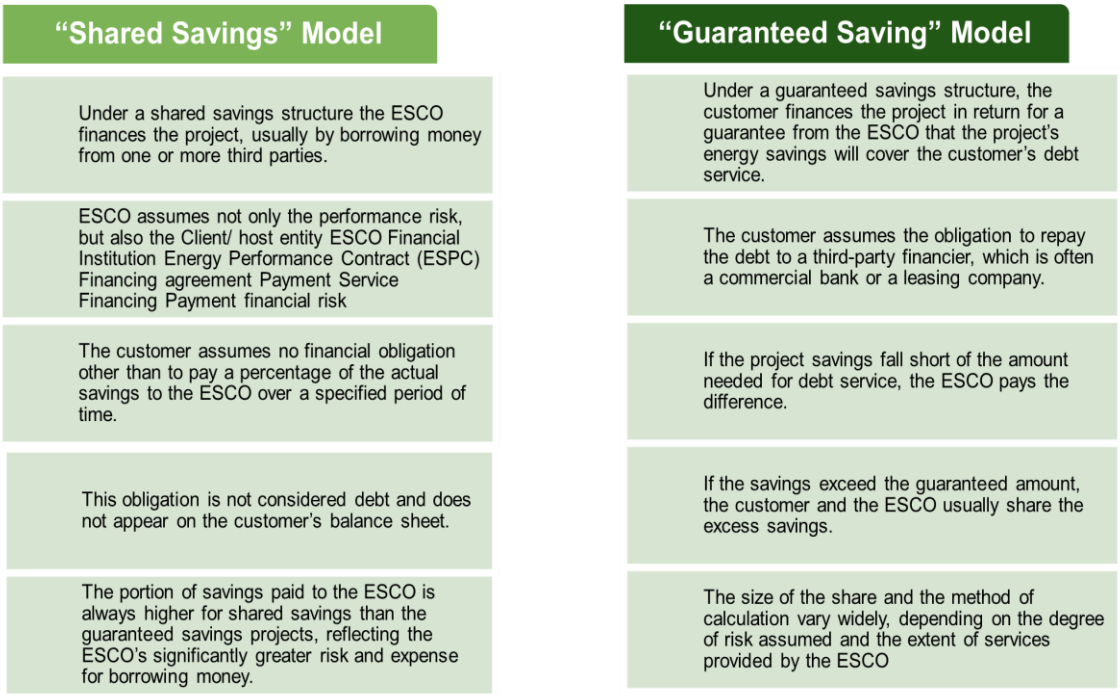


Figure 31: Energy Performance Contracting Models under PRSF Scheme

Project components

Total expenditure of the project was USD 43 million consisting of the "Partial Risk Sharing Facility for Energy Efficiency" component of USD 37 million and technical assistance component of USD 6 million. SIDBI managed the entire "Risk Sharing Facility" component of USD 37 million providing a cover share of default risk faced by Participating Financial Institutions (PFI) in extending loans to eligible EE projects implemented through ESCOs[24].

In the FY 2022-23, 16 Energy Efficiency cases have been supported and implemented under the SIDBI's PRSF scheme, with a combined total investment of Rs. 141 Crores. This targeted approach specifically addresses the energy-saving needs of Micro, Small, and Medium Enterprises (MSMEs) in India, highlighting a nuanced and focused effort to promote energy efficiency within the MSME sector.

The table below showcases the energy and emission savings obtained under SIDBI's PRSF scheme for the FY 2022-23:

[24] https://www.sidbi.in/en/prsf-project

Table 35: Cluster wise energy savings obtained under SIDBI- PRSF Programme in FY 22-23

Cluster	No. of Units	Total Investment (INR LAKHS)	MWh Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
Noida	1	400	3,070	264	2,824
Sonepat	1	1,974	7,086	609	5,811
Hyderabad	1	1,670	744	64	670
Ludhiana	1	152	66	6	54
Adityapur	1	940	825	71	652
Chinchwad	1	1,600	2,942	253	1,689
Chinchwad	1	500	466	40	396
Ludhiana	1	380	35	3	30
Chennai	1	318	2,416	208	1,305
Karnal	1	468	1,500	129	1,063
Ambattur	1	1,252	277	24	265
Adityapur	1	351	193	17	31
Delhi	1	204	135	12	130
Bangalore	1	1,900	297	26	244
Chandigarh	1	1,809	2,424	208	1,915
Adityapur	1	165	53	5	25
Total	**16**	**14,082**	**22,526**	**-**	**1,937**

Methodology for estimation of energy savings

Energy Saving = (Specific Energy consumption $_{Baseline}$ *– Specific Energy Consumption* $_{Post\ EE\ Interventions}$*)* Annual Production* [25]

The WB-GEF project has also created a revolving fund to promote the financing of energy efficiency projects in the MSME sectors. The fund is being used to provide financing at concessional interest rates to MSMEs for the implementation of energy efficiency interventions. Till date over 630+ industries have benefitted from the revolving fund.

3.6. SIDBI "4E Scheme-End to End Energy Efficiency" Scheme

SIDBI 4e scheme was launched to provide financial support to MSMEs. It helps MSMEs implement new technology and other energy efficiency measures. It mainly focuses on implementing those technologies in which machinery consumes less energy and provides big output. The MSME, which fulfils the eligibility criteria of this Scheme, will also get the financial facilitation and technical consultancy at very reliable rates of interest.

According to the rules and regulations mentioned in the Scheme, a Detailed Energy Audit of the MSME project is introspected by qualified Energy Auditors and consultants. These Energy Auditors and consultants work in the SME Services Technology Limited (ISTSL), a combined venture of SIDBI. After the project's approval, it was delivered to the other MSME Units. The MSME can provide financial help from ten lakhs to 1.5 Crores under this sustainable finance

[25] Energy savings estimated based on annual production details collected during year of EE implementation, at respective MSME unit for each implemented measure.

scheme. All the important faculties like verification support, implementation Support and monitoring support will be provided to the qualified MSME at a very low cost.

Purpose of the SIDBI 4E Scheme

- For implementing Energy Efficiency measures on an end to end basis. For meeting part cost of

  i. capital expenditure including for purchase of equipment/ machinery, installation, civil works, commissioning, etc. for implementing the Energy Efficiency measures as recommended in the DPR

  ii. any other related expenditure required by the unit, provided it is not more than 50% of (i).

- Financing of secondhand machinery/equipment; purchase of land and construction of building (except minor civil works) shall not be taken up under the scheme.

Benefits of the SIDBI 4E Scheme

There are lots of benefits of this sustainable finance scheme. Here are some benefits of 4e (end to end energy efficiency) listed:

- The 4E programme helps MSMEs improve the bottom line through energy savings (10 to 25%), by getting the services of Technical Consultants at a reasonable cost with assurance on the quality of services and savings.

- A back-to-back financing product support is granted with the help of the World Bank to offer loans to Energy Efficiency projects to MSME. The term loans are granted at concessional interest rates and on the softer term.

- Normal Detailed Energy Audit, Implementation supports and M&V charges range from Rs. 1.5 Lakhs to 2.5 Lakhs. ISTSL also offers all services at very high concessional rates for all the services.

- Rs. 30,000 plus applicable taxes for micro and small category units (i.e. Rs. 35,400/- inclusive of taxes. Considering GST at 18%)

- Rs. 45,000 plus applicable taxes for medium category units (i.e. Rs.53,100/- inclusive of taxes. Considering GST at 18%)

- Areas covered under the detailed energy audit are all the energy consuming equipment. Recommendations will be based on the retrofits in the existing system, new equipment installation and Technology up gradation.

- ISTSL grants its consultancy services for the implementation of all Energy Conservation Measures described in the Detailed Project Report after the Energy Audit conducted by ISTSL for three months from the date of Energy Audit.

- IISTSL also provides its consultancy services in the field of resource efficiency, water audit and renewable energy like solar power generation and solar thermal energy.

- ISTSL ensures the quality and performance of the review entirely.
- SIDBI can consider financing for the projects under its existing schemes.
- The empanelled energy audit firm will do the energy audit.

A total of 1088 cases have been successfully processed under the 4E scheme, reflecting a robust engagement in facilitating economic empowerment. The cumulative loan amount disbursed in these cases amounts to a substantial Rs. 1962.75 Crores, indicating a significant financial infusion into diverse economic activities.

The 4E scheme, with its comprehensive approach, has proven to be instrumental in fostering economic development by supporting a wide range of MSME enterprises.

Chapter 4: Building Sector

4. *Buildings*

4.1. Introduction

Real Estate Growth in India

In India, the real estate sector is the second-highest employment generator, after the agriculture sector. Real estate sector in India is expected to reach US$ 1 trillion in market size by 2030, up from US$ 200 billion in 2021. By 2025, it will contribute 13% to country's GDP. Emergence of nuclear families, rapid urbanisation and rising household income are likely to remain the key drivers for growth in all spheres of real estate, including residential, commercial, and retail. Rapid urbanisation in the country is pushing the growth of real estate.

India's real estate sector is expected to expand to US$ 5.8 trillion by 2047, contributing 15.5% to the GDP from an existing share of 7.3%[26].

The Securities and Exchange Board of India (SEBI) has given its approval for the Real Estate Investment Trust (REIT) platform, which will allow all kind of investors to invest in the Indian real estate market. It would create an opportunity worth Rs. 1.25 trillion (US$ 19.65 billion) in the Indian market in the coming years. The residential sector is expected to grow significantly, with the central government aiming to build 20 million affordable houses in urban areas across the country by 2023, under the ambitious Pradhan Mantri Awas Yojana (PMAY) scheme of the Union Ministry of Housing and Urban Affairs. Expected growth in the number of housing units in urban areas will increase the demand for commercial and retail office space[27].

The construction industry in India is undergoing remarkable expansion, constituting more than 30% of the country's overall electricity consumption. The current pace of development indicates that India is adding 300,000 square feet of commercial floor space daily, projecting one of the most substantial growth periods in commercial and residential construction over the next twenty years[28]. India stands at a critical juncture, with 40% of the buildings that will exist in the next two decades yet to be constructed. This surge in construction is expected to escalate energy demand significantly, emphasizing the immediate necessity to optimize energy consumption in both upcoming and existing building structures.

The current shortage of housing in urban areas was estimated to be ~10 million units. An additional 25 million units of affordable housing are required by 2030 to meet the growth in the country's urban population. The number of Indians living in urban areas is expected to reach 525 million by 2025, which will also create demand for building 35 billion square meters of residential and commercial spaces by 2050[29]. India has witnessed a remarkable surge in skyscrapers and high-rise buildings over the past decade. Mumbai, in particular, leads with nearly 200 skyscrapers and 12,000 high-rise projects under construction. According to the UN Habitat, India's urban population is projected to exceed 600 million by 2030. Consequently, the country must unlock new avenues for growth within its cities, suggesting that tall buildings could serve as a solution to meet the demand for urban space.

[26] Source: IBEF
[27] Source: https://www.ibef.org/industry/real-estate-india
[28] SAATHEE – BEE portal
[29] Source: https://dste.py.gov.in/PCCC/pdf/Reports/Energy%20Benchmark%20Report.pdf

Figure 32: Indian buildings landscape (Source: Shutterstock)

India's overall population is on a continuous upward trajectory, with projections indicating a population of 1.72 billion by 2060[30]. Rapid urban expansion and urbanization are contributing factors, with an expected two-thirds of India's population residing in urban areas by 2050. This urban population is set to increase from 33% to 50% of the total population by 2050[31], accompanied by the addition of over 70 million new urban housing units in the next two decades. It is anticipated that approximately two-thirds of the built-up area will be constructed within this twenty-year timeframe.

This rapid increase in built-up areas is expected to result in a substantial increase in electricity consumption in buildings soon.

Energy consumption in buildings

The combined residential and commercial building sector in India currently accounts for 33% of the total electricity consumption. Projections suggest a substantial increase in electricity demand, expected to escalate from 414 terawatt-hours (TWh) per year to 4,697 TWh per year by 2047. It is anticipated that buildings will contribute to 55% of the total electricity demand in the country by that year. Specifically, the electricity demand in the residential and commercial

[30] McKinsey Global Institute. India's urban awakening
[31] McKinsey Global Institute. India's urban awakening

building sectors is forecasted to increase by fivefold and threefold, respectively, by the year 2032[32].

Details of the national electricity consumption including the share of commercial and domestic buildings sectors are presented in the figure below. Out of the total consumption of electricity in 2022-23(P), industry sector accounted for the largest share (41.16%), followed by domestic (25.77%), agriculture (17.67%) and commercial sectors (8.29%). The Domestic sector has experienced the highest CAGR of 6.87 between FY:2012-13 to FY:2022-23.[33]

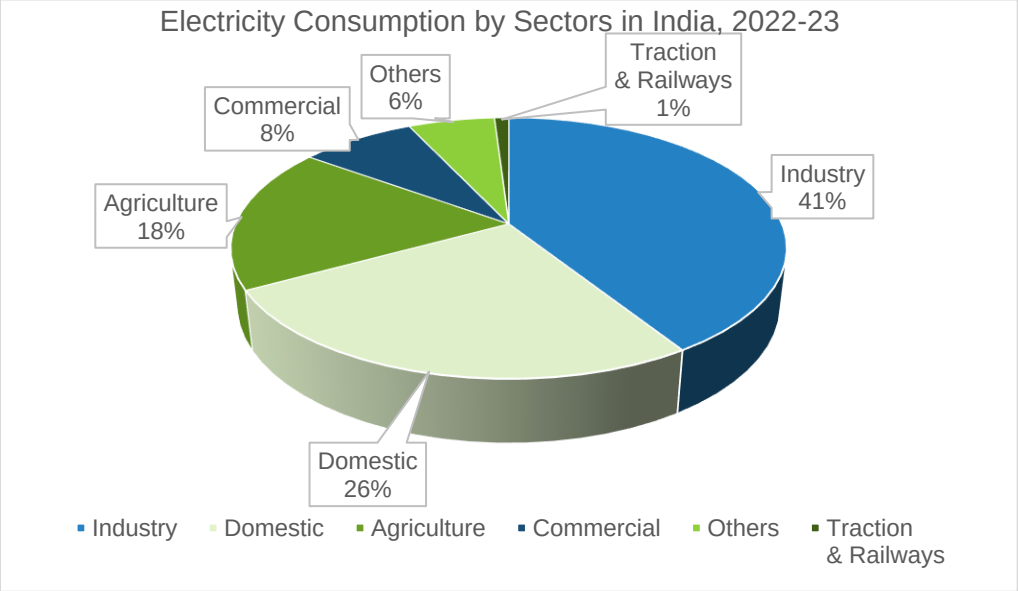


Figure 33: Electricity consumption by sectors in India 2022-23

As per the study conducted by the USAID, it is estimated that, India will be adding about 1 billion square meter of new commercial buildings by 2030, with increased demands of air conditioning and artificial lighting in the buildings.

Commercial buildings

In general, approximately 8-9% 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.

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

[32] Source: https://dste.py.gov.in/PCCC/pdf/Reports/Energy%20Benchmark%20Report.pdf
[33] Source: Energy Statistics 2023, Ministry of Statistics and Program Implementation; Pg- 75

primarily driven by shifts in living standards and a heightened reliance on achieving thermal comfort affordably.

Schemes from BEE for buildings (commercial and residential & new and existing)

The Government of India, in collaboration with the Ministry of Power and the Bureau of Energy Efficiency (BEE), has introduced and implemented several energy efficiency programs targeting the buildings sector, encompassing both commercial and residential structures. These initiatives aim to enhance and optimize energy consumption within buildings. There are various green building rating systems developed by the Government bodies or Industry associations. The various initiatives and programs undertaken by various ministries and institutions in India for the building sector are presented in figure:

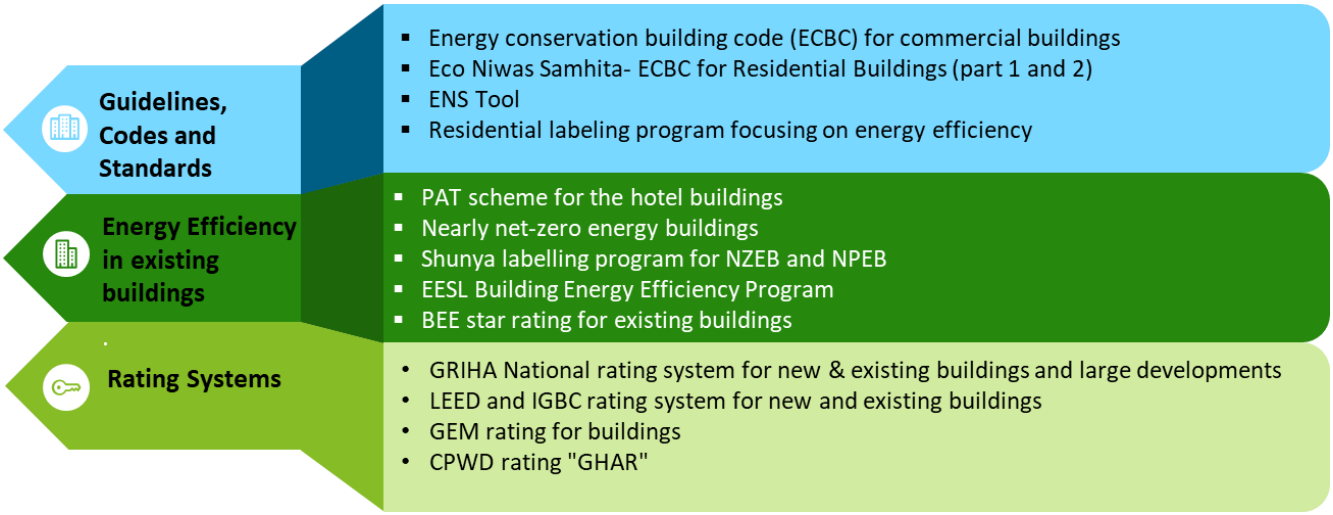


Figure 34: Various programs and schemes for building sector by Government and Industry associations

4.2. Energy Conservation Building Code (ECBC)

The Energy Conservation Building Code (ECBC) serves as a regulatory instrument aimed at monitoring and overseeing the energy footprint within commercial buildings in India. This code was formulated to streamline the design and operation of commercial structures, with the primary objective of reducing their energy demand and consumption. Consequently, a tailored energy conservation code is essential for each building type, taking into account its specific energy usage patterns.

Initiated by the Bureau of Energy Efficiency (BEE) in 2007, the Energy Conservation Building Code (ECBC) establishes minimum energy performance standards for buildings in India. The onus of implementing this code rests with the State/Union Territory governments. The code addresses key components of buildings, including the envelope (comprising walls, roofs, and windows), lighting systems, HVAC systems, water heating, water pumping, and the electrical power system.

Building energy codes undergo periodic updates to align with the latest advancements in energy-efficient technologies and measures for greenhouse gas (GHG) mitigation. These updates ensure that the codes reflect contemporary standards and accommodate innovations in energy efficiency. Additionally, the revision of codes involves the establishment of optimal

user case scenarios and benchmarks, providing guidelines for future developments in the construction and energy sectors.

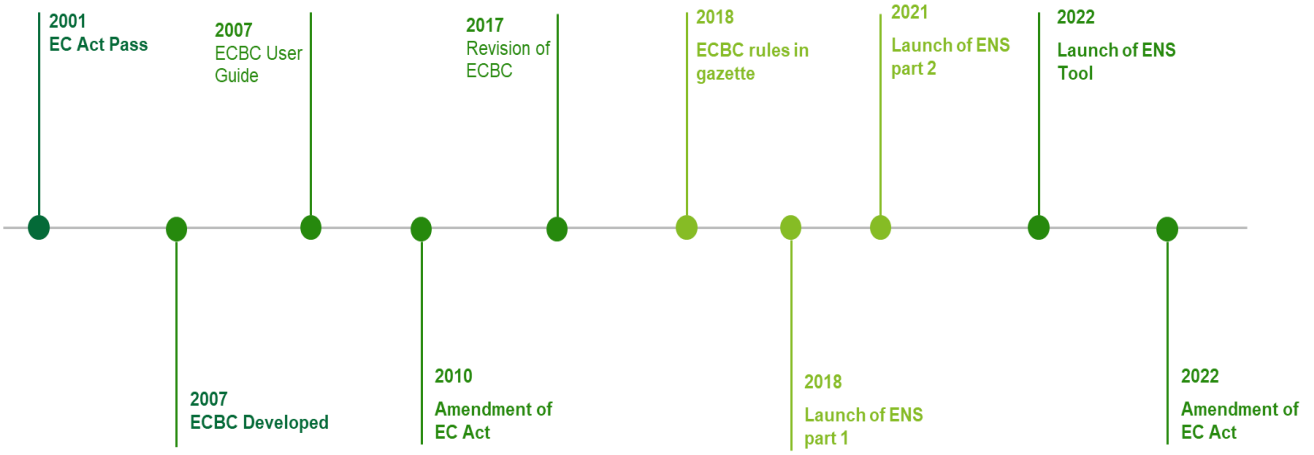


Figure 35: Timeline for evolvement of energy codes (ECBC and ENS) over the years in India

The initial iteration of the Energy Conservation Building Code (ECBC) was introduced by the Government of India in 2007. In 2009, the Bureau of Energy Efficiency (BEE) initiated the Star rating scheme for commercial buildings in India. The Energy Conservation Act underwent an amendment in 2010, accompanied by a subsequent update to the Commercial ECBC in 2017.

In June 2017, the Energy Conservation Building Code (ECBC) 2017 was introduced, encompassing both existing and forward-looking advancements in building technology. This updated code aims to not only continue the reduction of building energy consumption but also foster low-carbon growth, going beyond the provisions outlined in ECBC 2007. ECBC 2017 aligns with several objectives set by the Government of India, including enhancing energy security, promoting economic growth, and ensuring environmental sustainability. Serving as a pivotal policy driver for guiding building construction, this forward-looking code is designed to propel the building sector toward achieving near-zero energy targets.

On June 19, 2017, the Bureau of Energy Efficiency (BEE) introduced the latest version of the code, ECBC 2017. This newly devised code is characterized by its futuristic, pragmatic, and easily implementable features. It is specifically designed to motivate both the public and private sectors not only to meet the fundamental ECBC criteria but also to surpass them. The sustained success of ECBC hinges significantly on the collaborative efforts of various stakeholders, who play pivotal roles in the development, adoption, and effective implementation of building codes.

In the recently amended EC Act (December 2022), ECBC is now referred as “energy conservation and sustainable building code”.

Program/scheme overview

The Energy Conservation Building Code (ECBC) establishes the baseline energy standards for newly constructed commercial buildings with a connected load of 100 kW or more, or a contract demand of 120 kVA or more. The effective implementation of this code not only ensures energy efficiency but also enhances occupant comfort through the adoption of passive design strategies and daylight integration. Notably, the code is technologically neutral, advocating for renewable energy use and placing emphasis on the life cycle cost of buildings.

The most updated version of the code has additional priorities to renewable energy integration, ease of compliance, inclusion of passive building design strategies, and flexibility for the designers. One of the major updates to the code is inclusion of incremental voluntary energy efficiency performance levels. There are three levels of energy performance standards in Energy Conservation Building Code (ECBC) i.e. ECBC, ECBC plus and super ECBC. In ascending order of efficiency, ECBC compliant building has approx.. 25% energy savings, ECBC plus building approx. 35% energy savings and compliance with super ECBC building will show energy savings by 50% or more as compared to the conventional building.

The updated code places additional emphasis on priorities such as the integration of renewable energy, ease of compliance, inclusion of passive building design strategies, and flexibility for designers. In accordance with Section 15 of the Energy Conservation Act of 2001, the code and rules are appropriately modified to align with local requirements. Following this modification, the integration process with the existing building approval procedures is undertaken, facilitating the subsequent enforcement and implementation of the code in the respective jurisdiction. There are 6 types of buildings classified under ECBC:

	Healthcare	• Hospital • Out-patient Healthcare
	Hospitality	• Star Hotel • No Star Hotel • Resort
	Educational	• College • University • Institution • School
	Shopping Complex	• Shopping Mall • Stand-alone Retails • Open Gallery Malls • Super Markets
	Business Centers	• Large Office (>30,000 m^2) • Medium Office (10,000m^2-30,000m^2) • Small Office (<10,000 m^2)
	Assembly	• Multiplex • Theatre • Building used for Transport Services

Figure 36: Types of buildings classified under ECBC

ECBC 2017 adopts a technology-neutral approach, allowing architects and engineers both artistic and technical freedom within the framework of fulfilling minimum efficiency requirements. The code encourages the use of passive design strategies, such as daylighting and shading, to enhance energy efficiency. Moreover, it encompasses additional parameters like lighting, electrical systems, and renewable energy, providing designers with flexibility to efficiently design buildings across various components. This approach ensures that while meeting minimum efficiency standards, there is room for creativity and innovation in the architectural and engineering aspects of building design.

Impact of the code:[34]

- Implementation of ECBC has started in Andhra Pradesh, Assam, Andaman & Nicobar Islands, Haryana, Karnataka, Kerala, Punjab, Sikkim, Telangana, Uttarakhand, Madhya Pradesh, Uttar Pradesh. About 392 ULBs have covered under these states.
- 25 numbers of building cells have been working for the states/UTs in 2022-23. the aim is to provide technical assistance to states/UTs for effective implementation and enforcement of building energy efficiency schemes. These cells oversee ECBC and ENS related activities in the states/UTs.
- ECBC Rules and ECBC 2017 was notified in Goa, Puducherry, Tamil Nadu Jharkhand and Chhattisgarh. Jammu and Kashmir and Bihar ECBC and rules are submitted to state cabinet for approval. Till March 2023, 22 States and 2 UTs notified ECBC.
- Inclusion of energy efficiency building materials/technologies in CPWD schedule of rates (SoR): a draft document (civil, mechanical, electrical) prepared and submitted to CPWD with their field survey for official comments and inputs.

ECBC level of compliance

Recognizing and rewarding performance beyond mandatory code requirements is crucial. In a significant update, ECBC 2017 acknowledges voluntary measures and their positive impact on overall building energy efficiency. To gauge compliance with the code, an essential parameter, the energy performance index (EPI), has been introduced. EPI is calculated as the ratio of annual energy consumption (in kWh) to the total built-up area, excluding unconditioned basements. ECBC compliance is assessed based on the EPI ratio, where the building's EPI ratio should be less than or equal to 1 to demonstrate compliance with the code.

The buildings that fall within the scope of ECBC shall comply with the code by meeting all mandatory requirements of the code. Further, it can follow any of the compliance paths for compliance the EPI ratio shall be calculated based on either of the below approaches:

- Prescriptive Methods
    - Prescriptive Method
    - Whole Building Performance Method
- Whole building performance method
    - A building complies with the Code using the Whole Building Performance (WBP) Method when the estimated annual energy use of the Proposed Design is less than that of the Standard Design, even though it may not comply with the specific provisions of the prescriptive requirements. The mandatory requirements shall be met when using the WBP Method.
    - The EPI Ratio of a building that uses the Whole Building Performance Method to show compliance, should be less than or equal to the EPI Ratio for the applicable building type and climate zone, mentioned in the code.

There are three levels of energy performance standards in the code. In ascending order of efficiency, these are ECBC, ECBC Plus, and Super ECBC. The adherence to the minimum

[34] BEE annual report 2022-23

requirements stipulated for ECBC level of efficiency would demonstrate compliance with the code. The other two efficiency levels are voluntary.

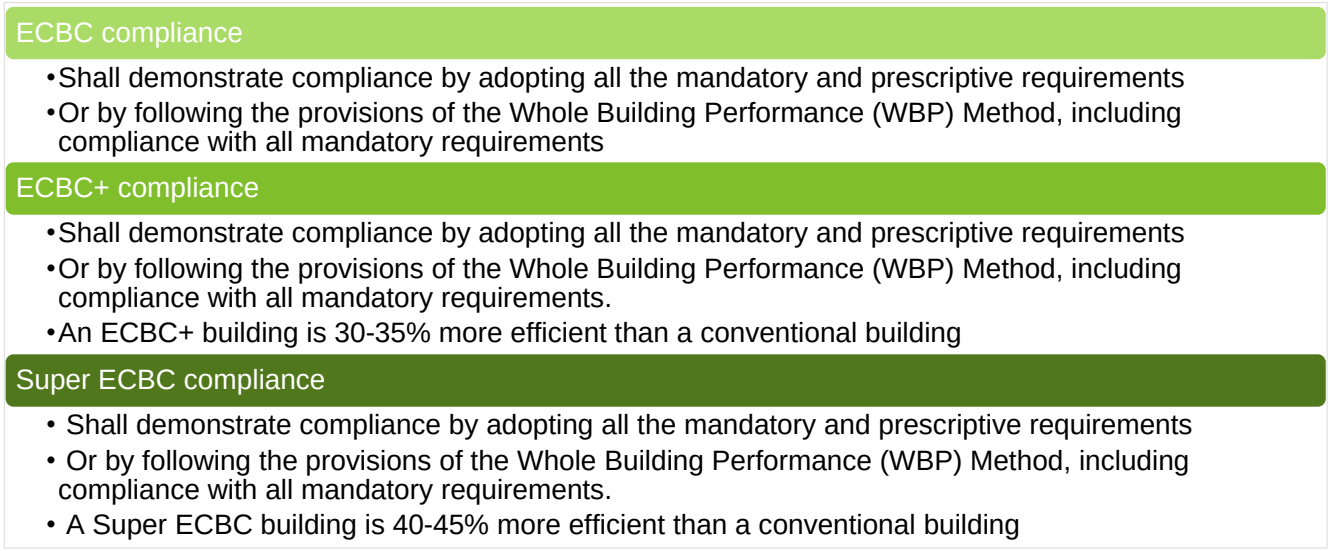


Figure 37: Three level of energy performance standards as per ECBC

Minimum energy efficiency requirements

The ECBC provides minimum energy efficiency requirements for four building systems:

1. **Building Envelope**- Opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT), and building envelope sealing documentation; overhangs and side fins, building envelope sealing details
2. **Comfort system and controls-** Ventilation, space conditioning equipment efficiencies, controls, piping and ductwork, system balancing, condensers, service water heating
3. **Lighting and controls –** Lighting controls, and exit signs
4. **Electrical power and motors-** Efficiency and losses for transformers, motors, DG sets, metering and monitoring, power correction factor, power distribution system, UPS, and renewable energy systems (System peak installed capacity, technical specifications, solar zone area)

Also considers the five climatic zones (Hot Dry, Warm Humid, Temperate, Composite, and Cold) present in India. The National Building Code of India 2016 (NBC) is the reference standard for lighting levels, heating, ventilating, and air conditioning (HVAC), thermal comfort conditions, natural ventilation, and any other building materials and system design criteria addressed in this Code.

Technical assistance has been provided for ECBC pilot demonstration projects. About 107 number of building projects for different categories of buildings in different climatic zones were supported to showcase ECBC compliance across the country. Based on the anticipated growth it is projected that if the future building stock is made in compliance with this code,

about 300 BU electricity will be saved by 2030, which can result in emission reduction of about 250 MntCO2.

Methodology for saving calculation

To measure the level of compliance of buildings with the code, a parameter – energy performance index (EPI) has been used as mentioned in the code. EPI is defined as the ratio of the annual energy consumption (in kWh) and total built-up area (excluding unconditioned basements). In the assessment year 2022-23, 644 number of buildings have been approved by UB/SD at the design stage and these buildings are at the different stages of construction in states:[35]

Table 36: No of ECBC compliant buildings in India

S.No.	States/UTs	No. of ECBC-compliant buildings
1	Andhra Pradesh	352
2	Haryana	43
3	Kerala	29
4	Punjab	133
5	Telangana	71
6	Uttar Pradesh	16
	Total	**644**

In year 2022-23, there were a total of 173 buildings across India that are either in the construction or under construction stage as per ECBC guidelines across various states in India. The details are presented in the table below:

Table 37: Details of buildings complied under ECBC in FY 2022-23[36]

Construction Stage	No. of Buildings	Total Area in Mn. Sqm
Completed	41	0.66
Design stage	132	1.54
Grand Total	**173**	**2.20**

Estimation of energy savings in year 2022-23[37]

To calculate the energy (electrical) savings, the difference between the conventional EPI and proposed EPI of the respective buildings is considered, which is then multiplied by the total built-up area in square meters (sqm). The EPI benchmarks are calculated as per the approved guidelines under the ECBC program and conventional EPIs are calculated using % Saving of ECBC over and above the baseline EPI.

*Total Built-up area * (Conventional EPI – Proposed EPI for ECBC Complaint Building)*

Where Conventional EPI, (1+%Saving of ECBC as per USAID ECO -III) (Baseline EPI)*

Also, EPI for the building is calculated on annual basis to account for seasonal factors, and this EPI cannot be broken down on monthly basis. ***Therefore, to calculate the energy***

[35] BEE annual report 2022-23
[36] Keeping same data as obtained in the previous impact assessment period 2021-22
[37] Keeping same data as obtained in the previous impact assessment period 2021-22

savings for buildings compliant during FY 2022-23, 50% of total energy savings are considered.

We have considered the energy savings achieved in the buildings since the year 2018-19. As the buildings have previously achieved necessary ECBC compliance, the energy savings shall be counted for its entire lifecycle each year.

To calculate the reduction in the total CO_2 emission, the conversion factor of 0.71 kg CO_2/kWh for electricity is considered. The total energy (electrical) saved under the ECBC program is 0.099 BU and the total reduction in CO_2 emission is 0.070 MtCO2 for year 2022-23.

Table 38: Energy savings and emissions reduced by ECBC[38]

From year 2018 to 2023	No. of Buildings	Energy Savings in MU	Total Area in Mn. Sqm
Total	**538**	**99.08**	**7.73**

It is considered that some of the electrical energy savings obtained under this scheme are due to the replacement of inefficient electrical & mechanical appliances with BEE star-rated appliances. Therefore, to avoid this duplication, only 90% of total energy savings have been considered for the ECBC program. Therefore, total electricity savings for the ECBC program in FY 2022-23 is considered as 0.089 BU and the total reduction in CO_2 emission is 0.063 $MtCO_2$.

Impact of the code

BEE has published ECBC, whereas the implementation of the code lies with the state/UT government. The code and rules suitably modified, as per the local requirements and then the process of integration with the present building approval process is undertaken, which subsequently paves the way for enforcement and implementation of the code in the said jurisdiction.

In keeping with the global launch of LiFE (Lifestyle for Environment) movement, the scope of energy conservation building code is proposed to be widened to include renewable energy and sustainable building concept. It will also be renamed as Energy Conservation and Sustainable Building Code (ECSBC). Also, it is proposed that ECSBC will be implemented through building bylaws of the respective state government.

Training and capacity building

- 3 No. of regional meeting conducted to review the status of building energy efficiency activities in the States/UTs and to update state about the updated ECBC program.
- In 2022-23, 309 number of training programs have been conducted and 13,802 No. of professionals have been trained.

[38] Keeping same data as obtained in previous impact assessment period 2021-22

4.3. Eco Niwas Samhita (ENS)

Approximately 75% of the total electricity consumed in the building sector is attributed to residential buildings. The gross electricity consumption in residential buildings has exhibited a significant upward trend over the years. Notably, the consumption escalated from around 98 TWh in 2000-01 to approximately 414 TWh in 2019-20, marking an increase of more than fourfold within a span of 20 years. Projections indicate a continued rise, with estimates ranging from 630 to 940 TWh by 2032[39].

The primary catalyst for this rapid surge in energy consumption in the buildings sector is the increasing ownership levels of appliances, particularly air conditioners. This trend is driven by the growing demand for maintaining comfortable indoor temperatures, especially in urban areas, reflecting a notable shift in recent years.

Figure 38: Residential building development in India

The impending construction of new buildings presents a unique opportunity to establish sustainable and comfortable living conditions. By integrating strategies and interventions that prioritize optimized building design and efficient resource consumption, we can contribute to long-term environmental benefits. Acknowledging significant potential for energy savings in new residential construction, the BEE took a proactive step by introducing the Residential Energy Conservation Building Code in 2018, known as Eco Niwas Samhita (ENS). This initiative aims to elevate thermal performance standards and diminish overall energy consumption in residential buildings.

[39] Source: https://dste.py.gov.in/PCCC/pdf/Reports/Energy%20Benchmark%20Report.pdf

Program/scheme overview

The purpose of any residential unit is to provide comfort which comes from appropriate thermal comfort and lighting in the unit, so as to ensure health and well-being of the occupants. Thus, BEE envisaged a focused performance standard for residential sector to ensure adoption of energy efficiency measures.

The inaugural section of Eco Niwas Samhita (ENS), titled Part – I Building Envelope, which encompasses the Energy Conservation Building Code for the Residential Sector, was formulated and launched in 2018. The launch event took place on National Energy Conservation Day and was officiated by the Hon'ble Speaker of Lok Sabha and the Hon'ble Minister of Power, New & Renewable Energy. ECO Niwas Samhita 2018 serves as an Energy Conservation Building Code specifically tailored for Residential Buildings (ECBC-R).

This code is designed to establish minimum performance standards for the building envelope, aiming to control heat gains (in cooling-dominated climates) and limit heat loss (in heating-dominated climates). Simultaneously, it ensures adequate natural ventilation and daylighting. Applicable to all residential building projects with a plot area exceeding 500 m2, the specific plot area criteria are subject to the regulations of individual states and municipal bodies within their respective jurisdictions.

The following are excluded from the definition of 'residential building' for this code.

- Lodging and rooming houses: This includes inns, clubs, motels, and guest houses.
- Dormitories: This shall include school and college dormitories, students, and other hostels and military barracks.
- Hotels: These shall include any building or group of buildings under single management, in which sleeping accommodation is provided, with or without dining facilities.

Eco Niwas Samhita (ENS), Part -1

Eco Niwas Samhita (Part I: Building Envelope) sets the minimum building envelope performance standards to limit heat gains and to limit heat loss, as well as for ensuring adequate natural ventilation and daylighting potential. The code provides design flexibility to innovate and vary important envelope components such as wall type, window size, type of glazing, and external shading to windows to meet compliance.

Below five are the key components of ENS Part 1 – Building Envelope:

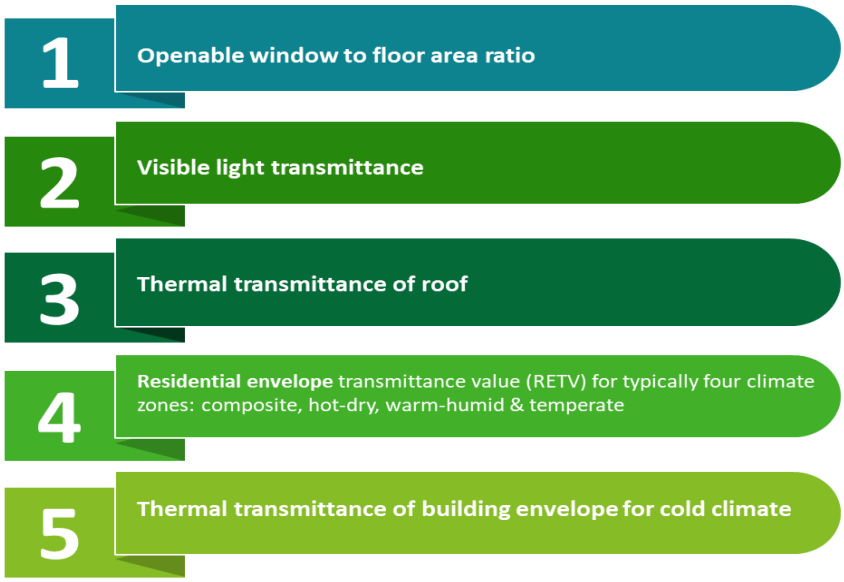


Figure 39: Key components of ENS part-1 building envelope

Eco Niwas Samhita (ENS), Part -2

The intent of Eco Niwas Samhita 2021, specifically focusing on Code Compliance and Part-II: Electromechanical and Renewable Energy Systems (ENS-C&2), is to ensure adherence to the code and establish the minimum requirements for building services. This code is applicable to residential buildings constructed on a plot area of ≥ 500 m2 and to the residential segment of mixed land-use building projects also built on a plot area of ≥ 500 m2.

ENS-C&2 delineates the minimum standards for the integration of renewable energy systems, including Solar Hot Water and Solar Photovoltaic systems. Additionally, it outlines requirements for electromechanical systems utilized in building services, encompassing common area and exterior lighting, elevators, pumps, basement ventilation, transformers, power distribution losses, power factor correction, electrical vehicle supply equipment, and more. The code also addresses indoor electrical end-use, covering aspects such as indoor lighting, comfort systems, and service hot water.

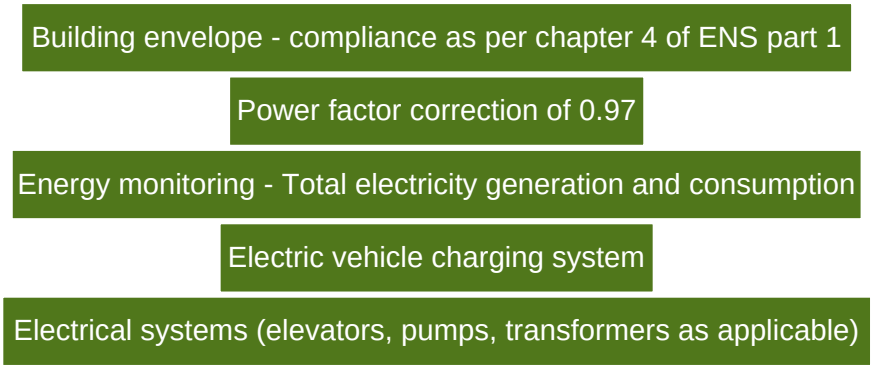


Figure 40: Key components of ENS part 2

Eco-Niwas Samhita Compliance (ENS) Tool

As part of its initiative, the Bureau of Energy Efficiency (BEE) has created online tools designed for the swift assessment of designs by homeowners, contractors, and builders concerning

energy efficiency parameters. Three distinct tools have been developed: the Basic tool, the Advanced tool, and the Optimization tool.

The **Basic tool** offers various categories of options, ranging from building envelope elements (walls, roofs, and windows) to air-conditioning and ventilation techniques, enabling a quick assessment of project performance. The Advanced tool is tailored for professionals such as architects, engineers, MEP consultants, project developers, and industry professionals who seek a detailed analysis of project design features in terms of both energy efficiency and economic feasibility. This tool allows for input on diverse building design parameters, including Building Geometry, Envelope, Lighting, Equipment, HVAC, and Economics, to comprehensively evaluate project performance.

The **Optimization tool** serves as a rapid evaluation module, calculating the most optimized set of envelope parameters (optimal wall, roof, and window) based on the life cycle cost of the available options for a selected location. By inputting the cost of common envelope assemblies at the project site, the tool identifies the most suitable envelope for the site. The Eco-Niwas Samhita Compliance (ENS) Tool, specifically Part 2, is currently in the final stages of development.

ENS Level of compliance

To demonstrate compliance with the ENS code, the residential building shall comply with all of the mandatory requirements stated in Chapter 4 (of ENS part 2) along with either of the two approaches which are either a prescriptive approach or a point-based system.

The code defines the minimum ENS score required for low-rise buildings, affordable housing, and high-rise residential buildings. The code also defines the compliance mechanisms for mixed-mode buildings. The minimum ENS score required is presented next:

Table 39: Minimum score required for different categories of ENS compliance building

Project Category	Definition	Minimum ENS score
Low rise buildings	A building equal to or below 4 stories, and/or a building up to 15 meters in height (without stilt) and up to 17.5 meters (including stilt).	47
Affordable housing	Affordable houses are Dwelling Units (DUs) with a Carpet area of less than 60 sqm. It also includes the Economically Weaker Section (EWS) category and Lower Income Group (LIG) category (LIG-A: 28-40 sq. m. and LIG-B 41-60 Sq.m.)	70
High rise building	A building above 4 stories, and/or a building exceeding 15 meters or more in height (without stilt) and 17.5 meters (including stilt)	100

The code provides liberty to the user to opt for the prescriptive method or point-based method after compliance with mandatory requirements.

Methodology for saving calculation

The methodology adopted for estimating savings is based on RETV calculations. Residential envelope heat transmittance (RETV) is the net heat gain rate (over the cooling period) through the building envelope (excluding the roof) of the dwelling units divided by the area of the building envelope (excluding the roof) of the dwelling units. Its unit is W/m2.

RETV characterizes the thermal performance of the building envelope (except the roof). Limiting the RETV value helps in reducing heat gains from the building envelope, thereby improving the thermal comfort, and reducing the electricity required for cooling.

As per ENS part 1, the RETV for the building envelope (except the roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate, shall comply with the ***maximum RETV of 15 W/m2***.

The demonstration projects in the states (where building (ECBC+ENS) cell was established) have complied with the minimum RETV requirements (as stated in ENS part 1). The energy saving is calculated by creating a baseline case and proposed case. Baseline case developed to achieve minimum RETV requirements where the proposed case is developed to achieve energy efficiency in building envelope with improved RETV.

Estimation of energy savings in the year 2022-23[40]

Technical assistance has been provided for ENS demonstration projects through the building cells. To calculate the energy (electrical) savings, the difference between the conventional RETV (baseline) and the proposed RETV of the respective residential buildings is considered.

We have considered the energy savings achieved in the buildings since the year 2021-22. As the buildings have previously achieved necessary ENS compliance, the energy savings shall be counted for its entire lifecycle each year.

Table 40: Energy savings by the adoption of ENS in selected states

From Year 2021 to 2023	Number of buildings	Built-up area (million sqm)	Energy savings (MU)
Total	108	3.10	4.84

Also, RETV for the building is calculated on annual basis to account for seasonal factors, and this saving cannot be broken down on monthly basis. ***Therefore, to calculate the energy savings for residential buildings compliant during FY 2022-23, 50% of total energy savings are considered***.

To calculate the reduction in the total CO_2 emission, the conversion factor of 0.71 kg CO_2/kWh for electricity is considered. The total energy (electrical) saved under the ENS program is 0.0048 BU and the total reduction in CO_2 emission is 0.0034 MtCO2 for year 2022-23. This is expected to grow exponentially in the coming years with much aggressive adoption of ENS in all states of India.

Star labeling of existing commercial buildings

In 2009, the Bureau of Energy Efficiency (BEE) introduced the Star rating scheme for commercial buildings. This program evaluates the actual performance of a building based on its specific energy usage, measured in kWh/sqm/year. Office buildings are rated on a 1-5 Star scale, with 5 Star labeled buildings recognized as the most efficient. The participation in this scheme is voluntary, and the awarded label remains applicable for a duration of 5 years from the date of issuance. ***Recently, BEE has revised the EPI band for Star Rating for Office Buildings and BPOs. The revision of the scheme is effective from January 2022***.

[40] Keeping same data as obtained in previous impact assessment period 2021-22

Presently, four typologies of the buildings are covered in the scope viz. Office buildings, BPO, Hospitals, and shopping malls. The buildings having connected loads 100kW and above are considered for the BEE star rating scheme. This national energy performance rating serves as an external benchmark, aiding energy managers in assessing the efficiency of their buildings relative to similar structures nationwide. Furthermore, building owners and managers can utilize these performance ratings to identify opportunities for improvement and recognition in energy efficiency. ***A web portal to ease the application and expedite the process for verification and approval is being developed and will be launched soon[41].***

Program/scheme overview

Within the existing labeling scheme, buildings are categorized based on their actual Energy Performance Indices (EPI) on a scale ranging from 1 to 5. Standard EPI bandwidths have been established to assess buildings under this program across different climatic zones, illustrating the spectrum of energy performance variations among various types of office buildings within a specific climatic zone.

To initiate the rating process for office buildings, a standardized format has been devised for collecting actual energy consumption data. This includes essential information such as the building's built-up area, conditioned and non-conditioned areas, building type, daily operational hours, climatic zone, and other pertinent details related to the facility. This structured approach ensures a comprehensive assessment of the energy performance of office buildings and facilitates a meaningful comparison within and across different climatic zones.

Within this initiative, users apply the building rating label in accordance with the specified design and material criteria, display guidelines, and the rating plan outlined by the Bureau of Energy Efficiency (BEE) for the specific building type. BEE consistently reviews its technical approach to the rating system's development, aiming to ensure accuracy, fairness, and statistical robustness. Given that each building type possesses unique features influencing energy efficiency, this ongoing review process is crucial.

Furthermore, BEE has undertaken the standardization of energy data collection, facilitating comparative assessments and target setting for existing buildings. This exercise enhances the overall effectiveness of the rating system, ensuring that it remains a reliable and valuable tool for users seeking to improve energy efficiency in diverse building types.

Level of compliance

The Energy Performance Index (EPI) in kWh / sqm/ year is considered for rating the building which is calculated as electricity purchased & and generated divided by built-up area in sqm. However, the total electricity would not include electricity generated from on-site renewable sources such as solar photovoltaic, etc.

The buildings are rated from 1 to 5 stars based on their performance as per applicable performance indicators.

Methodology for saving calculation

The methodology for estimating energy saving and applicable star labels in all four categories (Office buildings, BPO, Hospitals, and shopping malls) is different from each other.

[41] BEE Website

In case of *BPO building*, the performance of a building is measured on the basis of AAhEPI. AAhEPI (Wh/hr/m2) is defined as the Average Annual hourly EPI of a building. It is calculated as:

[EPI/(Daily hours of Operation x days of operation in a week x 52 weeks in a year)] x 1000

AAhEPI in Wh/hr/m2 will be considered for rating the building.

For buildings having multiple towers/floors having non-uniform working hours the AAhEPI will be calculated for individual towers/floors and an average of those will be net AAhEPI.

Star rating table: The Star Rating Band is formed by straight line equations in the form ***y=(a*b) +c***, where 'b' denotes the percentage of AC area out of the total built-up area.

Table 41: Table for Star Rating of the BPO Building[42]

Climatic Zone	1 Star	2 Star	3 Star	4 Star	5 Star
Composite	y = 0.21x + 28	y = 0.18x + 24	y = 0.15x + 20	y = 0.12x + 16	y = 0.09x + 12
Hot & Dry	y = 0.1x + 24	y = 0.08x + 20	y = 0.06x + 16	y = 0.04x + 12	y = 0.02x + 8
Warm & Humid	y = 0.17x + 36	y = 0.14x + 32	y = 0.11x + 28	y = 0.08x + 24	y = 0.05x + 20
Temperate	y = 0.13x + 31	y = 0.11x + 27	y = 0.09x + 23	y = 0.07x + 19	y = 0.05x + 15

The equations provide the upper limit of the corresponding Star Rating. Lower limit will be the value obtained by the equation of next higher rating.

Example: for a BPO building, in composite climatic zone and if AC area is 65% then, the lowest AAhEPI value for 1 star will be: 0.21*65 + 28 = 41.65 wh/hr./sqm. The lower limit for 2-star building will be: 0.81*65 + 24 = 35.7 wh/ hr./sqm. So, any building having 65% AC area, and having AAhEPI less than 41.65 wh/hr./sqm. but equals to or more than 37.5 wh/hr./sqm. that building will be awarded 2-star rating.

In case of office buildings, for the purpose of Star Rating the office buildings are categorized into three types large offices (BUA>30000 sqm), medium offices (30000 sqm<BUA<10000 sqm) and small offices (BUA<=10000 sqm). The performance of the building is measured on the basis of EPI which is the ratio of electricity purchased and built-up area in sqm.

The Star Rating Band is formed by straight line equations in the form y=(a*b) +c, where 'b' denotes the percentage of AC area out of the total built-up area.

[42] BEE Schedule for Star Rating of Commercial Buildings Typology-BPO, (w.e.f. 01st January 2022)

Table 42: Table for Star Rating of the Office Building[43]

Climatic Zone	Building Category	1 Star	2 Star	3 Star	4 Star	5 Star
Composite	Large office	y = 0.95x + 60	y = 0.9x + 50	y = 0.85x + 40	y = 0.8x + 30	y = 0.75x + 20
	Medium office	y = 1.1x + 60	y = 1.05x + 50	y = x + 40	y = 0.95x + 30	y = 0.9x + 20
	Small office	y = 0.65x + 60	y = 0.6x + 50	y = 0.55x + 40	y = 0.5x + 30	y = 0.45x + 20
Warm & Humid	Large office	y = 0.9x + 65	y = 0.85x + 55	y = 0.8x + 45	y = 0.75x + 35	y = 0.7x + 25
	Medium office	y = 0.9x + 65	y = 0.85x + 55	y = 0.8x + 45	y = 0.75x + 35	y = 0.7x + 25
	Small office	y = 0.7x + 65	y = 0.65x + 55	y = 0.6x + 45	y = 0.55x + 35	y = 0.5x + 25
Temperate	Large office	y = 1.1x + 55	y = 1.05x + 45	y = x + 35	y = 0.95x + 25	y = 0.9x + 15
	Medium office	y = 1.25x + 55	y = 1.2x + 45	y = 1.15x + 35	y = 1.1x + 25	y = 1.05x + 15
	Small office	y= 0.75x + 55	y = 0.7x + 45	y = 0.65x + 35	y = 0.6x + 25	y = 0.55x + 15

Example: Any Large Office Building in a Composite climatic zone, having 75% AC area Highest EPI value for 1-Star should be less than: 0.95*75 + 60 = 131.25 kwh/sqm. The lower limit for 1-star building will be: 0.9*75 + 50 = 117.5 kwh/sqm. So, any building having 75% AC area, and having EPI less than 131.25 kwh/sqm. but equals to or more than 117.5 kwh/sqm. that building will be awarded 1-star rating.

In case of hospital buildings, the performance evaluation method is based on a statistical model using regression and distribution analysis. The model is calibrated from sample data from across the nation and focuses on the key drivers of energy consumption including physical, locational, and operational characteristics of hospital. The method compares the energy consumption of a hospital with its benchmark value. The benchmark value represents the average energy consumption of hospitals with similar characteristics and is derived using regression analysis based on sample data.

The ratio of the actual energy consumption of a hospital to its benchmark value depicts the relative energy efficiency of the building. A performance rank is derived by comparing this ratio to a distribution derived from the sample data set. The performance rank lies in the range of 1-100. A rank of one implies performance amongst the top 1% of hospital buildings in the nation, while a rank of 50 represents an average performance. This rank is converted into star labels based on the Table 43:

[43] BEE Schedule for Star Rating of Office Buildings

Table 43: Performance and star rating of hospital buildings[44]

	5 star	4 star	3 star	2 star	1 star	No Star
Performance rank	<= 4	> 4 and <= 12	> 12 and <= 24	> 24 and <= 40	> 40 and <= 60	> 60 and <= 100

In case of shopping mall buildings, performance is measured on the basis of the Energy Performance Index (EPI) in kWh / sqm/ year is considered for rating the building which is calculated as electricity purchased & and generated divided by built-up area in sqm.

For different climate zones, the BEE has developed a bracket of EPIs to star-rated shopping malls.

Table 44: EPI range for shopping malls in different climate zones[45]

Climate zone	EPI for 1 star	EPI for 2 star	EPI for 3 star	EPI for 4 star	EPI for 5 star
Composite	350-300	300-250	250-200	200-150	Below 150
Hot and Dry	300-250	250-200	200-150	150-100	Below 100
Temperate	275-250	250-225	225-200	200-175	Below 175
Warm and Humid	450-400	400-350	350-300	300-250	Below 250

Estimation of energy savings in the year 2022-23

As per the data provided by BEE, there are a total of 279 buildings[46] have been star rated under different categories of buildings as of date (since the start of the program in 2009).

As the star rating is valid for 5 years and 91 buildings had received a star rating from 2018-19 to 2022-23; so, it has been assumed that these buildings have been sustaining the energy savings post the star rating certification. ***Out of these buildings, a total of 15 commercial establishments have received BEE star ratings in FY 2022-23.***

[44] BEE Schedule for Star Rating of hospital buildings
[45] BEE Schedule for Star Rating of shopping mall buildings
[46] Till March 2023

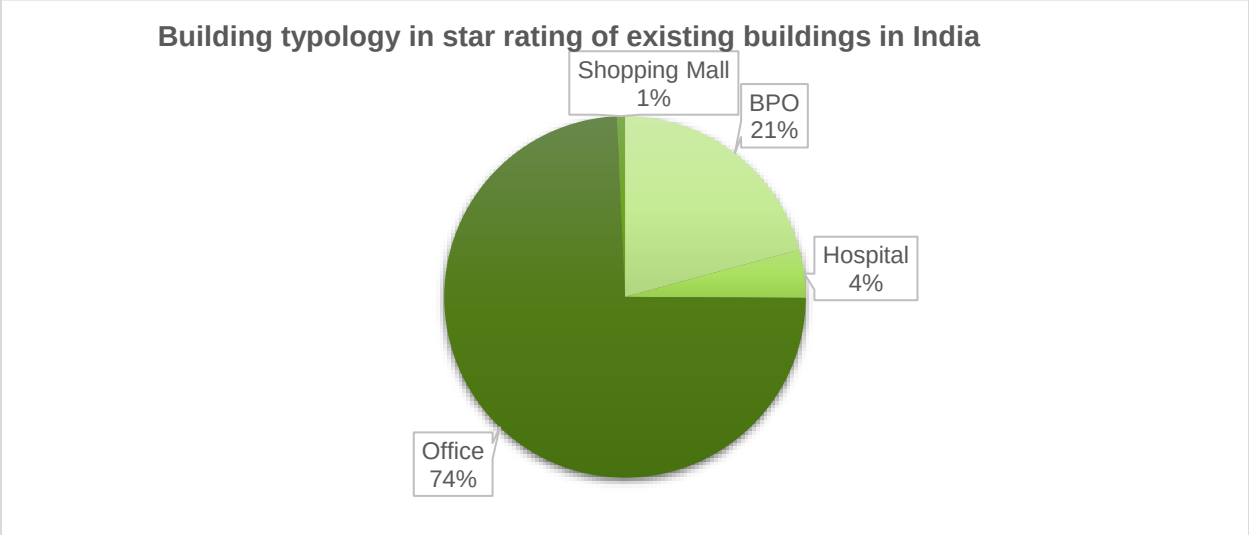


Figure 41: Building typology in star raring of existing buildings in India

On account of the total number of star-rated buildings in the last 5 years, the total energy (electrical) saved by these commercial establishments in the year 2022-23 is 274.47 MU. This has led to a reduction of 0.1949 Tonnes of CO_2. Details are presented in Table 45:

Table 45: Energy-saving summary of Star rating scheme for existing commercial buildings

Building typology	Total energy Saving (MU) in the FY 2022-23	CO_2 Emission Reductions (MntCO2) in the FY 2022-23
Office	105.57	0.0750
BPO	155.6	0.1105
Hospital	4.4	0.0031
Mall	8.9	0.0063
Total	**274.47**	**0.1949**

As the electrical energy savings obtained under this program is mainly due to the replacement of inefficient electrical & mechanical appliances with BEE star-rated electrical and mechanical appliances, therefore, to avoid any duplication, the energy savings of the Star Rating Programme have been already considered under the S&L program. The savings are not counted for the assessment year 2022-23 as the above-mentioned savings have been included in the S&L chapter.

4.4. Star labelling of residential buildings

Over the past few decades, the residential sector in India has witnessed a substantial increase in energy consumption. It is now crucial to construct homes that prioritize energy efficiency to prevent a long-term burden of excessive electricity consumption in residential buildings. This initiative aligns with this objective by introducing an energy-efficient residential labeling system.

The Ministry of Power inaugurated EcoNiwas Samhita 2018 on December 14, 2018, outlining the minimum energy performance standards through the promotion of an energy-efficient building envelope design. The proposed labeling program builds upon the principles of EcoNiwas Samhita 2018 and encourages consumers to engage in the design of more energy-

efficient constructions. Energy labels play a vital role in empowering consumers to make informed decisions by providing direct, reliable, and cost-free information.

The ***objective of this program*** is to introduce the Energy Efficiency Label as an instrument to provide information to users about the energy performance of a residential building and constitute an additional decision tool when carrying out a real estate operation, evaluating a new project or carrying out interventions in existing buildings. The objectives of the proposed labeling program are to provide:

1. Information to consumers on the energy efficiency standard of the Homes
2. A benchmark to compare one home over the other on the energy efficiency standards
3. A consumer-driven market transformation business model solution for Energy Efficiency in the housing sector
4. Steering the construction activities of India towards international best practices norms

Benefits of the program

The proposed labeling program is expected to save a large amount of energy by implementation of energy efficiency measures to residential sector across the nation. The estimated energy-saving potential through the proposed labeling program is around 388 BU by the year 2030 which is greater than the energy consumption in 2016 (250 BU).

In conjunction with this, the program also brings up various ancillary benefits which are the following:

1. The labelling program will create awareness among end users to not use energy efficient appliances but also incorporate energy efficient technology and sustainable building material in their homes which shall create the demand in the market and give enough impetus to suppliers to produce the same.
2. Labeling mechanism and energy efficient technology implementation requires sector expertise in the entire value chain of housing industry and hence labeling regime shall also be a stimulant to the Indian job market.
3. The proposed labeling program also is in sync with “Make in India” policy. As the demand of energy efficient materials will rise, manufacturers will be motivated to invest in sustainable material manufacturing in India
4. Labeling mechanism shall cause a reduction in energy bills. This will empower individuals with a greater disposable income that can be consumed at other avenues, saved for future contingencies, or invested for cash-generating asset creation for the overall economic growth.
5. It helps the nation in working towards the fulfillment of Global Sustainable Development Goals 7 of United Nations: Affordable and Clean Energy The proliferation of energy-efficient houses through the proposed labeling scheme shall increase the rate of energy efficiency.

Level of compliance

There is no minimum requirement with respect to the Area or Connected load (kW) for a building dwelling unit to be covered under this labeling program. The star rating indicator is the Energy performance index (EPI). The EPI calculation in residential buildings is calculated as:

EPI Calculation = EPI for air-conditioned spaces (25% area) with 24 deg C as set point (E1) + EPI for other spaces (75% area) with natural ventilation (E2) set points defined by IMAC with Air conditioner switched ON*[47]

And EPI for other appliances: E3 (constant value)

Where E1 and E2 includes following systems: Building envelope characteristic; Lighting system; and Comfort system (AC), E3 includes appliances such as: Microwave oven, Grinder, Refrigerators, TV, Water Pump, Washing Machine, etc.

Methodology for saving calculation

The BEE will provide an online platform for the User of Label to apply for seeking an award of label under this program. The online platform will consist of a Simulation-Based Tool which will be used to calculate the EPI of the respective dwelling unit. The user will be required to feed in information of the respective dwelling unit in the Tool based on which the Tool will automatically calculate the EPI.

Table 46: Star rating plan for residential building[48]

Residential building star rating plan				
Period: 14 December 2018 to 31 December 2024				
Star rating	EPI (E1 + E2) of dwelling unit			
	Composite	Warm & Humid	Hot and Dry	Temperate
1 – Star	52 < EPI ≤ 60	58 < EPI ≤ 64	55 < EPI ≤ 67	28 < EPI ≤ 31
2 – Star	45 < EPI ≤ 52	49 < EPI ≤ 58	47 < EPI ≤ 55	24 < EPI ≤ 28
3 – Star	37 < EPI ≤ 45	39 < EPI ≤ 49	38 < EPI ≤ 47	21 < EPI ≤ 24
4 – Star	29 < EPI ≤ 37	30 < EPI ≤ 39	29 < EPI ≤ 38	17 < EPI ≤ 21
5 – Star	EPI ≤ 29	EPI ≤ 30	EPI ≤ 29	EPI ≤ 17

In addition to the above, the EPI (E3) for appliances is to be considered in the range 7 to 9.

4.5. Shunya Labelling Programme for Net Zero and Net Positive Energy Buildings

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.

[47] *IMAC refers to India model for adaptive thermal comfort tool assistant developed by CEPT University. IMAC has defined temperature set points for naturally ventilated spaces and these set points have been used for establishing the E2. To achieve these set points air conditioners have been switched ON

[48] Residential building energy labeling program by BEE

Chapter 5:
Standards & Labeling

5. *Standards and Labeling*

Ranked as the world's third-largest energy consumer, India owes this status to the surge in incomes and improved standards of living. Since the year 2000, energy consumption in the country has doubled, with 80% of the demand still reliant on coal, oil, and solid biomass. Despite this, on a per capita basis, both energy use and emissions in India are less than half of the global average. Key indicators such as vehicle ownership, steel production, and cement output also exhibit levels below the world average.

As India rebounds from the economic downturn induced by the COVID-19 pandemic in 2020, it is entering a highly dynamic phase in its energy development. In the upcoming years, millions of Indian households are anticipated to acquire new appliances, air conditioning units, and vehicles. Moreover, India is on the brink of becoming the world's most populous country, adding a population equivalent to a city the size of Los Angeles to its urban centres annually. Addressing the burgeoning electricity demand over the next two decades will require India to expand its power system to an extent comparable to the size of the European Union. According to IEA, through energy efficiency the projected rise in energy demand could be restricted to a mere 82% from 2021 until 2040, preventing an additional 10 exajoules (EJ) of energy consumption. The primary areas for these savings would be the industrial sector (45%) and buildings (30%), with the transport sector following suit.

In this context, the Bureau of Energy Efficiency (BEE) initiated the Standards and Labeling (S&L) program in 2006. The program's objective is to furnish consumers with information regarding energy consumption and the potential cost-saving attributes of labeled appliances. It discerns between high-energy-consuming and efficient end-use equipment and appliances, fostering competitive dynamics to propel the domestic market toward more efficient choices. This program extends beyond specific appliances, encompassing the regulation of information quality, particularly at the point of sale for energy-intensive appliances. The Standards and Labeling program has garnered widespread recognition globally and is now a prevalent tool for promoting energy efficiency.

There are two components under the Standards and Labeling programme:

Standards: Standards establish criteria for the energy consumption or minimum energy efficiency levels of manufactured products. They enable the setting of a defined energy performance for these products, occasionally prohibiting the sale of those falling below a specified efficiency threshold. Standards often include precise test protocols or procedures to obtain an accurate estimate of a product's energy performance, ensuring at least a relative ranking compared to other models.

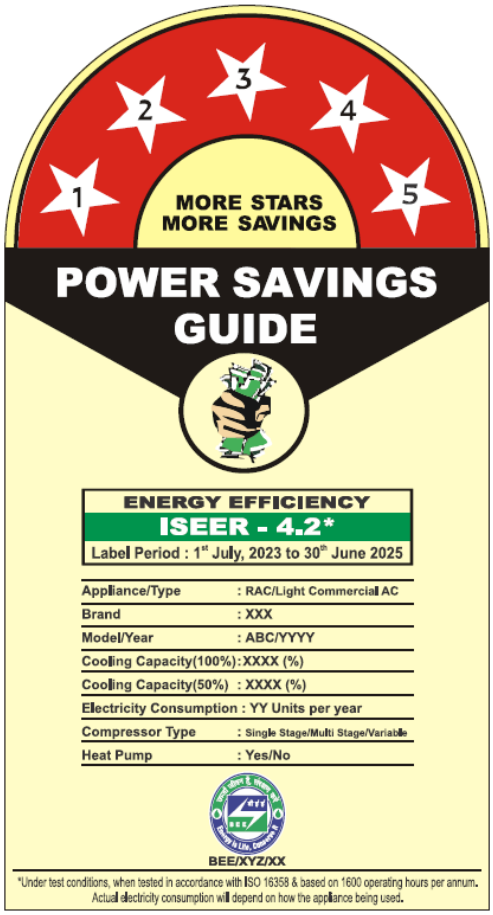
Labeling: Energy efficiency labels are informative labels affixed to products to describe energy performance (usually in the form of energy use or efficiency); these labels give consumers the necessary information to make informed choices in purchases.

There are two types of labels that are issued by BEE for the various appliances. First is a comparative label which allows consumers to compare the energy consumption of similar products, and factor lifetime running cost into their purchasing decision. The other is the endorsement label which provides a 'certification' to inform prospective purchasers that the product is highly energy efficient for its category.

Samples of both labels are illustrated in the figure below:

Figure 42: Energy efficiency labels

Comparative Label



Endorsement Label

The Standards and Labeling (S&L) program commenced by introducing voluntary labels for refrigerators and tubular fluorescent lamps. Over the years, numerous appliances have been progressively included in this initiative. In January 2009, it became obligatory to affix labels on appliances such as room air conditioners, tubular fluorescent lamps, frost-free refrigerators, and distribution transformers. Presently, the scheme encompasses thirty four appliances, with fourteen falling under the mandatory labeling regime, while the remaining twenty operate within the voluntary labeling framework.

In India, the Standards and Labeling (S&L) program operates under a model where the entity obtaining the permit furnishes information about the energy efficiency of the product as stipulated by the Bureau. The Bureau periodically updates the prescribed label information for various products. Products registered with the Bureau receive a star rating ranging from 1 to 5, ascending in order of energy efficiency. The energy performance standards undergo updates every two to three years, leading to the replacement of old, inefficient products with more energy-efficient counterparts. As an illustration, the 5-star air conditioner in 2009 had an ISEER of 3.5, which has significantly improved over the years.

For the labeling program, the Bureau works through technical committees of experts and stakeholders, comprising of representatives from industry, industry association, consumer organizations, academia, Non-Government Organizations (NGOs), Research & Development (R&D) institutions, testing laboratories, government organizations and regulatory bodies etc.

Presently, a 5-star Room Air Conditioner (RAC) must adhere to norms requiring an ISEER of 4.5 or higher.

The scheme as of 31st March 2023, covers 34 appliances under the S&L programme (14 mandatory and 20 voluntary). Details of the appliances are presented in section 5.1.

5.1 Appliances covered under S&L program

The appliances covered[49] are presented in Table 47 below:

Table 47: List of appliances covered under the S&L program as on 31st March 2023[50]

S.No	Appliance Name	Category
1.	Frost Free Refrigerator	Mandatory
2.	Tubular Florescent Lamp (TFL)	Mandatory
3.	Room Air Conditioners (Fixed Speed)	Mandatory
4.	Direct Cool Refrigerator	Mandatory
5.	Distribution Transformer	Mandatory
6.	Color TV	Mandatory
7.	Stationary Storage type Electric Water Heater	Mandatory
8.	Room Air Conditioners (Cassette, Floor Standing)	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.	UHD Color Television	Mandatory
15.	Pump Sets	Voluntary
16.	Induction Motors	Voluntary
17.	Washing Machine	Voluntary
18.	Computer (Notebook/Laptops)	Voluntary
19.	Ballast (Electronic/Magnetic)	Voluntary
20.	Solid State Inverter	Voluntary
21.	Office Equipment's	Voluntary
22.	LPG-Stoves	Voluntary
23.	DG Sets	Voluntary
24.	Diesel Engine Mono-set Pumps	Voluntary

49 Source: https://www.beestarlabel.com/SearchCompare.

S.No	Appliance Name	Category
25.	Chillers	Voluntary
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

5.2 Methodology adopted for saving

The Methodology adopted for the evaluation of the impact of the S&L programme is shown in Figure 43

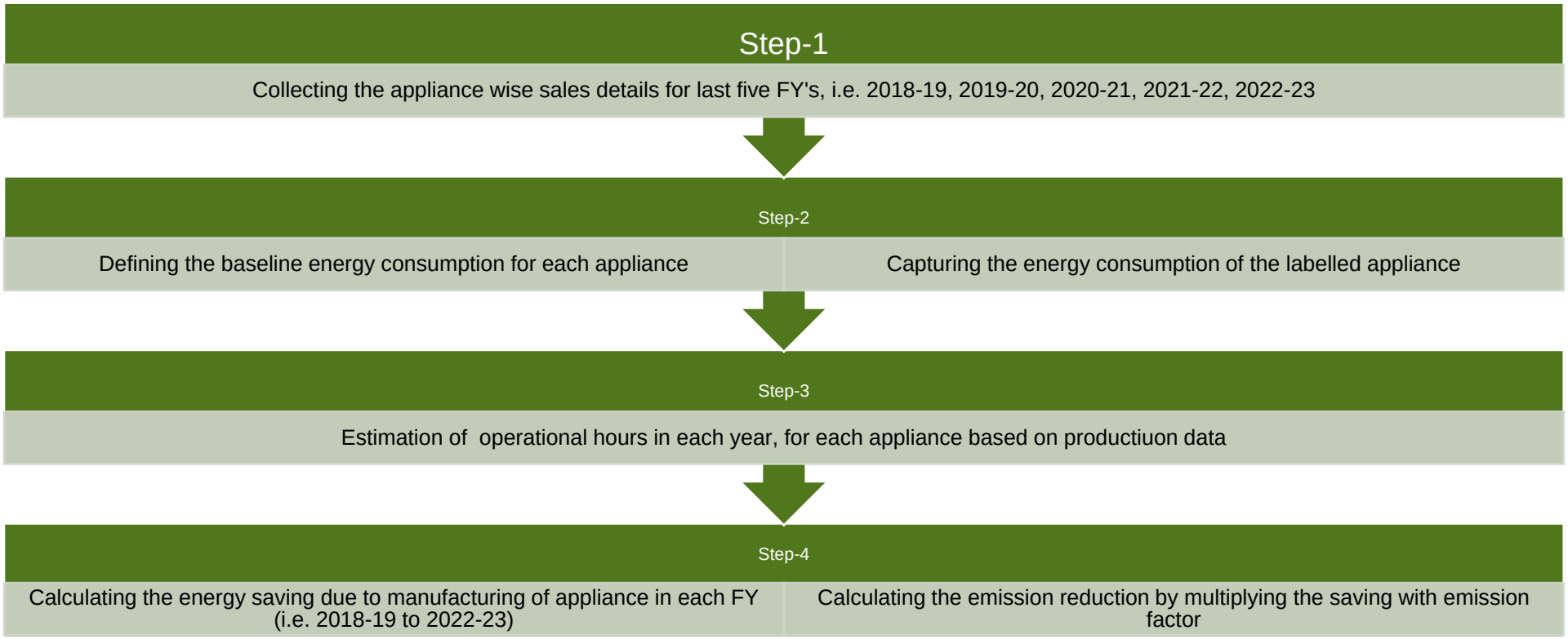


Figure 43: Methodology for impact assessment

*Note: Average life of the appliances is considered as four years, hence energy savings due to the sales of Star labeled appliances from FY 2018-19 to FY 2022-23 are considered while evaluating the impact of the scheme for FY 2022-23 in this report. We have considered inventory as zero at the end of every quarter for energy saving (sales volumes for particular quarter is considered as total appliances manufactured that quarter for estimating the energy saving and emission reduction)

5.3 Estimation of impact from S&L

5.3.1 Step-1: Production Volumes of Star-Labeled Appliances

5.3.1.1 Appliances considered for S&L impact assessment

To evaluate the impact of the S&L programme the production data must be captured for the registered appliances under the S&L program. Till 31st March 2023; 34 appliances were registered under the programme, out of which 21 have significant production volume based on data reported under the programme. For the other 13 appliances, the recorded production volume is presently low, and consequently, the savings accrued due to these appliances is not significant. These appliances are presently included under the voluntary category. A list of the 21 appliances being considered for impact assessment is presented in Table 48:

Table 48: List of appliances covered under the S&L programme for impact assessment[51]

S. No.	Appliance
Mandatory Appliances	
1.	Frost Free Refrigerator
2.	Tubular Florescent Lamp
3.	Room Air Conditioners (Fixed Speed)
4.	Direct Cool Refrigerator
5.	Distribution Transformer
6.	Color TV
7.	Stationary Storage type Electric Water Heater
8.	LED Lamps
9.	Room Air Conditioner (Variable Speed)
10.	Light Commercial AC (Fixed Speed)
11.	Light Commercial AC (Variable Speed)
12.	Ceiling Fans
13.	Deep freezer
Voluntary Appliances	
14.	Pump Set (Submersible)
15.	Microwave Oven
16.	Washing Machine
17.	Computer (Notebook/Laptops)
18.	Open Well Pump
19.	LPG-Stoves
20.	Mono-set Pumps
21.	Chillers

[51] For this study, 'Room Air conditioner (fixed speed)' and 'Room Air Conditioner (Cassettes, Floor Standing Fixed speed)' is taken as one item under the head of fixed speed air conditioner

5.3.1.2 Production Volumes of the appliances for the respective FY (2018-19 to 2022-23)

The star-wise production figures of both mandatory and voluntary appliances, which are considered for the study, for the current FY 2022-23 is showcased in the table below:

Table 49: Star-wise production figures of appliances (FY 2022 – 23)

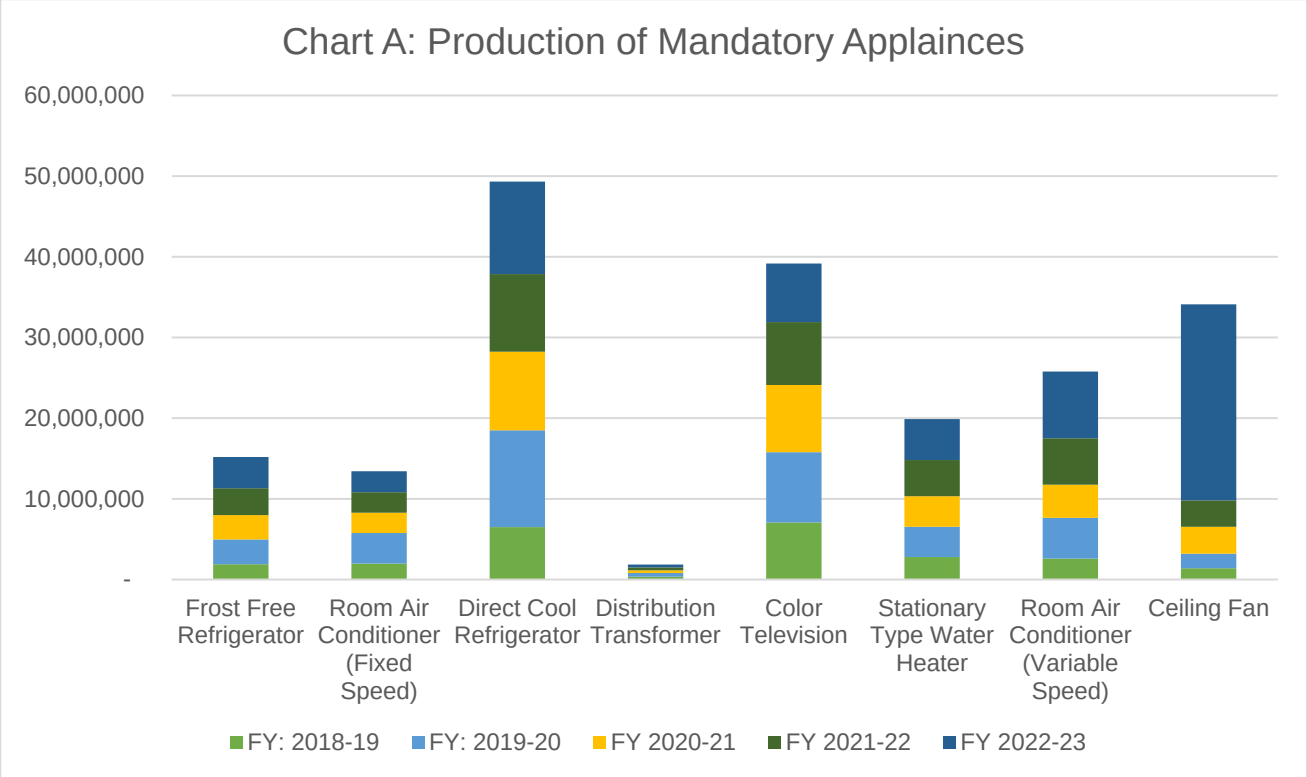
S.No	Appliance	5 Star	4 Star	3 Star	2 Star	1 Star	Total Sales
1	Frost Free Refrigerator	-	8,360	1,087,921	2,673,020	97,368	3,866,669
2	Tubular Fluorescent Lamps	-	-	1,089,177	-	22,863,918	23,953,095
3	Room Air Conditioners (RAC) Fixed Speed	52,255	61,272	1,777,179	585,039	124,755	2,600,500
4	Direct Cool Refrigerator	985,429	988,963	3,705,094	3,256,843	2,528,319	11,464,648
5	Distribution Transformer (DT)	25,802	19	1	137,393	193,632	356,847
6	Color Television	69,880	525,329	1,663,723	2,846,640	2,156,717	7,262,289
7	Stationary Storage Type Electric Water Heater (Geyser)	2,057,906	1,985,900	971,431	61,165	3,857	5,080,059
8	Air Conditioners Variable Speed	2,405,487	866,293	4,842,332	150,204	341	8,264,657
9	LED Lamps	103,840	266,010	210,827,925	228,899,805	24,817,416	464,914,996
10	Submersible Pump sets	174,858	155,588	200,875	70,027	40,793	642,141
11	Open well pump sets	195,905	72,072	28,833	34,969	6,653	338,432
12	Ceiling Fans	4,622,297	8,675	160,845	763,251	18,758,796	24,313,864
13	Washing Machine (Semi / Top Load / Front Load)	9,513,792	-	295,400	-	-	9,809,192
14	Computer	-	-	-	-	-	-
15	Domestic Liquefied Petroleum Gas (LPG) Stoves	-	-	-	45,311	412,693	458,004
16	Monoset Pumps	13,589	798	31,526	10,122	621	56,656
17	Chillers	2	9	41	3	-	55
18	Deep freezer	168,064	27,492	59,769	-	-	255,325
19	Light commercial AC (Fixed Speed)	-	-	-	2,804	1,614	4,418
20	Light commercial AC (Variable Speed)	12,300	689	8,031	6,323	-	27,343
21	Microwave Oven	-	-	-	6,296	-	6,296
	Total	**20,389,106**	**4,966,780**	**226,742,072**	**239,536,596**	**72,007,493**	**563,642,047**

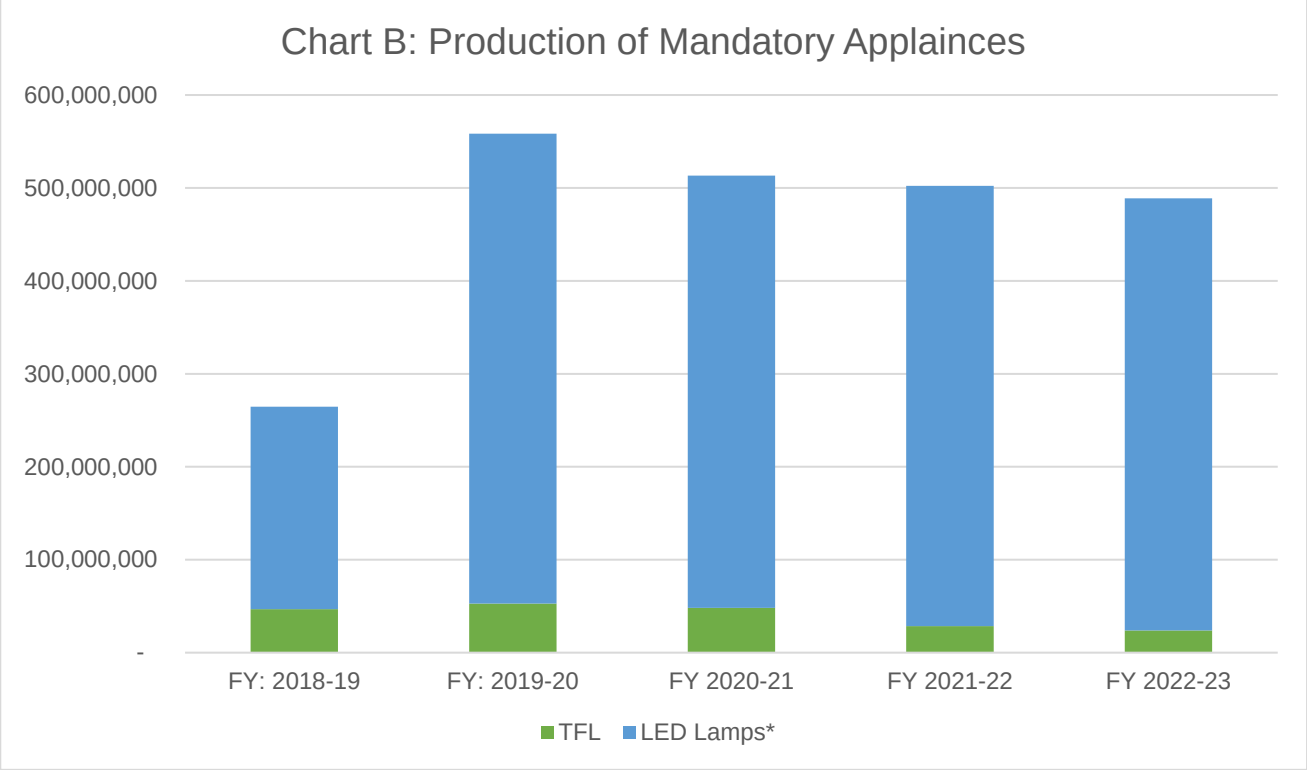
The consolidated production data of the appliances for the FY 2018-23, is presented in the table below:

Table 50: Production figures for appliances (FY 2018 – 23)

S.No	Appliances	FY: 2018-19	FY: 2019-20	FY 2020-21	FY 2021-22	FY 2022-23	Total in Millions
	Mandatory Appliances						
1	Frost Free Refrigerator	1,889,699	3,074,275	3,017,997	3,334,463	3,866,669	15.18
2	TFL	46,788,668	52,775,743	48,189,268	28,515,378	23,953,095	200.22
3	Room Air Conditioner (Fixed Speed)	1,968,651	3,797,043	2,511,348	2,543,997	2,600,500	13.42
4	Direct Cool Refrigerator	6,505,927	11,998,899	9,732,127	9,619,339	11,464,648	49.32
5	Distribution Transformer	344,246	464,389	338,115	355,950	356,847	1.86
6	Color Television	7,074,736	8,703,395	8,335,140	7,789,678	7,262,289	39.17
7	Stationary Type Water Heater	2,800,464	3,736,438	3,800,519	4,467,931	5,080,249	19.89
8	Room Air Conditioner (Variable Speed)	2,599,737	5,050,951	4,113,958	5,749,914	8,264,657	25.78
9	LED Lamps*	217,801,423	505,633,490	465,096,423	473,775,891	464,914,996	2,127.22
10	Ceiling Fan	1,412,061	1,795,718	3,323,670	3,275,211	24,313,864	34.12
11	Deep freezer	0	0	0	86,754	255,325	0.34
12	Light Commercial AC (Fixed Speed)	0	0	0	5,824	4,418	0.01
13	Light Commercial AC (Variable Speed)	0	0	0		27,343	0.03
	Total Mandatory Sales	**289.19**	**597.03**	**548.46**	**539.52**	**552.36**	**2,526.56**
	Voluntary Appliances						
14	Submersible Pump set	767,215	737,893	415,943	640,780	642,141	3.20
15	Open well pumps	193,012	299,188	176,582	254,367	338,432	1.26
16	Microwave Oven				13464	6,296	0.02
17	Washing Machine	-	1,791,020	6,681,960	8,790,055	9,809,192	27.07
18	Computer	-	-	330	-	-	0.00
19	Domestic LPG Stoves	821,804	1,326,632	1,213,959	990,824	458,004	4.81
20	Monoset Pump	57,246	70,835	48,200	65,290	56,656	0.30
21	Chiller		18	5	9	55	0.00
	Total Voluntary Sales	**1.84**	**4.23**	**8.54**	**10.75**	**11.31**	**36.67**

With reference to the data provided in the above table, the production figures for each mandatory and voluntary appliance for the FY 2018-23 are showcased in the figures below:





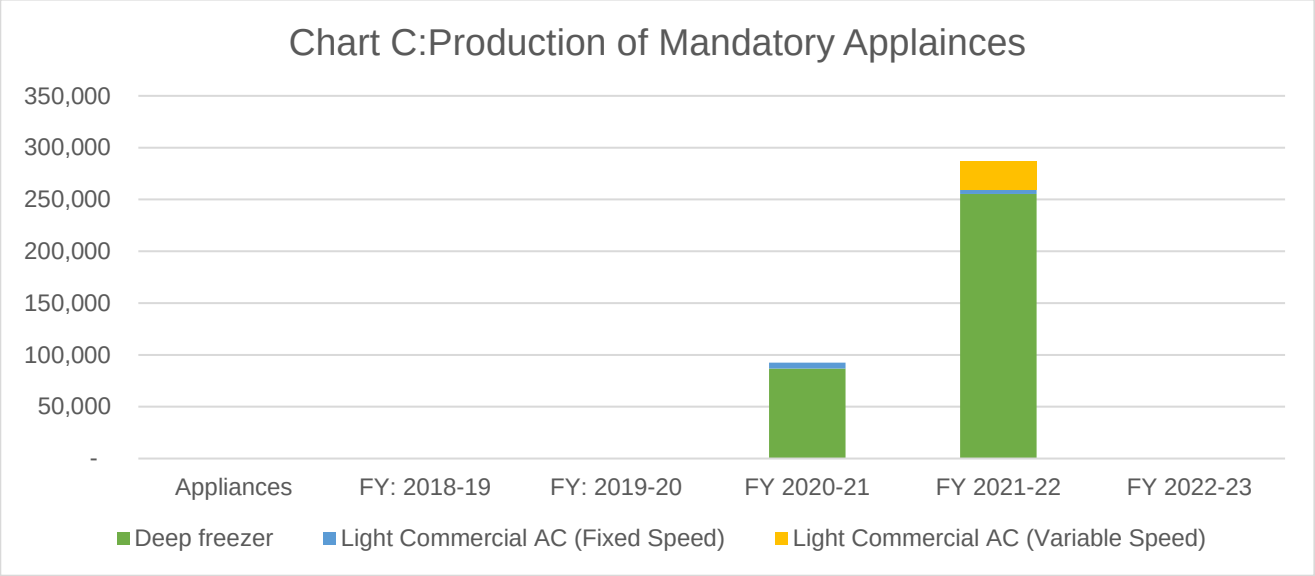
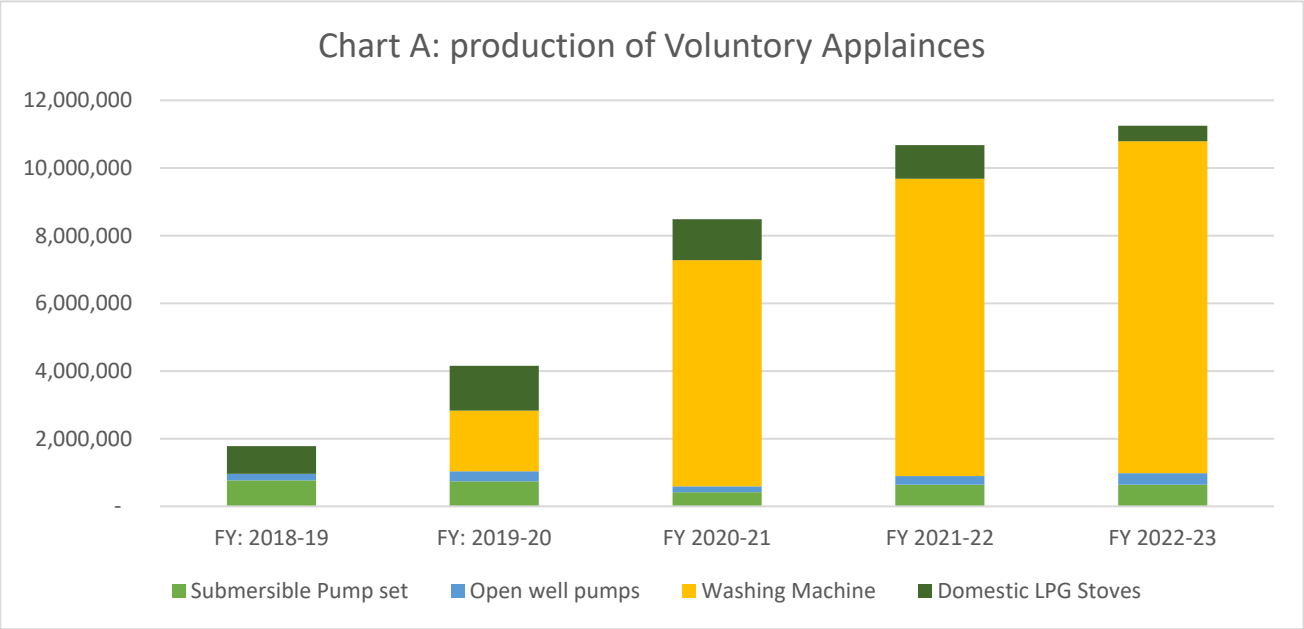


Figure 44: Production volume of mandatory appliances in FY 2018-23



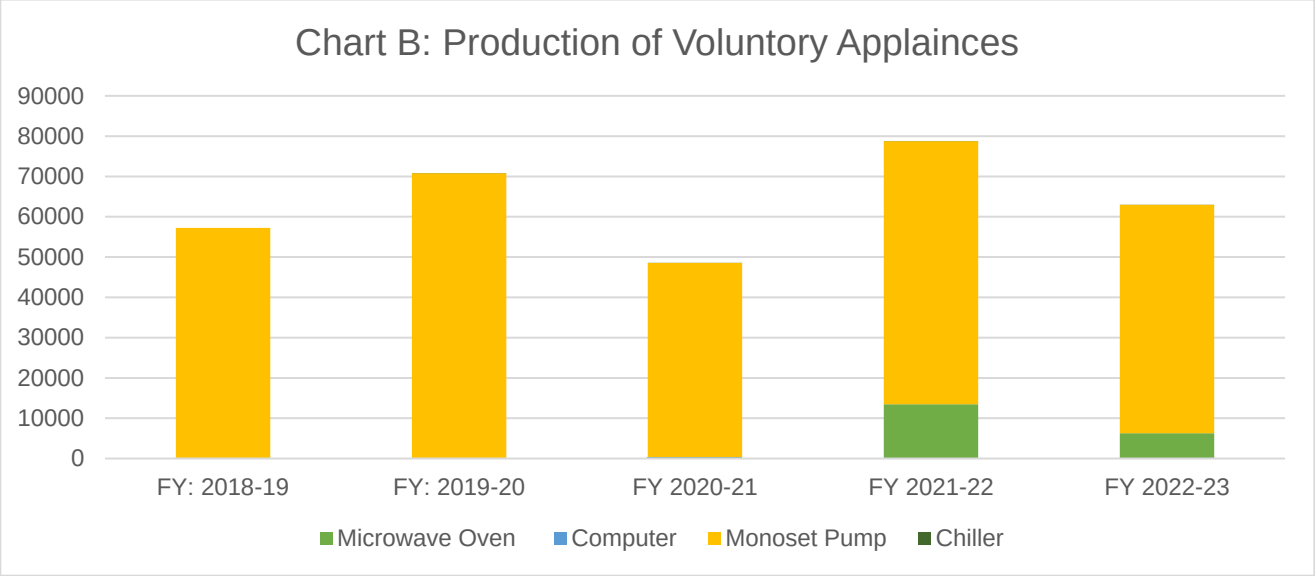
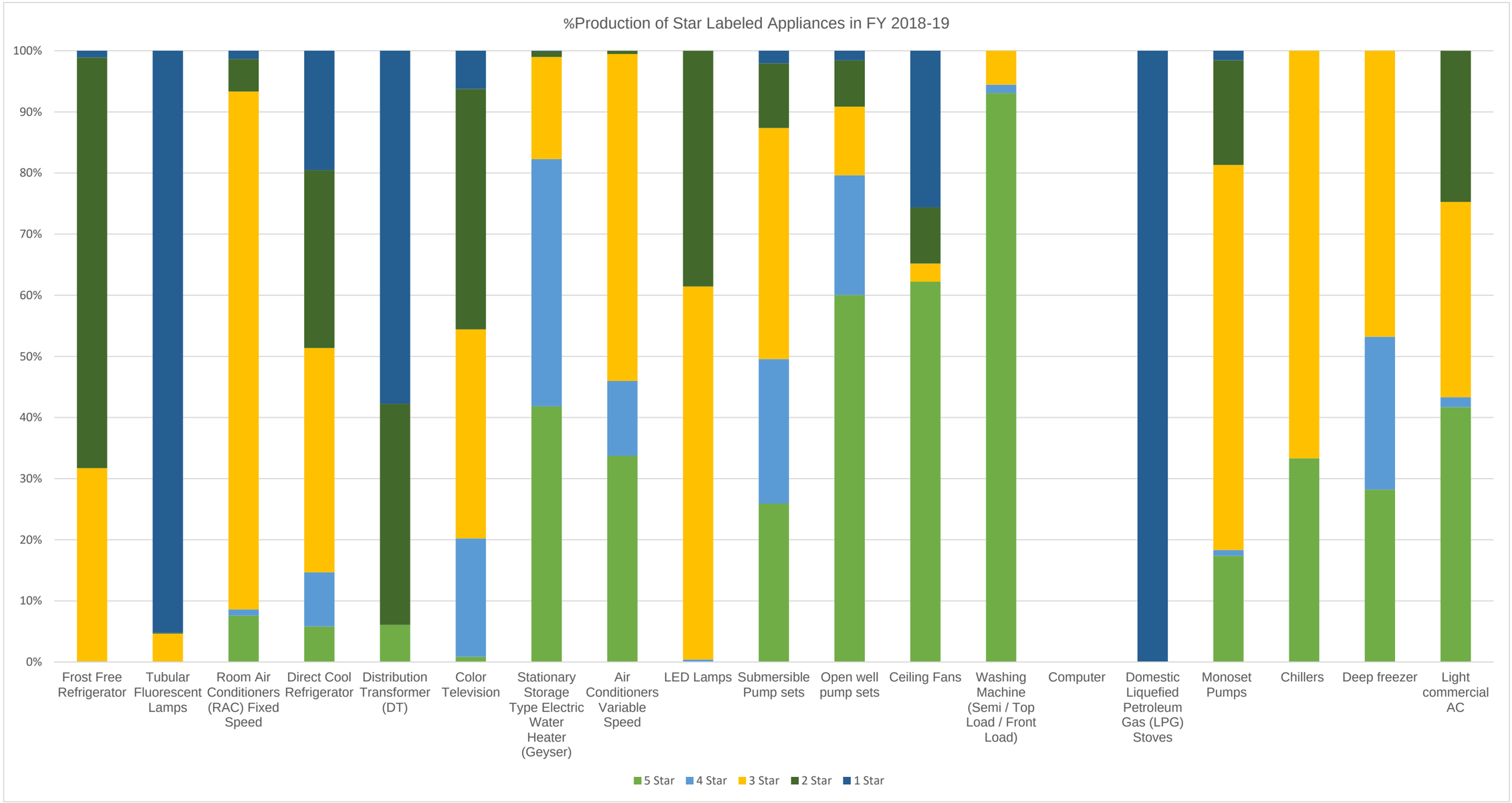


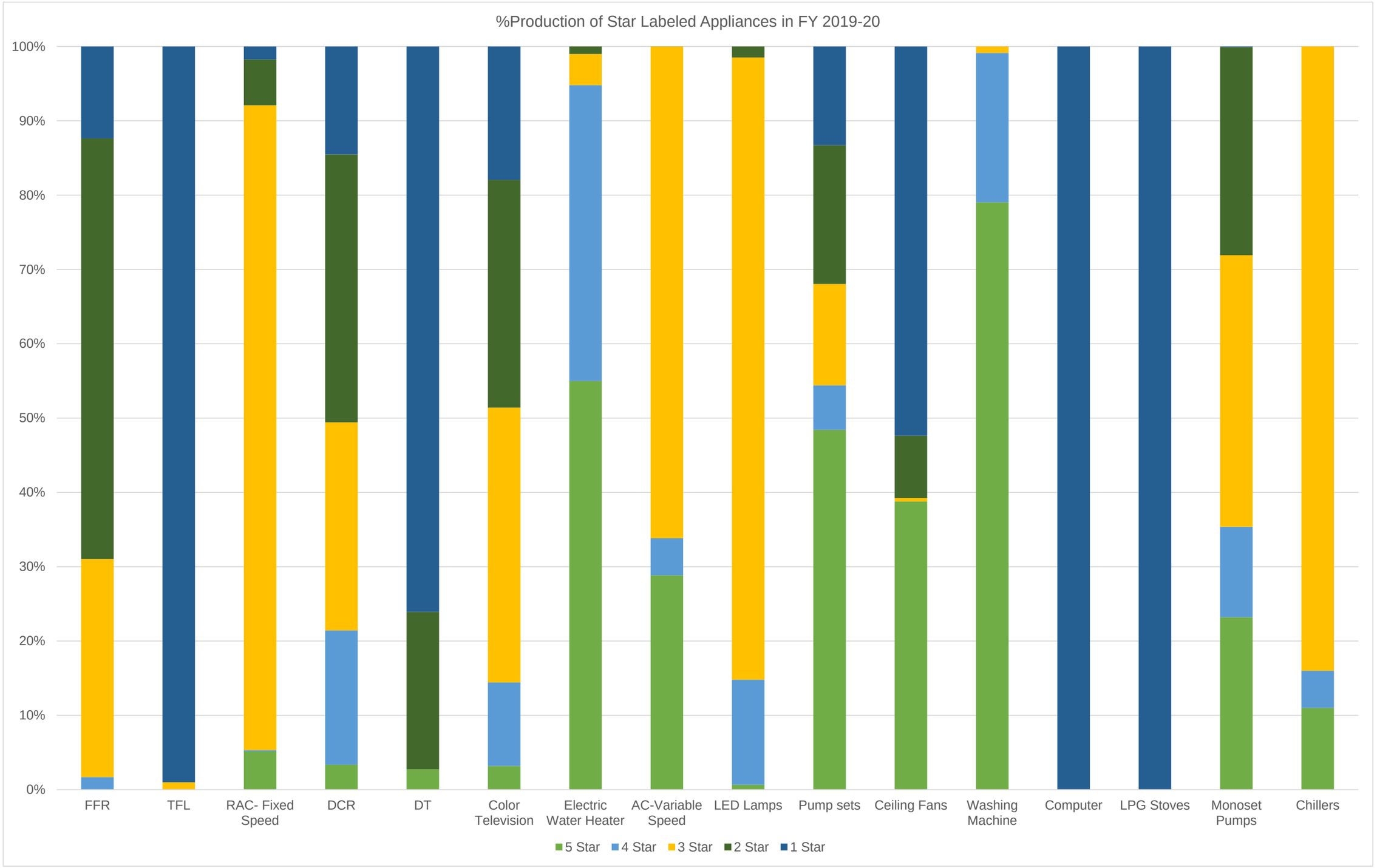
Figure 45: Production volume of voluntary appliances 2018 -23

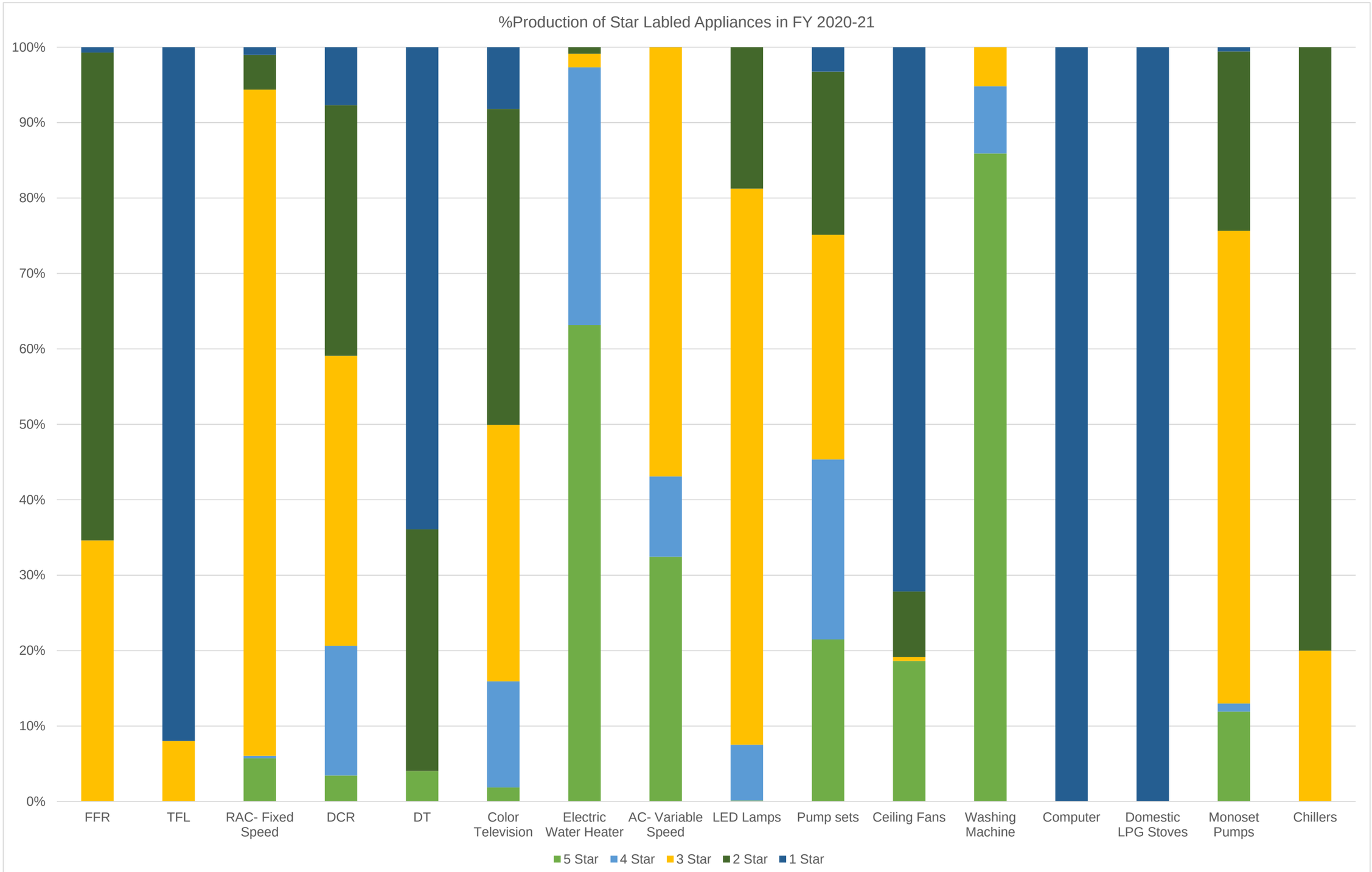
The conclusions drawn from the data represented in Figures 45 and 46 pertaining to the production volumes of appliances are as follows:

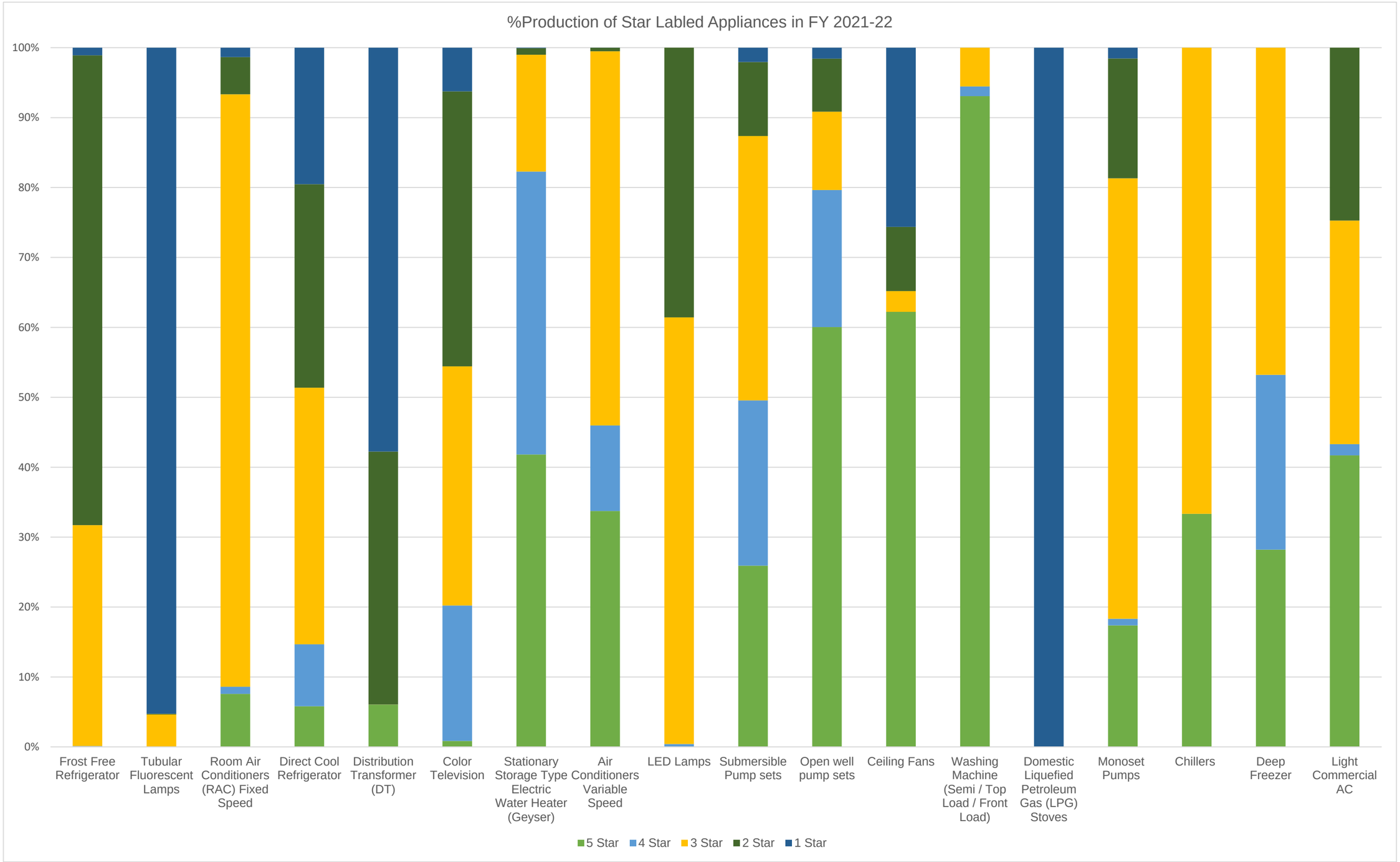
1. Among the mandatory appliances, the production peaked for LED lamps and Tubular Fluorescent Lamps, indicating a substantial demand for these energy-efficient lighting solutions.
2. In contrast, for voluntary appliances, the highest production was observed in washing machines, followed by ceiling fans and domestic LPG stoves during the fiscal years 2019-23. This suggests a notable consumer preference for these particular voluntary appliances, showcasing the diverse market dynamics and consumer choices in this period. The prominence of washing machines indicates a significant emphasis on household convenience and cleanliness, while the popularity of ceiling fans and domestic LPG stoves underscores the importance of comfort and domestic energy solutions in consumer preferences during this timeframe.

The consolidated year wise percentage production figures for mandatory and voluntary appliance (considered for the study) for each FY from 2018 to 2023 are showcased in the figures below:




%Production of Star Labeled Appliances in FY 2019-20
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
FFR
TFL
RAC- Fixed Speed
DCR
DT
Color Television
Electric Water Heater
AC-Variable Speed
LED Lamps
Pump sets
Ceiling Fans
Washing Machine
Computer
LPG Stoves
Monoset Pumps
Chillers
5 Star
4 Star
3 Star
2 Star
1 Star


%Production of Star Labled Appliances in FY 2020-21
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
FFR
TFL
RAC- Fixed Speed
DCR
DT
Color Television
Electric Water Heater
AC- Variable Speed
LED Lamps
Pump sets
Ceiling Fans
Washing Machine
Computer
Domestic LPG Stoves
Monoset Pumps
Chillers
5 Star
4 Star
3 Star
2 Star
1 Star


%Production of Star Labled Appliances in FY 2021-22
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frost Free Refrigerator
Tubular Fluorescent Lamps
Room Air Conditioners (RAC) Fixed Speed
Direct Cool Refrigerator
Distribution Transformer (DT)
Color Television
Stationary Storage Type Electric Water Heater (Geyser)
Air Conditioners Variable Speed
LED Lamps
Submersible Pump sets
Open well pump sets
Ceiling Fans
Washing Machine (Semi / Top Load / Front Load)
Domestic Liquefied Petroleum Gas (LPG) Stoves
Monoset Pumps
Chillers
Deep Freezer
Light Commercial AC
5 Star
4 Star
3 Star
2 Star
1 Star

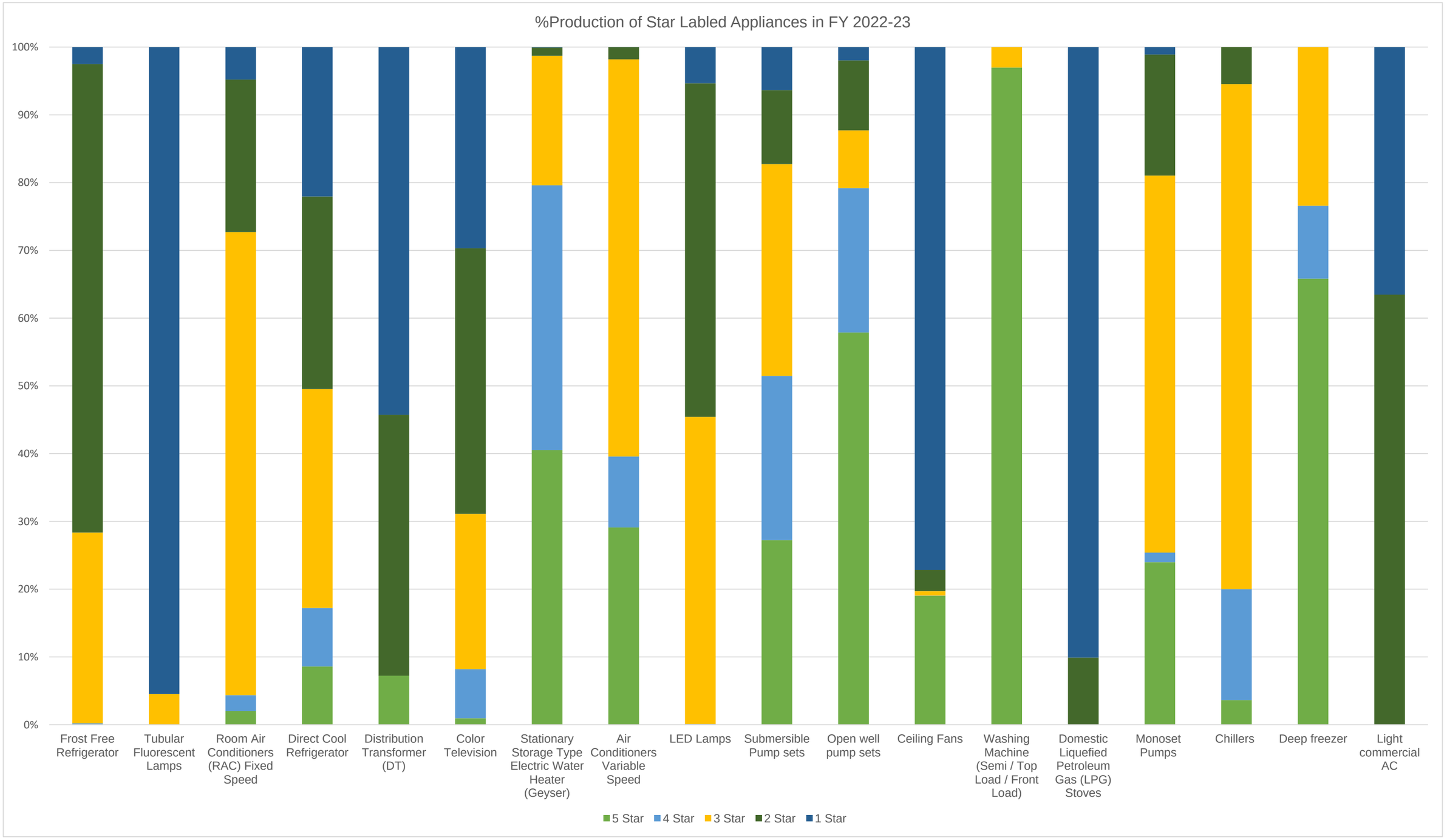


Figure 46: Production as % of total Production for different appliances for the FY 2018-23

It can be inferred from the above analysis that:

1. During the FY 2022-23, the highest percentage of appliances labeled with 5 stars pertains to washing machines, with deep freezers, open well pump sets, and electric water heaters following closely behind. This indicates a noteworthy emphasis on energy-efficient features in the manufacturing of washing machines during this period.
2. In the FY 2022-23, the largest percentage of appliances labeled with just 1 star includes TFL (Tubular Fluorescent Lamp), with domestic LPG stoves, ceiling fans, and distribution transformers ranking subsequently. This suggests that, within the 1-star category, TFL appliances were particularly prevalent in the market, potentially influencing consumer choices and manufacturing trends.
3. The sales data for the fiscal year 2022-23 highlights a distinct trend in the popularity of appliances based on their star ratings. The highest number of units sold corresponds to 2-star labeled appliances, followed sequentially by 3-star, 1-star, 5-star, and 4-star appliances. This information provides valuable insights into consumer preferences and purchasing patterns, indicating a significant demand for appliances with moderate energy efficiency, as reflected in the prevalence of 2-star rated products in the market.

5.3.2Step-2: Defining the baseline

For evaluation of the energy savings, defining of the energy consumption baseline is very crucial for the appliances under consideration. Savings of each appliance is evaluated using the following formula:

Annual Energy Savings = (Baseline Value- Actual Value) x Production *x Operating hours x (1-T&D losses)*

Details of baseline energy consumption for different appliances are presented in Table 51.

Table 51: Baseline energy consumption for appliances

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard
1.	Frost Free Refrigerator	Annual Energy consumption (kWh)	759 + adjusted volume*0.8716
2.	Tubular Fluorescent Lamps	Lumen /Watt	61
3.	Room Air Conditioners (RAC)	ISEER	2.3
4.	RAC (Cassette, Floor Standing Tower, Ceiling, Corner AC)	ISEER	2.3
5.	Distribution Transformer (DT)	Maximum loss at 50% and 100% of the loading	Base energy consumption is measured by the % loss corresponding to specific

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard
			rating (in kVA) of transformers and operational voltage (V of primary incomer)
6.	Direct Cool Refrigerator	Annual Energy Consumption (kWh)	561 + adjusted volume*0.645
7.	Stationary Storage Type Electric Water Heater (Geyser)	Standing energy loss in 24 hours (%)	Baseline energy consumption Matrix
8.	Color Television	Annual Energy consumption (kWh)	0.1494 * screen area in m^2 + 4.38
9.	Room Air Conditioners (Variable Speed)	ISEER	3.1 for Split AC 2.5 for Window AC
10.	LED Lamps	Lumen /Watt	79
11.	Induction Motors	Efficiency (%)	IE2
12.	Agricultural Pump sets	Performance factor	IS 14220 for Open well, IS8034 for Submersible pump set, IS9079 for moonset pump sets
13.	Ceiling Fans	Service value	3.1
14.	Domestic Liquefied Petroleum Gas (LPG) Stoves	Thermal Efficiency (%)	68%
15.	**a)** Washing Machine (Front loaders (drum type))	kWh/kg/cycle	0.18
	b) Washing Machine (Top loaders & semi-automatic machines)	kWh/kg/cycle	0.0185
16.	Computer (Notebook/Laptops)	Endorsement	
17.	Ballast (Electronic/Magnetic)	Ballast Efficiency Class	B1
18.	Office equipment (printer, copier, scanners)	Endorsement	
19.	Solid State Inverter	Efficiency Range	83%
20.	Microwave Oven	Energy consumption per cycle (Wh)	60 Wh/cycle
21.	Diesel Pump sets	Specific Fuel Consumption (g/h/m/l/s)	1
22.	Diesel Generator	Specific Fuel Consumption (g/kWh)	336
23.	a) Chillers (Air cooled)	ISEER	3 - 3.1 (Matrix)
	b) Chillers (Water cooled)	ISEER	4.8 - 6 (Matrix)
24.	Solar Water Heaters	Efficiency	40%
25.	Light Commercial Air conditioners	ISEER	2.7

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard
26.	Deep freezers	Annual Energy Consumption(kWh)	5.07*V + 151.98 (Hard Top) 9.21*V+613.4 (Glass Top)
27.	Air Compressor	Isentropic Efficiency (%)	44 ≤ ηisen < 50
28.	UHD TV	Annual Energy Consumption(kWh)	0.0325*A + 6.226
29.	High-Energy Lithium-Ion Traction Battery Packs and Systems	Energy efficiency for specified Delta SoCs at each standard discharge	85%
30.	Tires	Rolling Resistance Coefficient	12.6
31.	Induction Hob	Energy Consumption	200
32.	Pedestal fan	Service Value	0.75
33.	Table/Wall Fan	Service value	0.50
34.	Side by Side/Multi Door Refrigerator	Annual Energy Consumption	0.746* Total Volume + 201

5.3.3 Step-3: Defining the operating hours

Energy saving for the appliances covered in the S&L Programme in the FY 2022-23[52]

$$Energy\ Savings = \{Annual\ Energy\ consumption\ by\ appliance\ as\ defined\ by\ baseline\ (kWh) - Annual\ energy\ consumption\ of\ star\ rated\ appliance\ (kWh)\} * number\ of\ respective\ star - labeled\ appliances\ produced\ during\ the\ FY\ 2018-23 * annual\ operational\ hours\ of\ the\ appliance\ as\ defined\ under\ the\ S\&L\ program$$

Energy saving for the FY 2022-23 is calculated considering the production of the appliance on quarterly basis. For example, if Variable AC is having the 1600 annual operation hours, appliance manufactured in Q1 can be operated for 100% of the operational hours i.e. 1600 hours, and if appliance is manufactured in Q2, then appliance can operate to max of 75% of the available operation hours i.e. 1125 hours; if appliance is manufactured in Q3 then it can only work for 50% of the annual operation hours for that FY i.e. 750 hours; and if manufacturing occurs in Q4 then appliance can only work for 25% of operation hours during that particular FY i.e. 375 hours.

Assuming a 4-year or 16-quarter lifespan for the appliance, our analysis takes into account 100% of the operational hours for appliances sold in fiscal years 2019-20, 2020-21, and 2021-22. It is essential to highlight that, for the fiscal year 2018-19, appliances sold in Q1 have already completed their average lifespan by FY 2022-23. Consequently, the energy savings associated with these Q1 appliances in FY 2018-19 are not included in this year's calculations.

Similarly, appliances sold in Q2 of FY 2018-19 operated for 15 quarters within the 2018-23 timeframe, with one quarter of their average lifespan remaining. As a result, appliances

[52] Annual operating hours are considered as the appliances manufactured before the 1st April 2021 will operate for 100% hours as defined under the S&L guidelines

from Q2 of FY 2018-19 only contributed 25% of total annual running hours, e.g., 8760 in FY 2022-23, and consequently, their contribution to total energy savings in FY 2022-23 is also limited to 25%.

For appliances sold in Q3 and Q4 of FY 2018-19, they operated at full capacity from 2019-22. Despite this, they still have 2 and 3 quarters of their 4-year lifespan left, respectively. Consequently, appliances from Q3 and Q4 of FY 2018-19 only accounted for 50% and 75% of the total annual hours in FY 2022-23. Correspondingly, their contribution to energy savings is proportionate, standing at 50% and 75% of their running hours, respectively, in FY 2022-23.

Accordingly, the contribution of appliances to savings will vary proportionality. Details of the operation hours for the different appliance is defined in the table below:

Table 52: Annual operation hours for appliance

S.No	Appliance	Annual operation hours [53]
1.	Frost Free Refrigerator	8760
2.	Tubular Fluorescent Lamp	1200
3.	Room Air Conditioners (RAC)	1600
4.	Distribution Transformer	8760
5.	Direct Cool Refrigerator	8760
6.	Electric Geyser/ Stationary water heater	6000
7.	Color Television[54]	6570
8.	Variable Capacity Air Conditioner	1600
9.	LED Lamp	1200
10.	Pump set	2000
11.	Ceiling Fan	3600
12.	Domestic LPG stove	730
13.	Chillers	4000
14.	Washing machine	220 Cycles per year
15.	Domestic LPG stove	730
16.	Deep Freezer	8760
17.	Light Commercial AC	1600

[53] https://beeindia.gov.in/content/standards-labeling
[54] Note: For Color Television 6 Hours has been considered as operating daily hours of television, while 12 hours considered for Standby Active Low mode on daily use

5.3.4 Step 4: Estimation of the energy savings and emission reduction

Energy saving for each appliance is calculated using the formula defined in Step 2 and operating hours defined in Step 3. Energy savings for the different appliances is presented in the table below:

Table 53: Energy Savings in the FY 22-23 from the appliances covered under S&L programme [55]

S.NO	Appliance	Total Savings (MU)	Monetary Savings (Rs Millions)
1	Frost Free Refrigerator	10122	63669.67
2	TFL	958	6028.95
3	Room Air Conditioner (Fixed Speed)	6093	38323.26
4	Direct Cool Refrigerator	20465	128724.7
5	Distribution Transformer	2671	16798.6
6	Color Television	13437	84521.25
7	Stationary Type Water Heater	2947	18538.51
8	Room Air Conditioner (Variable Speed)	7931	49888.16
9	LED Lamps*	5229	32890.44
10	Ceiling Fan	1628	10240.97
11	Deep Freezer	480	3016.63
12	Light Commercial AC (Fixed Speed)	4	22.71
13	Light Commercial AC (Variable Speed)	7	44.04
14	Submersible Pump set	5232	32907.58
15	Open well pumps	1835	11544.16
16	Washing Machine	1604	10086.62
17	Computer	0	0
18	Mono-set Pump	202	1268.78
19	Chiller	15	93.13
20	Microwave Oven	0.03	0.17
Total Energy Savings (BU) and Monetary Savings (Rs. Millions)		**80.86**	**508.61**

[55] Energy savings attributed to the sale of 76.87 million LEDs are factored into the calculations within the UJALA program for the FY 2018-23. To prevent any duplication of calculations, the savings derived from the UJALA initiative are subtracted from the LED savings associated with the S&L program for the FY 2022-23. This approach is adopted to avoid redundancy, ensuring accuracy in the assessment of energy conservation. The total discounted energy savings for LEDs amounting to 866.96 million units (MU) due to sales of LEDs under UJALA program. This thorough methodology serves to eliminate the risk of double counting and provides a reliable foundation for evaluating the overall impact of energy-efficient measures during the specified period. Similar approach is used for emission calculations

** Unit cost is taken as Rs 6.29/kWh

An example of calculation demonstrating the energy savings achieved for each appliance, including both mandatory and voluntary ones, is outlined in the annexure for clarity.

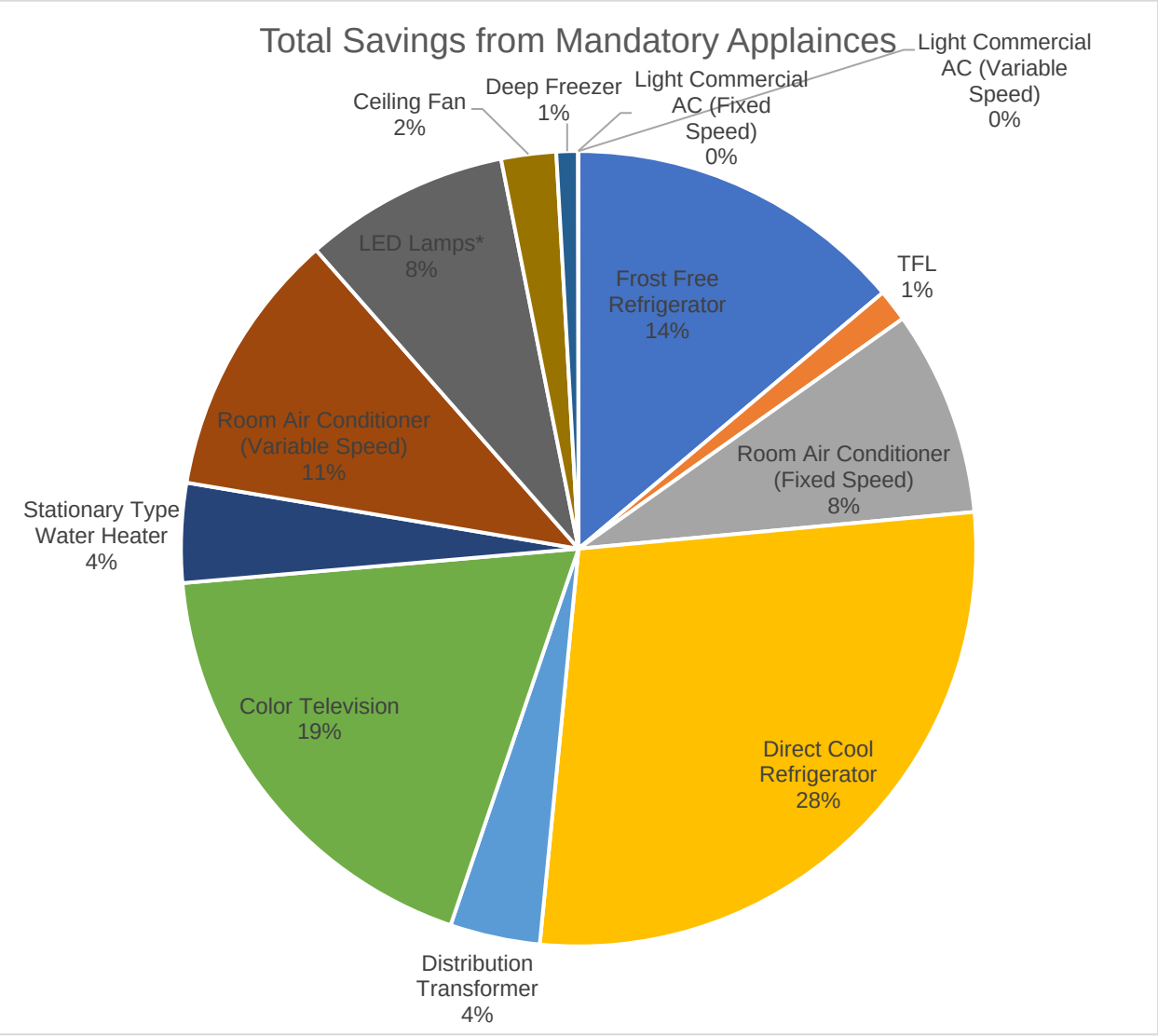
These electrical savings don't include savings incurred due to LPG stove, as the fuel consumed by the domestic stove is LPG, the energy savings achieved due to improving energy efficiency in the appliances is in the form of thermal energy. Accordingly, thermal energy saved in domestic LPG stoves is presented in Table 54 below:

Table 54: Thermal Energy saving due to production of Domestic LPG stoves in the FY 2022-23

FY 2022-23	Total (TOE)	Monetary Savings (Billion Rs.)
Total Thermal Energy savings	18419	0.338

S&L programme has led to savings of 81.64 BU and 18,419 toe during 2022-23 and annual savings of Rs 508.94 Billion

The energy savings from each appliance considered in the study (both mandatory and voluntary), is showcased in the form of a pie chart below:



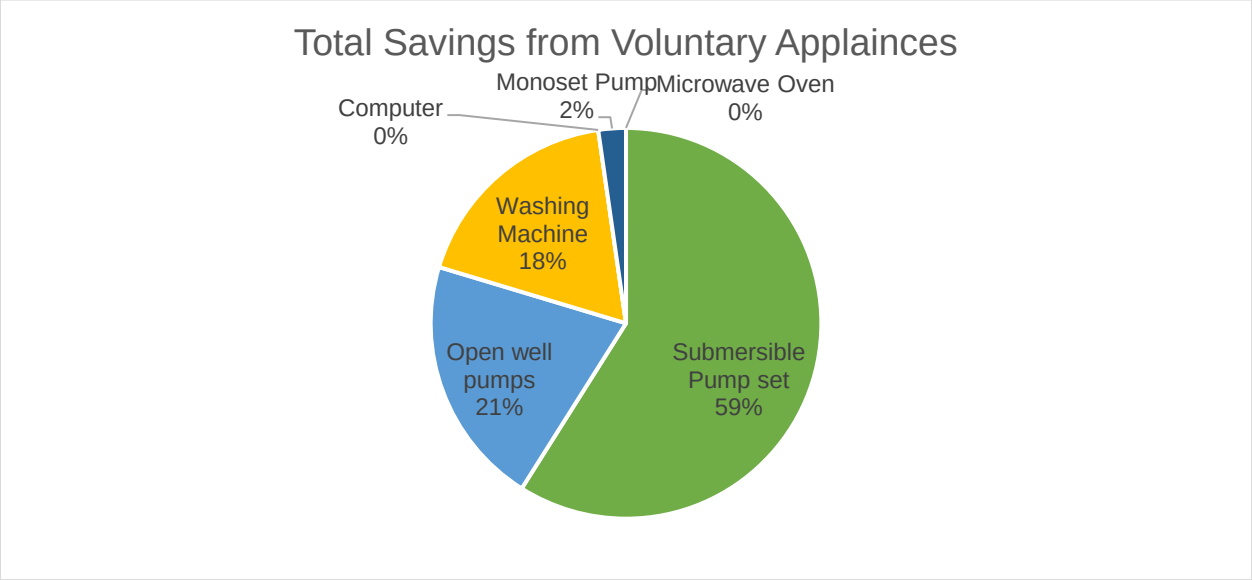


Figure 47: Energy savings analysis for mandatory and voluntary appliances in the FY 2022-23

It can be inferred from the figure above that Direct Cool Refrigerator (28%) followed by Color Television (19%) and Frost Free Refrigerator (14%), contributed to 61% of the total energy savings due to star rated appliances under S&L programme.

Summary of the emission reduction is tabulated in Table 55[56]

Table 55 : Annual Emission reduction (MntCO2) in the FY 2022-23 due to S&L programme

S.No	Appliances	Total Savings (MntCO2)
1.	Frost Free Refrigerator	7.187
2.	TFL	0.681
3.	Room Air Conditioner (Fixed Speed)	4.326
4.	Direct Cool Refrigerator	14.530
5.	Distribution Transformer	1.896
6.	Color Television	9.541
7.	Stationary Type Water Heater	2.093
8.	Room Air Conditioner (Variable Speed)	5.631
9.	LED Lamps*	3.713
10.	Ceiling Fan	1.156
11.	Deep Freezer	0.341
12.	Light Commercial AC (FS)	0.003
13.	Light Commercial AC (VS)	0.005
14.	Submersible Pump set	3.715
15.	Open well pumps	1.303
16.	Washing Machine	1.139
17.	Computer	0.000
18.	Monoset Pump	0.143
19.	Chiller	0.011
20.	LPG Stove (TOE)	0.049
21.	Microwave Oven	0.00
Total Savings (MntCO2)		**57.46**

[56] Note: Emission reduction by the initiatives under the programme is evaluated considering the grid emission factor of 0.71 kg of CO2 emission reductions per kWh of the energy saved and for LPG stove the emission factor was taken as 2.984 kg of CO2 per kg of LPG saved.

Total CO_2 emission savings achieved by S&L program, as showcased in the Table 55, for the FY 2022-23:

S&L programme has led to reduction of 57.46 Mn tonne of carbon dioxide emissions during FY 2022-23 due to interventions carried out during this fiscal year.

Energy Efficiency initiatives by EESL

Apart from the energy efficiency initiative taken by BEE, EESL has also taken several Energy Efficiency initiatives some of which are

Super - Efficient Air Conditioner (SEAC) Program

With the goal of integrating energy efficiency into India's cooling sector, EESL had initiated a first of its kind, Super-Efficient Air Conditioning (SEAC) programme. These Super-Efficient ACs are 5 star rated product and have high 5.4 ISEER and use environment friendly refrigerant with low Global Warming Potential (GEP) and Zero Ozone Depletion Potential (ODP) introduced in the market at competitive prices.

The SEACs provides 1.5-TR cooling capacity at high ambient temperature while also reducing the cost of cooling by 50%. As on 31st March 2023, EESL has sold 3,146 Super-Efficient Air Conditioners which lead to an energy saving of 34.44 Lakhs Units annually and CO2 emission reduction of 2790.34 tCO2e. Further, EESL also supported GEM authority for adding Green AC in its categories of products which are super energy efficient having ISEER 5.4 and above.

Energy Savings from Super-Efficient Air-conditioners Program in FY 22-23			
State	**No. of Super-Efficient Air-conditioners (Split AC) sold**	**Total Electricity Savings (kWh) per annum**	**Total CO2 emission reduction (tCO2) per annum**
PAN India (Residential)	3146	3,444,870	2790.34


MORE STARS, SAVINGS!
Why choose BEE Star Rated appliances?
High energy efficiency
Environment friendly
Reduced electricity bill
Bachat Ke Sitare Dost Hamare

Chapter 6: Agriculture

6. *Agriculture*

Brief about the sector

Agriculture in India serves as the backbone of the nation's economy, employing a significant portion of its workforce and contributing substantially to the Gross Value Added. Its rich diversity and vast cultivation areas showcase the country's agricultural significance on a global scale. A crucial role is held by agriculture in India's economy, with 54.6% of the total workforce involved in agriculture and allied sector activities according to the Census of 2011. This sector also contributes to 18.6% of India's Gross Value Added (GVA) at current prices for the year 2022-23.[57]

The electricity consumption in the sector since 2010 till 2022 is presented in the below figure-

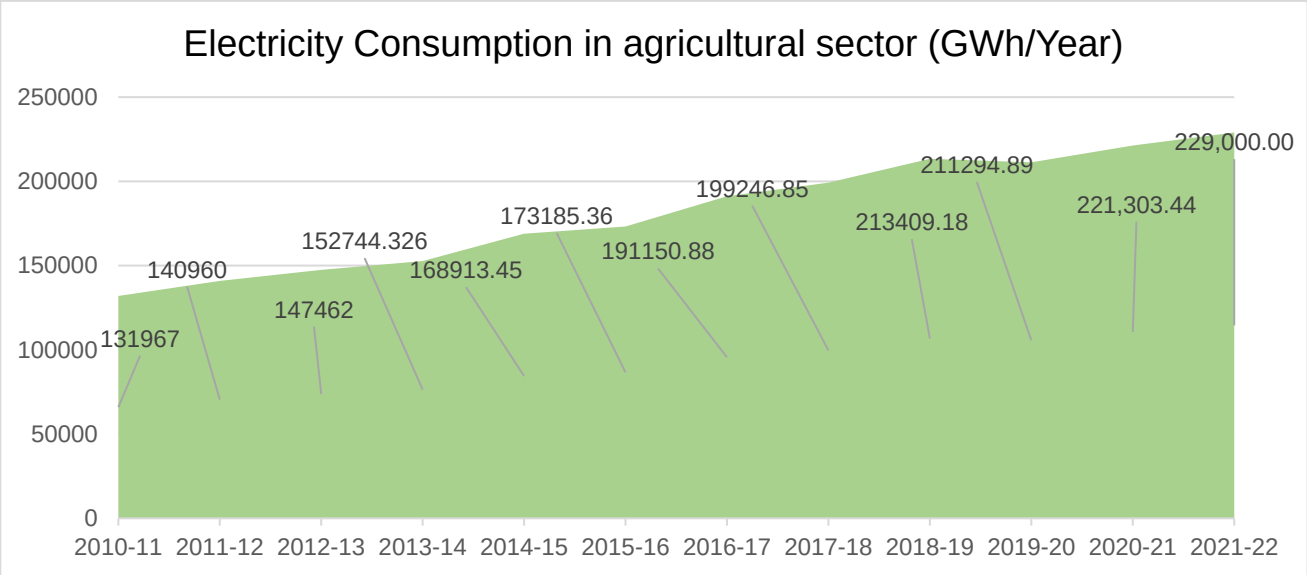


Figure 48: Energy consumption in agriculture sector[58]

It is clearly visible from the figure above that the energy consumption by the agriculture sector has been rising rapidly from the FY 2015-16. The consumption has increased from 173,185.36 GWh to 229000 GWh. An increase in energy consumption by around 25.3%.

Supply of electricity agricultural sector is mostly free or high subsidized across most of the states of India. Under this scenario, as a consumer, farmer has little or no motivation in making any serious effort for saving energy.

[57] Source - https://agricoop.gov.in/Documents/annual_report_english_2022_23.pdf
[58] Source - https://www.ceicdata.com/en/india/electricity-consumption-utilities/electricity-consumption-utilities-agriculture

The agricultural sector stands as a significant pillar of the Indian economy, contributing roughly 17% to the total GDP and offering employment to over 60% of the population. The AgDSM initiative encompasses strategies and policies designed to alter power consumption behaviors among consumers, particularly farmers. All AgDSM projects in India prioritize the substitution of inefficient agricultural pump sets with BEE star-rated energy-efficient models, while also promoting awareness about the benefits of using energy-efficient pumps.

To promote the Energy Efficiency in various fields of Agriculture sector the major initiative that have been undertaken by BEE are as follows:

Driving nationwide awareness programs for farmers to promote the adoption of EE pumps.

Organizing technical training programs for pump technician and Development of the mobile application

Demonstration project on “IoT and sensor-based Climate Smart Agriculture Initiatives.

Energy Efficiency in Aquaculture (Fisheries) through use of Energy Efficient Aerators

Figure 49:Major initiatives taken to promote energy efficiency in various fields of agriculture.

In addition to increased energy usage, the current pump sets indirectly contribute to groundwater wastage, as farmers presently lack incentives to monitor or adjust the pump operation based on the actual water demand for irrigating crops. Given this scenario, Agricultural Demand Side Management emerges as an appealing choice to curb both water and energy wastage in the agricultural sector.

Pump set replacement programs have been the primary driver for Energy Efficiency and DSM in Indian agriculture. The figure below presents a timeline of the significant Agriculture DSM initiatives:

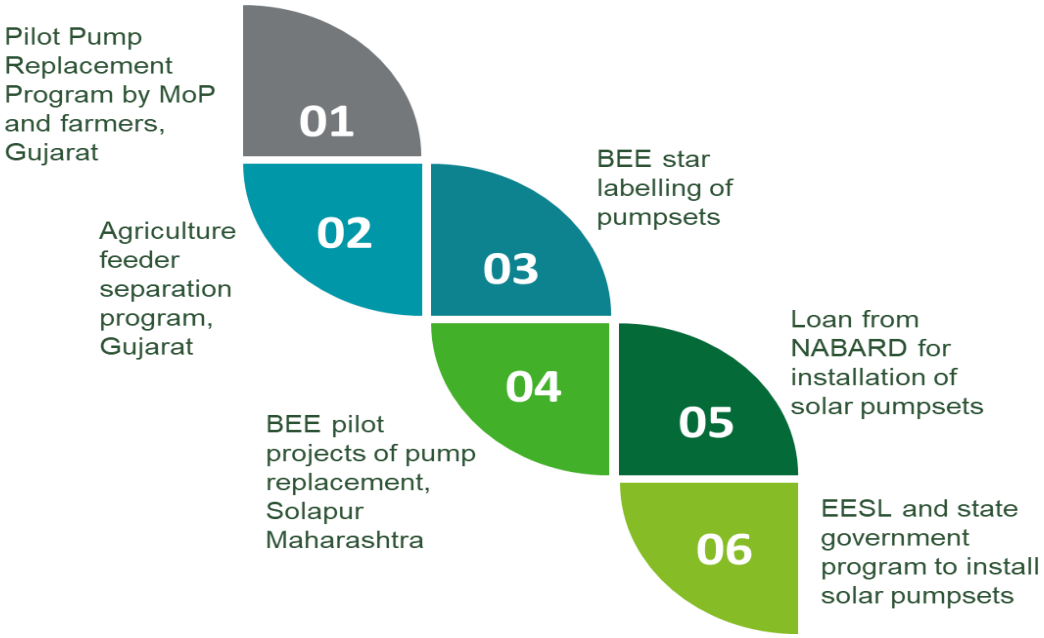


Figure 50: Timeline of major Agriculture DSM programs in India

Energy Efficiency in Integrated Cold-chain Sector

India ranks as the world's second-largest producer of fruits and vegetables. However, increased transit time for farm produce has led to amplified food losses throughout the supply chain. According to the Indian Council of Agricultural Research (ICAR), losses in fruits range from 5.8% to 18%, while for vegetables, it's between 6.8% to 12.98%. These post-harvest losses represent a significant economic burden, reducing the saleable volume and value before reaching the markets.

The India Cooling Action Plan (ICAP) from March 2019 emphasizes the potential in the cold chain sector to decrease cooling demand, energy use, and refrigerant necessity through enhanced design and energy-efficient technology. The Bureau of Energy Efficiency conducted a recent study, focusing on packhouses, to assess ways to enhance energy efficiency in the cold chain sector.

To reduce the energy consumption by the agriculture sector of India, the Agriculture Demand Side Management (Ag-DSM) scheme of BEE was initiated during XI plan and is being implemented to the present.

This program pledges to enhance Energy Efficiency in agriculture by reducing overall power consumption, improving groundwater extraction efficiency, alleviating subsidy burdens on state utilities, and preventing additional investments in power plants.

Ag DSM scheme of BEE was initiated during XI plan in eleven DISCOMs of selected eight states (Maharashtra, Haryana, Punjab, Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh and Karnataka) which were agriculturally intensive and accounted for more than 70% of electricity consumption in this sector.

Agriculture Demand Side Management (AgDSM) programme

This program ensures Energy Efficiency in agricultural demand management by reducing overall power consumption, enhancing groundwater extraction efficiency, alleviating subsidy burdens on state utilities, and steering clear of additional investments in power plants. With agriculture accounting for roughly 80% of India's water use, pumps stand as essential components in irrigation, affecting both water regulation and rural households—over 70% of which rely on agriculture. This sector significantly contributes to the economy, constituting about 17% of the GDP and employing over 60% of the population. India's agriculture sector boasts over 2.1 crore pump sets, predominantly inefficient, with an annual addition of 2.5 to 5 lakh new connections. These pumps, averaging around 5 HP, currently operate at efficiency levels ranging from 25% to 30%.

In situations where power supply to farmers is subsidized, there is typically no direct economic incentive for farmers to invest in energy-efficient pumps. Consequently, in the majority of Agricultural Demand Side Management (AgDSM) initiatives, Distribution Companies (DISCOMs) are taking the initiative to fund the replacement of traditional pump sets. This is achieved either by sharing the energy savings with the farmers in an Energy Service Company (ESCO) model or by making capital investments in the upgraded pump systems.

Under AgDSM Programme, farmers gain several advantages from Krishi Vigyan Kendra's (KVKs). Following are the benefits -

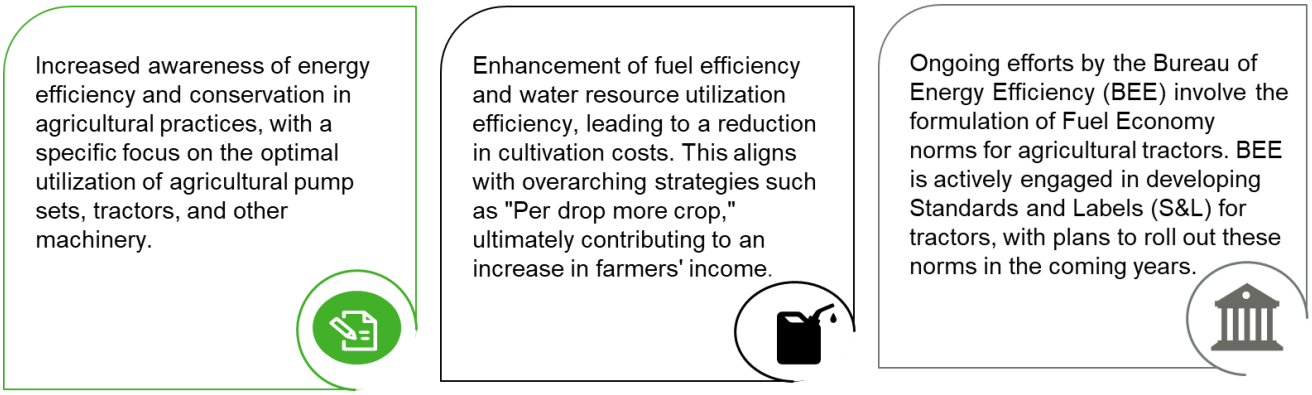


Figure 51: Benefits of Farmers from Krishi Vigyan Kendra

To foster Energy Efficiency in the agriculture sector, the following measures and interventions are being implemented:

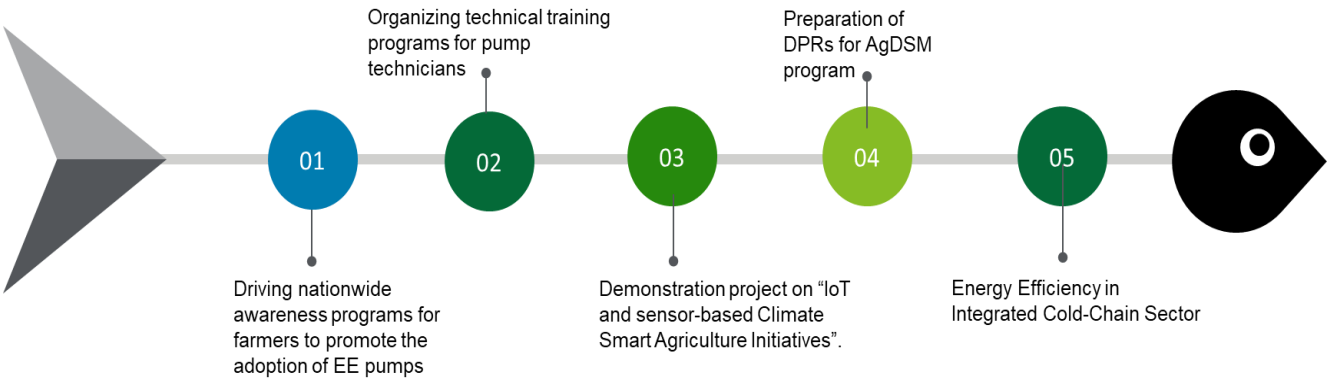


Figure 52: Measures and interventions implemented by BEE

In collaboration with State Designated Agencies (SDAs), BEE is organizing a range of training and awareness initiatives targeting farmers and equipment technicians. In the fiscal year 2022-23, approximately 280 number of programs were conducted to promote energy-efficient pump sets in the agricultural sector, emphasizing water conservation. These sessions reached out to around 22,267 farmers and stakeholders. The table below shows the numbers of farmers, stakeholders and beneficiaries trained under AgDSM Programme.

Table 56: Number of farmers, stakeholders and beneficiaries trained under AgDSM

Status of programmes under AgDSM programme 2022-23			
S.No.	**Name of the SDA**	**No. of programmes conducted**	**No. of participants (Farmers/Pump technicians/Stakeholders)**
1.	**Andhra Pradesh**	17	2320
2.	**Arunachal Pradesh**	12	630
3.	**Assam**	9	650
4.	**Chhattisgarh**	7	682
5.	**Haryana**	12	742
6.	**Himachal Pradesh**	8	480
7.	**Jharkhand**	14	1380
8.	**Karnataka**	22	2670
9.	**Kerala**	15	1098
10.	**Madhya Pradesh**	5	347
11.	**Maharashtra**	8	546
12.	**Manipur**	4	322
13.	**Meghalaya**	13	887
14.	**Mizoram**	15	1481
15.	**Nagaland**	11	508
16.	**Punjab**	21	2125
17.	**Rajasthan**	11	768
18.	**Sikkim**	11	560
19.	**Tamil Nadu**	15	555
20.	**Telangana**	27	1800
21.	**Tripura**	3	218
22.	**Uttar Pradesh**	8	678
23.	**Uttarakhand**	9	540

Status of programmes under AgDSM programme 2022-23			
S.No.	Name of the SDA	No. of programmes conducted	No. of participants (Farmers/Pump technicians/Stakeholders)
24.	Puducherry	3	280
	TOTAL	280	22267

Recent efforts by BEE to promote AgDSM scheme

In the preceding year, the Bureau of Energy Efficiency implemented several initiatives to advocate for the adoption of energy-efficient pumps. This involved raising awareness about the program and forging strategic partnerships with pivotal institutions operating in the agricultural sector. The subsequent section outlines some of the key initiatives undertaken in the past year:

Driving nationwide awareness programs for farmers to promote the adoption of EE pumps

BEE in coordination with the State Designated Agencies (SDAs) is conducting various training and awareness programmes for farmers and equipment technicians. In 2022-23 around 280 number of training and awareness programmes for farmers/stakeholders have been conducted for promoting EE pump sets in the agriculture sector.

Organizing technical training programs for equipment technicians

In AgDSM space particularly, BEE in coordination with the SDAs is organizing training programs for equivalent technicians who have a major role to play in replacing old inefficient pumps with BEE start rated pump sets. In 2022-23 around 21 numbers of capacity building programs for equipment technicians have been conducted.

Demonstration project on "IoT and sensor-based Climate Smart Agriculture Initiatives".

The pilot intervention is intended to showcase and mainstream the business model of climate smart sustainable agriculture practice. With the main objective of judicious water usage, the operation of solar driven agriculture pump is guided by automatic soil moisture sensors regulating the operation of drip, sprinkler or generic water flow to the irrigation network.

Methodology adopted to calculate energy savings and CO_2 emission savings

Around 83,107 BEE 5 star rated pumps which were distributed during FY 2022-23 to replace inefficient pumps. For the purpose of energy saving calculations in 2022-23, 50% of the total number of installations in the year 2022-23 is considered since pumps are installed at different times during the year. The energy savings and CO_2 emission savings were calculated on account of these number of inefficient pumps that were replaced by the energy efficient pumps in the past few years. The methodology to calculate each is explained below:

Step 1: Identification of the Energy Efficient Pumps installed during the FY 2022 -23

Total number of pumps installed during the FY 2022-23 are presented in the table below:

Table 57: State wise installations of EE Pumps in different states of India during the FY 2022-23[59]

States	No. of EE Pumps installed
Andhra Pradesh	73055
Uttar Pradesh	8125
Karnataka	1927
Total	**83,107**

Step 2: Estimation of the energy saving

This calculation involves assessing the energy savings per pump by factoring in the total number of installed pumps and applying an overall efficiency factor of 30%. The assumptions for this computation include the pump's daily usage of 6 hours and operational days per year at 270 days. These parameters are derived from on-site surveys conducted for the implementation of the Agricultural Demand Side Management (AgDSM) program in Andhra Pradesh.

Table 58: Energy savings 2019-23 from installed EE Pumps:

States	No. of EE Pumps installed	Total Electricity Savings (kWh)	Savings in TOE
Andhra Pradesh	73055	227,230,272.00	19,538.29
Uttar Pradesh	8125	4,576,162.50	393.48
Karnataka	1927	4,075,854.55	350.46
Total	**83,107**	**235,882,289.05**	**20,282.23**

Step 3: Estimation of the emission reduction[60]

To calculate the reduction in total CO_2 emission, conversion factor of CO_2 for electricity is considered (1 MWh = 0.71 t CO_2).

Table 59: Energy saving and emission reduction from AgDSM programme in the FY 2022-23

States	Total Electricity Savings (kWh)	Total CO2 emisison reduction (tCO2)
Andhra Pradesh	227,230,272.00	161,333.49
Uttar Pradesh	4,576,162.50	3,249.08
Karnataka	4,075,854.55	2,893.86
Total	**235,882,289.05**	**167,476.43**

Based on results obtained, the impact under the AgDSM programme is discussed below.

Impact of the scheme

EESL is implementing the Energy Efficient Pump Programme to distribute BEE 5-star energy efficient agricultural pumps and ensures a minimum of 30% reduction in energy consumption with smart control panels which can be remotely operated to enhance the ease of operation

[59] EESL has installed a cumulative total of 5,74,413 lights across various states and UTs during FY 2015-19
[60] http://www.cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver13.pdf

of pumps by the farmers. During the financial year 2022 – 23, EESL has installed, 83,107 agricultural pumps have been installed in Andhra Pradesh, Uttar Pradesh, and Karnataka.

The emission savings achieved by installing these pumps is provided in the table below:

Table 60: Emission reduction due to installation energy efficient agricultural pumps in FY 2022-23

State	Energy Savings from Energy Efficient pumps			
	No. of pumps replaced	Total Electricity Savings (kWh)	Savings in TOE	Total CO2 emisison reduction (tCO2)
Andhra Pradesh	73055	227,230,272.00	19,538.29	161,333.49
Uttar Pradesh	8125	4,576,162.50	393.48	3,249.08
Karnataka	1927	4,075,854.55	350.46	2,893.86
Total	83107	235882289.1	20282.22606	167476.42

The current status of the number of pumps installed in state of Andhra Pradesh, Uttar Pradesh and Karnataka and summary of these installations for the FY 2019-23 is presented in Table 61.

Table 61: Number of pump-set installations under AgDSM in the FY 2019-23[61]

Particular	2019-20	2020-21	2021-22	2022-23
Pump-set installation (Number)	10,784	2500	81,180	83,107

Prior to the FY 2022-23, **total 74,399** BEE five star rated 5 HP pumps were installed across India. In the financial year 2022-23, there were total 83,107 number of inefficient 5 HP pumps that were replaced by 5 HP BEE five star rated pumps under AgDSM program, details are presented in Figure 53:

[61] Source – AgDSM Dashboard

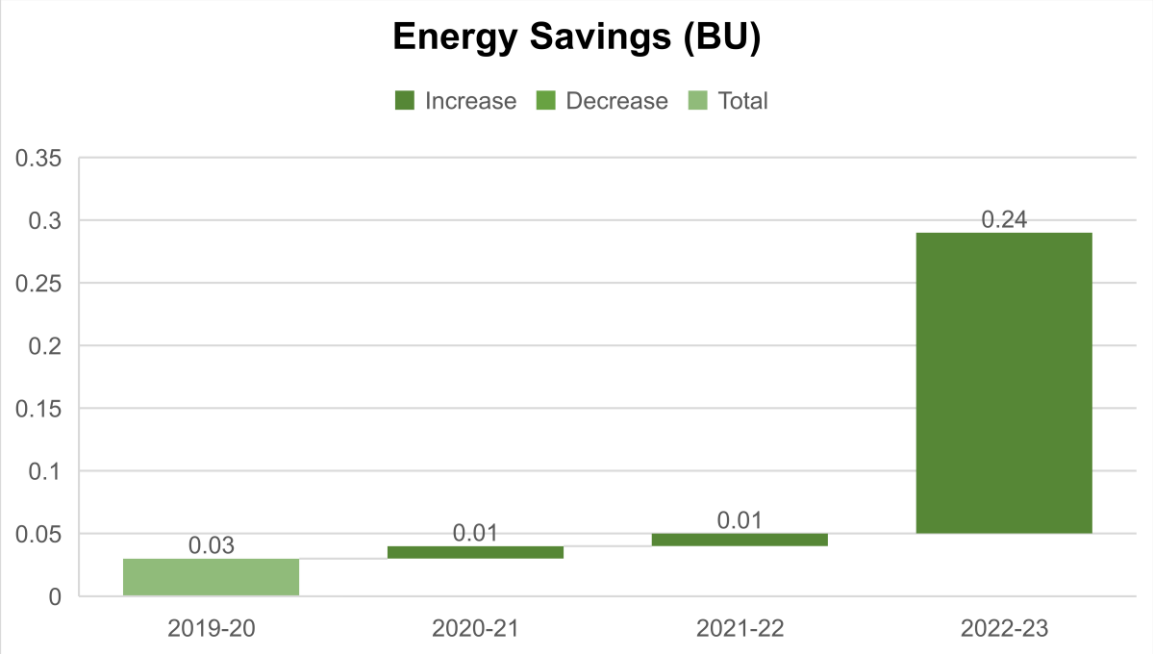


Figure 53: Energy saving from AgDSM

On account of number of Energy Efficient pumps getting distributed over the past few years, the impact of the AgDSM scheme in terms of energy (electrical) saved across India in FY 2022-23 is 0.236 BU and reduction in emission of CO_2 is 0.167 million Tonnes.

Benefits to various stakeholders under the programme

The Agricultural Demand Side Management (AgDSM) program engages multiple stakeholders, including farmers (the primary beneficiaries), DISCOM (acting as the implementing agency or project owner), the State Electricity Regulatory Commission (SERCs), and Energy Service Companies (ESCOs). The figure below illustrates the benefits realized by various stakeholders through the implementation of the AgDSM:

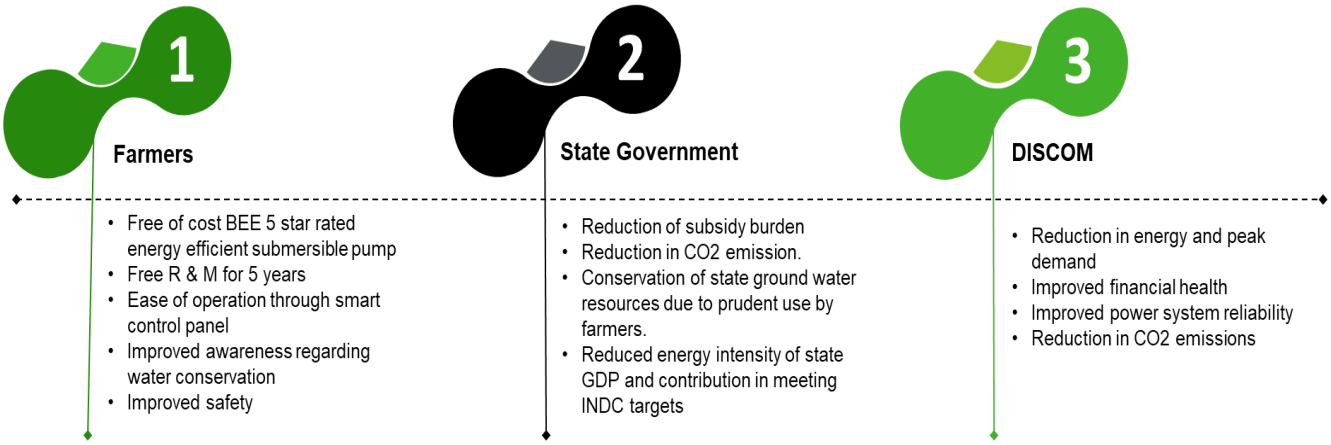


Figure 54: Benefits of the AgDSM programme

Chapter 7: Municipality

7. Municipality

Brief about the sector

Urbanization is an essential, unstoppable phenomenon in India, significantly influencing the country's economic development and poverty reduction. This transformation involves a notable rise in the number of major cities, signifying India's shift from primarily rural to a semi-urban society. The United Nations' 2030 development agenda underscores the importance of sustainable urban areas through the inclusion of Sustainable Development Goal (SDG) focused on "Sustainable Cities and Communities." According to Census 2011, as many as 53 cities in India had a million plus population. Over successive decades, the number of urban areas and towns has increased, as per the census 2011[62]:

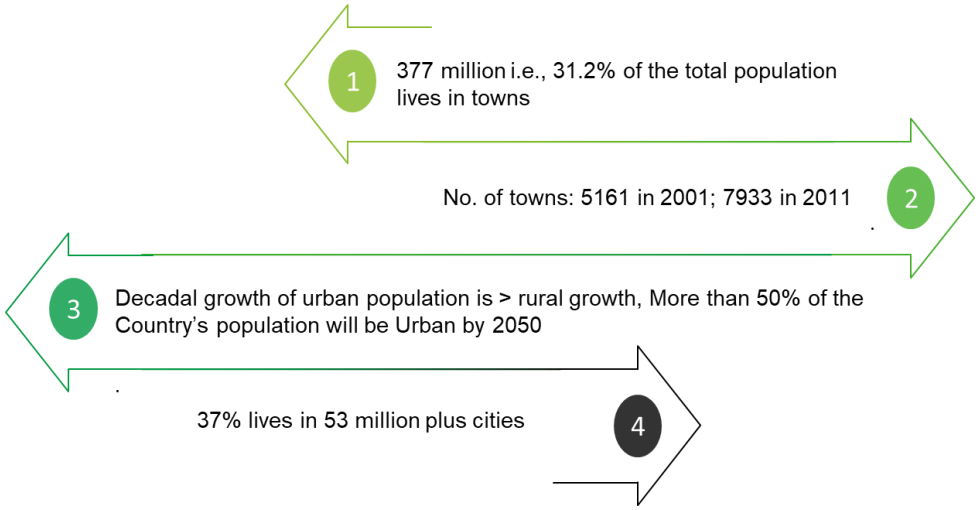


Figure 55: The Urban population, as per the Census 2011

The energy requirement in ULBs is showcased in the figure below:

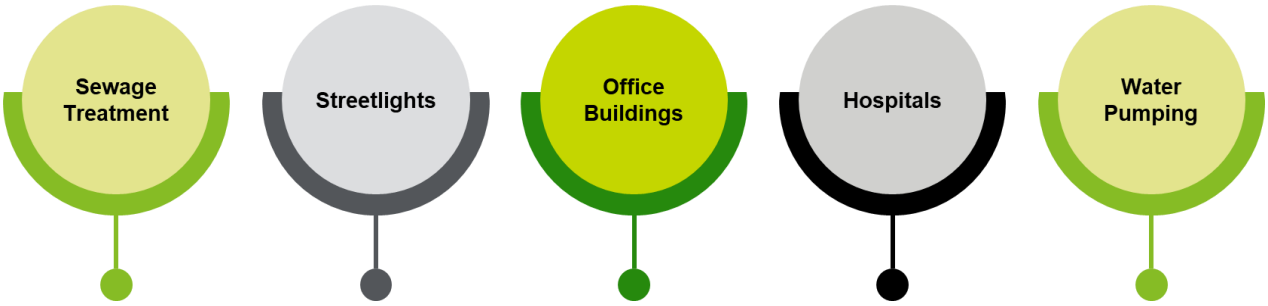


Figure 56: Energy Requirement in ULBs

Municipal energy consumption is erratic, primarily during water pumping in the morning and street lighting in the evening, leading to high operating costs. The Municipal Demand Side

[62] Source - https://mohua.gov.in/upload/uploadfiles/files/Annual_Report_2020_21_MoHUA_ (Final).pdf

Management (MuDSM) program aims to enhance Energy Efficiency in Urban Local Bodies (ULBs), offering significant electricity cost savings.

BEE introduced MuDSM recognizing the sector's substantial energy-saving potential during the XI plan.

7.1. *Municipal Demand Side Management (MuDSM) Programme*

MuDSM intervention is anticipated to alleviate utility strain during peak hours and curb financial losses resulting from excessive electricity use in municipalities. To harness energy savings in urban areas, BEE launched a nationwide MuDSM program targeting energy inefficiencies in activities such as drinking water and sewage pumping, street lighting, and public buildings across Urban Local Bodies (ULBs) and municipalities.

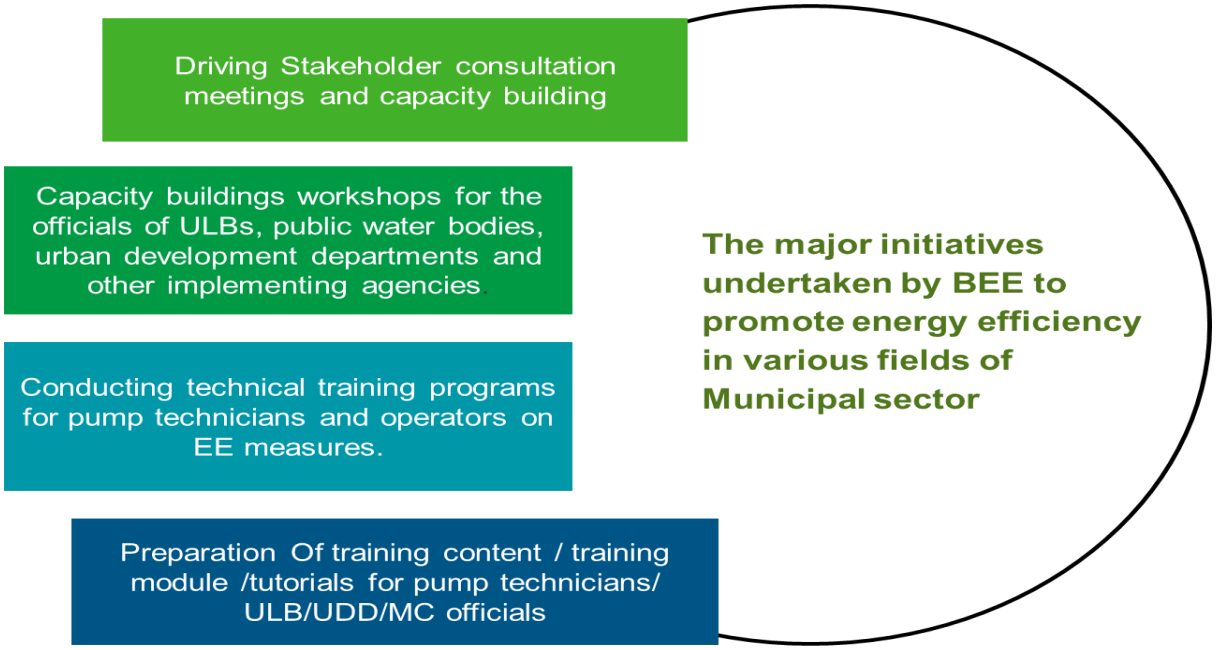


Figure 57: Major Initiatives taken by BEE to promote Energy Efficiency

In the fiscal year 2022-23, approximately 78 number of programs were conducted to promote energy efficiency, especially on Energy Efficient pump sets. These sessions reached out to around 3,270 pump technicians and other key officials from ULB, UDD and MC. The details of such capacity building workshops conducted in the FY 2022-23 is given in the table below:

Table 62: Capacity Building workshop conducted by BEE under MuDSM Programme

Status of programmes under MuDSM programme 2022-23			
S.No.	**Name of the SDA**	**No. of programmes conducted**	**No. of participants**
1.	**Andhra Pradesh**	22	1035
2.	**Arunachal Pradesh**	5	147
3.	**Assam**	3	127
4.	**Chhattisgarh**	3	104
5.	**Haryana**	3	134
6.	**Himachal Pradesh**	2	63
7.	**Jharkhand**	3	106
8.	**Karnataka**	6	178
9.	**Kerala**	2	73
10.	**Maharashtra**	2	75
11.	**Meghalaya**	1	43
12.	**Mizoram**	3	129
13.	**Nagaland**	1	32
14.	**Punjab**	2	96
15.	**Sikkim**	1	23
16.	**Tamil Nadu**	4	146
17.	**Telangana**	4	178
18.	**Tripura**	2	86
19.	**Uttar Pradesh**	4	309
20.	**Uttarakhand**	3	118
21.	**Puducherry**	2	68
	TOTAL	**78**	**3270**

In the following section, we'll dredge into the different initiatives implemented by BEE and EESL under MuDSM to enhance energy efficiency in street lighting and pumping systems:

7.2. Street Lighting National Programme

Streetlights in India are a vital component of urban and rural infrastructure, illuminating roads, public spaces, and enhancing safety. The country has been transitioning from traditional lighting to energy-efficient LED streetlights, aiming to reduce energy consumption, lower

operational costs, and minimize environmental impact. This shift underscores India's commitment to modernize its lighting infrastructure and make cities and towns more sustainable and well-lit.

Public lighting constitutes a mere 1% of India's overall electricity usage. The current electricity consumption for public lighting in India stands at 7,753 GWh. By enhancing efficiency with an estimated saving potential of 30%, India could conserve 2,326 GWh of electricity annually, potentially reducing CO2 emissions by up to 1.9 million tons per year[63].

To be more focused on Sustainability and efforts for Energy Efficiency, On January 5, 2015, the honorable Prime Minister launched the Street Lighting National Programme (SLNP) to replace traditional streetlights with energy-efficient LED lights throughout India. In the 2022-23 fiscal year, EESL installed 800,000 LED streetlights (P), with a cumulative achievement of 12.8 million as of March 31, 2023. The India over all LED Lighting Market is growing at a CAGR of 24.3% over the next 5 years.

Through the SLNP initiative, 1576 Urban Local Bodies (ULBs) have enrolled, with 1060 of these having completed the transition. EESL takes on the expense of replacing conventional streetlights with LEDs, sparing municipalities from any financial burden. The resulting savings in energy and maintenance costs for the municipality are utilized to reimburse EESL over a specified period. EESL usually engages in 7-year contracts with ULBs, ensuring a minimum energy saving of around 50% while offering complimentary replacements and maintenance of lights without extra charges for the municipality.

Over 13 million LED streetlights have been installed as of November 2023 across India

EESL extends its LED Street lighting projects to Gram Panchayats, employing a service model akin to the SLNP for municipalities, aiming to encourage efficient lighting in rural regions. Presently, EESL has deployed 2.6 million LED streetlights in the rural areas of Andhra Pradesh, Jharkhand, Goa, and Telangana.

The LED streetlights set up by EESL through the program come with a Central Control and Monitoring System (CCMS), enabling remote oversight and functionality. This guarantees automatic activation of streetlights post-sunset and deactivation after sunrise, fostering energy conservation through precise light control. Additionally, the system generates alerts for any light requiring maintenance, curbing failures and the necessity for abrupt repairs.

[63] Source - https://www.wisions.net/study/energy-efficiency-improvement-of-city-street-lighting-in-india/

Methodology for energy saving estimations

Energy savings due to number of inefficient streetlights that have been replaced by LED streetlights during FY 2022-23, are calculated. To calculate the energy (electrical) savings and emission reduction, following steps are used:

Step 1: Identification of the lights installed during the FY 2019-23

The energy-efficient LED lights that have been installed come with a lifespan of approximately 5 years. When evaluating energy savings for the fiscal year 2022-23, it is important to take into account the accrued energy savings from the implementation of these LED lights during the years 2019-22 as well.

The total number of lights installed during the FY19 -23 are presented in Table 63 below:

Table 63: State wise installations of LED streetlights[64]

S. No.	States/UTs	No. of LED streetlights installed during FY 2019-23				Total Number of LED lights installed (Lakhs)
		2019-20	2020-21	2021-22	2022-23	2019-23
1	Andaman & Nicobar Islands	1,237	258	-	-	1,495
2	Andhra Pradesh	357,639	970	10674	-	369,283
3	Assam	17,086	-	180	-	17,266
4	Bihar	250,920	105,866	59650	10547	426,983
5	Chandigarh	1,534	1,995	702	-	4,231
6	Chhattisgarh	58,606	-	3210	-	61,816
7	Delhi	26,078	17,400	20240	4677	68,395
8	Goa	2,866	-	73	-	2,939
9	Gujarat	5,081	230	2638	10895	18,844
10	Haryana	16,340	4,515	446	-	21,301
11	Himachal Pradesh	3,789	3,318	2160	346	9,613
12	Jammu & Kashmir	74,728	18,896	11184	21782	126,590
13	Jharkhand	389,493	31,692	4200	14113	439,498
14	Karnataka	2,428	-	124	-	2,552
15	Kerala	46,768	161,639	183125	-	391,532
16	Lakshadweep	1,000	-	-	-	1,000
17	Madhya Pradesh	35,567	33,730	80392	32961	182,650
18	Maharashtra	420,956	105,613	116490	37416	680,475
19	Odisha	29,601	4,657	-	13827	48,085
20	Puducherry	0	-	-	-	0
21	Punjab	29,288	7,056	12626	3786	52,756
22	Rajasthan	68,827	3,642	16891	996	90,356
23	Sikkim	0	-	205	-	205

[64] EESL has installed a cumulative total of 5,74,413 lights across various states and UTs during FY 2015-19

		2019-20	2020-21	2021-22	2022-23	2019-23
24	Tamil Nadu	1,010	-	-	-	1,010
25	Telangana	161,403	196,942	136843	229988	725,176
26	Tripura	375	625	-	-	1,000
27	Uttar Pradesh	204,178	113,868	74579	27625	420,250
28	Uttarakhand	12,304	16,561	59751	444	89,060
29	West Bengal	59,690	3,400	6043	3276	72,409
Total (Lakhs)		**22.79**	**8.33**	**8.02**	**4.13**	**43.27**

Step 2: Estimation of the energy savings in the FY 2022-23

Energy saving due to SLNP intervention is calculated by multiplying the numbers of lights with saving details as per SLNP dashboard. Annual operational hours considered are 11 hours per day and 365 days a year, Savings due to the implementation is illustrated in the table below:

Table 64 Energy savings in the FY 2022-23 from Street-Lighting programme:

FY 2022-23	Number of Installations	Annual energy savings in BU
Total	**4,326,770**	**4.366**

Step 3: Estimation of the emission reduction in the FY 2022-23[65]

The emission reductions accomplished through the SLNP are outlined in the table below:

Table 65: Energy saving and emission reduction from SLNP programme in the FY 2022-23

FY 2022-23	Annual energy savings in kWh	Emission Reduction in MtCO2
Total	**2,904,507,612**	**2.062**

SLNP program has led to energy savings of 2.90 billion KWh/year and reduction of 2.06 million tonnes of CO_2 emissions during FY 2022-23 and estimated annual monetary savings of INR 1,742 crore in electricity bills of municipalities in the FY 2022-23.

Since the inception, the SLNP Scheme has resulted in estimated energy savings of more than 8587 Million Units (MUs) of electricity per annum, peak demand reduction of over 1431 MW and 5.92 million tonnes of CO2 emission reduction annually. Under SLNP, there has been an estimated annual monetary savings of Rs. 5,688 crores in electricity bills of municipalities.

Recent efforts by BEE to promote MuDSM scheme

To promote the Energy Efficiency in Municipality sector following interventions are being taken:

Capacity Building workshops for the officials of Urban Local Bodies (ULBs), Public Water Bodies, Urban Development Departments (UDDs) and other implementing agencies

[65] http://www.cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver13.pdf

BEE in coordination with the State Designated Agencies (SDAs) is organizing various capacity building workshops for the officials of Urban Local Bodies (ULBs), Public Water Bodies, Urban Development Departments (UDDs). In 2022-23, around 78 number of capacity building programmes for the officials of ULBs, UDDs and Municipalities on Energy Efficiency measures in Municipality sector have been conducted.

7.3. Municipal Energy Efficiency Programme (MEEP)

India, hosting one of the globe's largest municipal systems, faces significant operational costs in providing water. A substantial 40% to 60% of energy expenses are solely attributed to water supply, leading to an estimated annual waste of 4800 million units of electricity due to inefficient water pumps. **The Municipal Energy Efficiency Programme (MEEP)** presents an extensive opportunity for India to unlock savings, primarily through the retrofitting of inefficient municipal pump sets.

To expand the Municipal Energy Efficiency Programme (MEEP) extensively across India and foster a market transformation, the Ministry of Housing and Urban Affairs, Government of India, and Energy Efficiency Services Limited (EESL), a public sector entity under the Ministry of Power, Government of India, have collaboratively launched an initiative. This initiative aims to facilitate the replacement of inefficient pumps within Public Water Works & Sewerage Systems without any initial cost to the Municipal bodies. The investment incurred will be recuperated through the energy savings achieved. In order to drive extensive market transformation in India, MEEP is being executed hand in hand with the Atal Mission for Rejuvenation and Urban Transformation (AMRUT). This joint initiative will allow for the replacement of inefficient pumps in Public Water Works & Sewerage Systems without any initial cost to the Municipal bodies. The investment will be recuperated through the achieved energy savings.

Based on the data available on the MEEP Dashboard, total 22 states of India are involved in this project, three Union territories and 390 cities has tied up with EESL as of November 2023.[66]

Up to March 31, 2023, successful IGEA studies have been completed for 390 cities with submitted reports. EESL has finalized implementation agreements with 39 ULBs in West Bengal, and the project is currently underway in phases. By the end of March 2023, 18 pumps were replaced in Khardah, and an additional 12 pumps were installed in Bankura, West Bengal, bringing the total number of installed pumps to 30.[67]

Impact of Municipal Energy Efficiency Programme (MEEP)

The MEEP aims to establish a comprehensive framework to enhance collaboration between Urban Local Bodies (ULBs) and State Governments/Union Territories (UTs) with EESL, focusing on the Energy Efficiency Programme in Public Water Works & Sewerage Systems across 500 Indian cities.

MEEP has impacted in potential energy savings PAN India. By conducting energy audits, it has been established that energy expenses constitute a substantial 40% to 60% of the

66 Source - https://meep.eeslindia.org/dashboard/

67 Source – EESL Annual Report 2021-22

operational costs associated with water supply in India. Embracing Energy Efficiency presents Urban Local Bodies (ULBs) with the opportunity to[68]:

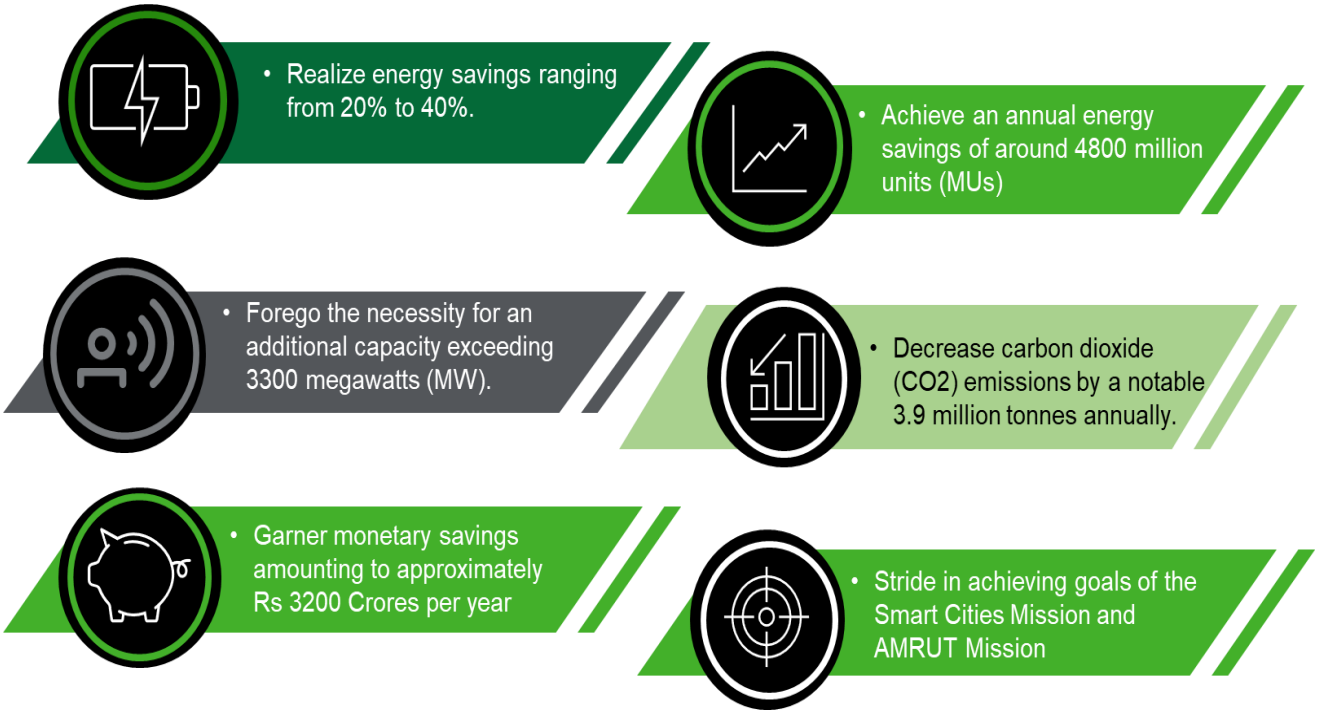


Figure 58: Impacts of MEEP

[68] Source - https://vikaspedia.in/energy/policy-support/energy-efficiency/municipal-energy-efficiency-programme

Chapter 8: Lighting

8. *Lighting*

India is witnessing urbanization rate of 31.41%, with present urban population is 377 million, projected to reach 590 million by 2030[69]. As our economies grow and populations expand, the demand for lighting in India will also increase. Lighting is a basic necessity and widely used in everyday life. It is a significant factor contributing to our quality of life and productivity of our workforces. Artificial illumination enables people to work in homes, offices, buildings, and factories. In India, building sector account for 35% of total energy consumption and growing at 8% annually.[70] According to international research, energy consumption for residential and commercial buildings in India is expected to increase by an average of 2.7% per year between 2015 and 2040[71]. It is also projected that among all regions of the world, the fastest growth in buildings energy consumption through 2040 will occur in India[72]. In terms of the saving potential, building sector in India offers a huge opportunity through use of efficient lighting.

Over the past decade, lighting market has seen a bend towards LED lighting technology, which is up to 75% more energy efficient than traditional incandescent and compact fluorescent (CFL) bulbs. India's LED lighting market grew 130-fold within five years, skyrocketing from annual sales of 5m bulbs per year in 2014 to about 670 million in 2018. This resulted in 30 terawatt hours (TWh) of annual energy savings – roughly enough to power 28 million average Indian households[73]. There is a trend towards first-time LED use in low-income households and in regions like Uttar Pradesh, households have leap-frogged from having no electrical lighting straight to LED lights[74].

Image Source: www.pragmaticinstitute.com

The key driver of India's market transformation was a policy initiative, known as "Unnat Jyoti by Affordable LEDs for All" or "UJALA", which procured LED bulbs for the national market. UJALA scheme was launched in 2015 by Ministry of Power. This scheme led to LED prices coming down reasonably through the process of bidding, consequentially the bulbs were sold at profitable, but lesser price in comparison to the retail prices through kiosks and vendors. UJALA succeeded in bringing down the retail price of LED bulbs from INR 300-350 per bulb to INR 70-80 per bulb[75]. Energy Efficiency Services Limited (EESL), a government company under the administrative control of Ministry of Power, Government of India, has been designated as the implementing agency for this program.

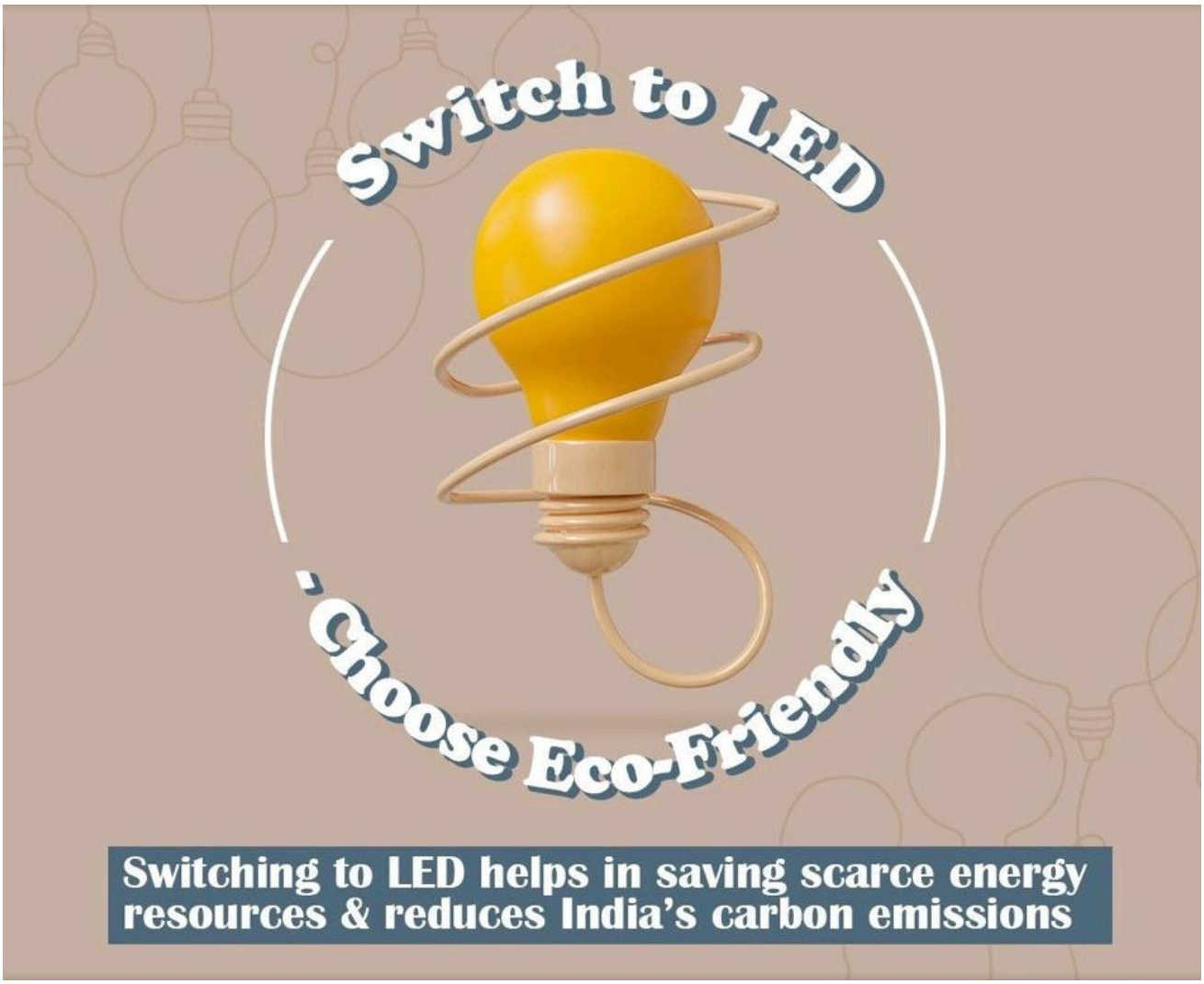
69 Source: MoHUA, 2019. Handbook of Urban Statistics, New Delhi: Government of India Press: http://mohua.gov.in/pdf/5c80e2225a124Handbook%20of%20Urban%20Statistics%20 2019.pdf
70 Source: https://www.beeindia.gov.in/sites/default/files/Flyer_22nd%20Jan.pdf
71 Source: https://www.eia.gov/todayinenergy/detail.php?id=33252
72 Source: https://www.eia.gov/todayinenergy/detail.php?id=33252
73 Source: https://www.carbonbrief.org/guest-post-how-energy-efficient-led-bulbs-lit-up-india-in-just-five-years/
74 Source: https://www.carbonbrief.org/guest-post-how-energy-efficient-led-bulbs-lit-up-india-in-just-five-years/
75 Source: https://www.pib.gov.in.

As on 31 March 2023, EESL distributed 10.50 lakh LED bulbs covering all 36 States and Union Territories (UTs.) This resulted into estimated energy savings of 47.78 billion kWh per year, and avoided peak demand of 9567 MW and GHG emission reduction of 38.70 million CO_2 per year[76].

The Unnat Jyoti by Affordable LEDs for All (UJALA) observed the need for DISCOMs to invest in the upfront cost of LED bulbs. EESL has evolved a service model where it works with electricity distribution companies (DISCOMs) through a benefit sharing approach The upfront investment made by EESL is paid back in two different ways as indicated under:

(a) DISCOM Cost Recovery: The investments of EESL are recovered from the DISCOMs as annuity over a period of 3-10 years by monetizing the energy savings that accrue as a result of replacement of incandescent lamps with LEDs. Each replacement leads to a reduction of connected load by 53W. The energy savings are monetized based on the peak procurement cost of DISCOM and is used to pay back the investment made by EESL under an approval by the State Electricity Regulatory Commission.

(b) On Bill Financing (OBF): Cost recovery from consumers by deduction of easy instalments of 12.66 INR every month for 8-12 months. The entire cost of the LED bulbs, including the awareness, distribution and cost of capital is recovered from the consumer bills.



[76] Source: https://eeslindia.org/wp-content/uploads/2022/09/Annual-Report-FY-2021-22.pdf

8.1 Methodology for estimation of the saving

Methodology adopted for the energy saving for the UJALA program is illustrated in the figure below:

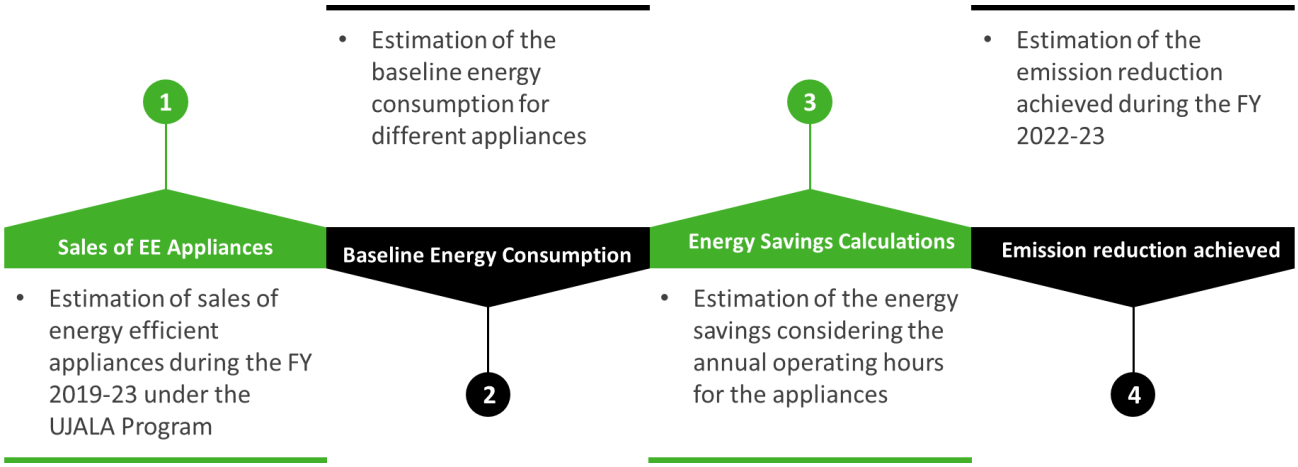


Figure 59: Methodology for estimation of Saving under UJALA scheme

Total number of different appliances retrofitted under UJALA programme is shown in the Table 66

Table 66: Sales of appliances under UJALA programme

Year	Number of units distributed (Million)		
	LED bulbs	LED Tube lights	EE Fans
2019-20	12.03	0.24	0.11
2020-21	4.98	0.103	0.043
2021-22	1.04	0.052	0.056
2022-23	0.74	-	-
Total	**18.79**	**0.395**	**0.209**

The distribution of the LED lamps in the FY 2022-23 across Indian states have been shown in the Table 67:

Table 67: Distribution of LEDs in the FY 2022-23

States/UTs	Total No of lamps replaced by LED bulbs
Andhra Pradesh	925
Delhi	39,349
Haryana	1
Himachal Pradesh	3,757
Karnataka	1,645
Punjab	5,887
Telangana	686,134
Uttar Pradesh	1,061
Uttarakhand	33
Total	738,792

As per the figure above, Telangana has the highest distribution of the LED bulbs followed by Delhi under the UJALA programme, in the FY 2022-23.

Baseline power consumption and power consumption of the energy efficient appliance replaced under the programme is tabulated in Table 68:

Table 68: Power saving estimation per appliance

Appliance	Base line wattage of appliance	Wattage of energy efficient appliance	Reduction in wattage
LED Lamp[77]	59	9	50
LED tube light	40	20	20
EE Fan[78]	75	50	25

Note: The energy-efficient appliances that have been installed come with a lifespan of approximately 5 years. When evaluating energy savings for the fiscal year 2022-23, it is important to take into account the accrued energy savings from the implementation of these appliances during the years 2019-22 as well.

Energy savings are estimated considering the operation of led lights for 7 hours a day and 365 days a year, tube lights are considered for operation for average of 6 hours a day with 365 days of operation during the year. Similarly, the assumed operation hours for the fans are 16 hours a day and with average operation of 240 days a year. Number of LED installed are presented in Energy saving estimations are tabulated in Table 69: Number *of LED bulbs distributed across different states*

Table 69: Number of LED bulbs distributed across different states

S. No.	States/UTs	No. of LED lamps distributed in Millions				Total No. (Millions) FY: 19-23
		FY 19-20	FY 20-21	FY 21-22	FY 22-23	
1.	Andaman & Nicobar Islands	0.0	-	-	-	-
2.	Andhra Pradesh	0.01	0.00	0.01	0.00093	0.021
3.	Arunachal Pradesh	0.01	0.00	0.00	-	0.010
4.	Assam	0.10	0.01	0.01	-	0.120
5.	Bihar	0.20	0.05	0.04	-	0.290
6.	Chandigarh	0.01	-	0.03	-	0.40
7.	Chhattisgarh	0.13	0.15	0.03	-	0.310
8.	Dadra & Nagar Haveli	0.03	-	0.06	-	0.090
9.	Daman & Diu	0.02	-	-	-	0.020
10.	Delhi	0.25	-	0.12	0.039	0.409
11.	Goa	0.0	-	-	-	-
12.	Gujarat	0.37	0.22	0.06	-	0.650
13.	Haryana	0.08	0.02	0.02	0.00001	0.120
14.	Himachal Pradesh	0.23	0.14	0.04	0.0037	0.414
15.	Jammu & Kashmir	0.01	-	-	-	0.010
16.	Jharkhand	0.14	0.34	-	-	0.480
17.	Karnataka	1.21	0.62	0.37	0.0016	2.202
18.	Kerala	0.14	0.03	0.03	-	0.200

[77] Wattage of 59 is considered using the assumption that LED lamps replace the incandescent bulbs and CFL, with 100 W and 18W as the respective wattage. It is assumed the equal proportion of incandescent and CFL are replaced
[78] EE fan is 5 star rated 50 W BEE fan

S. No.	States/UTs	No. of LED lamps distributed in Millions				Total No. (Millions) FY: 19-23
		FY 19-20	FY 20-21	FY 21-22	FY 22-23	
19.	Madhya Pradesh	0.50	0.07	0.04	-	0.610
20.	Maharashtra	0.02	0.01	0.00	-	0.030
21.	Manipur	0.03	-	-	-	0.030
22.	Meghalaya	0.0	-	-	-	0.000
23.	Mizoram	0.0	0.00	0.00	-	0.000
24.	Nagaland	0.05	-	-	-	0.050
25.	Odisha	7.02	-	0.01	-	7.030
26.	Puducherry	0.0	-	-	-	0.000
27.	Punjab	0.12	1.57	0.04	0.0059	1.736
28.	Rajasthan	0.33	0.09	0.05	-	0.470
29.	Sikkim	0.0	0.00	-	-	0.000
30.	Tamil Nadu	0.42	0.15	0.00	-	0.570
31.	Telangana	0.01	1.26	0.00	0.686	1.956
32.	Tripura	0.01	0.02	0.01	-	0.040
33.	Uttar Pradesh	0.31	0.08	0.05	0.0011	0.441
34.	Uttarakhand	0.23	0.06	0.03	0.00003	0.320
35.	West Bengal	0.05	0.00	-	-	0.050
36.	**Total**	**12.0**	**4.89**	**1.05**	**0.74**	**18.679**

Table 70: Energy saving from UJALA programme[79]

The energy-efficient LED lamps/lights/fans that have been installed come with a lifespan of approximately 5 years. When evaluating energy savings for the fiscal year 2022-23, it is important to take into account the accrued energy savings from the implementation of these LED lamps/lights/fans during the years 2019-22 as well.

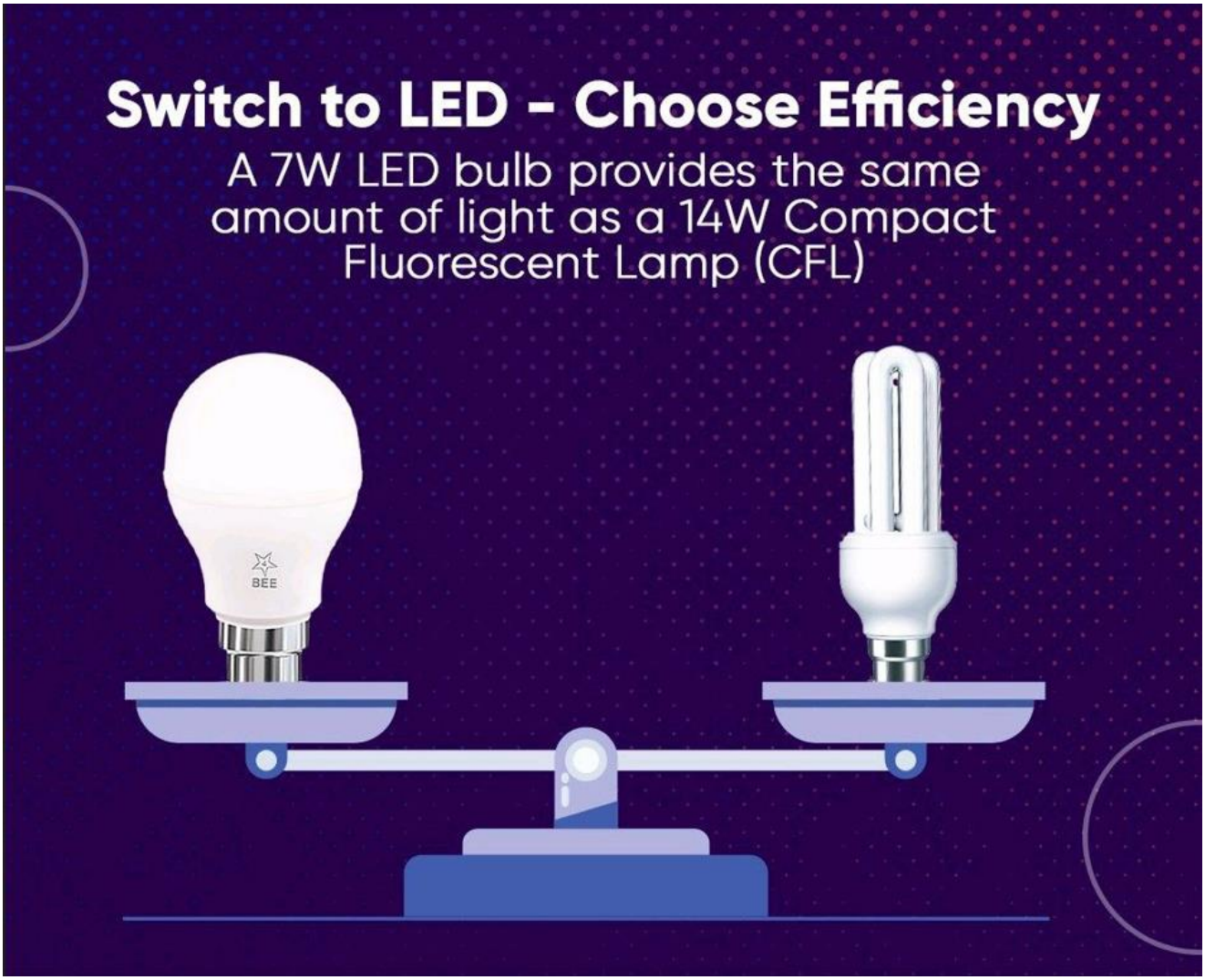
Year	Energy savings (MU): LED lamps	Energy savings (MU): LED Tube lights	Energy savings (MU): EE Fans
Total Savings in the FY 2022-23	**2393.72**	**15.52**	**19.21**

LED's contribute to 98.51% of the total energy savings under the programme, and tube lights contribute 0.73% of the savings and EE fans contribute 0.74% of the savings[80]. CO_2 emission reductions are calculated considering the grid emission factor as 0.71 kg/kWh[81].

***UJALA programme has led to energy savings of 2.43 BU** on account of the implementations carried out during the FY 2022-23*

[79] Saving of the fans is considered under S&L programme
[80] Source: https://eeslindia.org/wp-content/uploads/2022/09/Annual-Report-FY-2021-22.pdf
[81] Source: https://cea.nic.in/wp-content/uploads/baseline/2023/01/Approved_report_emission__2021_22.pdf

The UJALA scheme has resulted in large scale market transformation in the LED industry and has enabled market creation of approximately 70 crores LED bulbs annually. This has resulted in a cumulative distribution of 419 crore LED bulbs and 151 crore LED Tube lights as on 31.03.2023 since the inception of UJALA Scheme. This has resulted in estimated saving of 176.19 billion units of electricity per annum (including private market distribution), cost saving of INR 70,477 crore per annum, avoided peak demand of 32.18 GW and 125 Million Tonnes of CO2 reduction annually.



Chapter 9: Transport

9. *Transport*

An efficiently organized and synchronized transportation system is a key factor in fostering the long-term economic advancement of a nation. It influences the speed, composition, and configuration of progress. Over the last decade, improved economic activity has led to a significant increase in income per capita. As living standards rise and the desire for individual transportation grows, India has witnessed a substantial shift from non-motorized mobility to motorized modes of transport. A country's capacity for sustaining steady economic growth is greatly influenced by its cohesive and well-coordinated transportation network. India's transportation network is made up of a variety of different modes and services, including airports, airlines, inland waterways, ports, railroads, highways, and road transport.

Transport plays a significant role in the overall development of a nation economy. However, this sector also accounts for a substantial and growing proportion of air pollution in cities. In addition, the sector contributes significantly to greenhouse gases emissions and is a major consumer of petroleum fuels. The transport sector accounts for about 50%[82] of the oil demand in India. Transport accounts for a significant share of the total energy in demand in India, with only three other countries dedicating a larger share of their energy to transport – the US, China, and Russia.

In a country as diverse as India, the significance of transportation is heightened due to its extensive geographical conditions. The current transportation network in India encompasses multiple modes, such as railways, roadways, coastal shipping, air transport, and more. Over the years, the transportation sector has witnessed significant expansion, both in terms of its reach and overall performance.

The Road Transport Sector plays a pivotal role, representing approximately 87% of passenger traffic and 60%[83] of freight traffic movement within the country. Factors such as convenient accessibility, flexibility to cater to individual requirements, and cost-effectiveness contribute to the prominence of road transport. Additionally, road transport serves as a vital feeder service supporting railway, shipping, and air traffic.

[82] Source: India Transport Energy Outlook- CEEW
[83] Source: Ministry of Road Transport and Highways

The escalating demand for motorized transport has resulted in a consistent upward trajectory in the consumption of petroleum products over the years. This upward trend is evident in the data, which reflects a noteworthy increase from 157.06 million metric tons (MTs) in the fiscal year 2012-13 to 214.20 million metric tons (P) in the fiscal year 2022-23. This signifies a substantial growth of 36% over the span of seven years. The surge in petroleum consumption underscores the evolving dynamics of transportation needs and highlights the consequential impact on the overall demand for petroleum-based fuels during this period. The figure below showcases the consumption of petroleum products over the years 2017-2023:

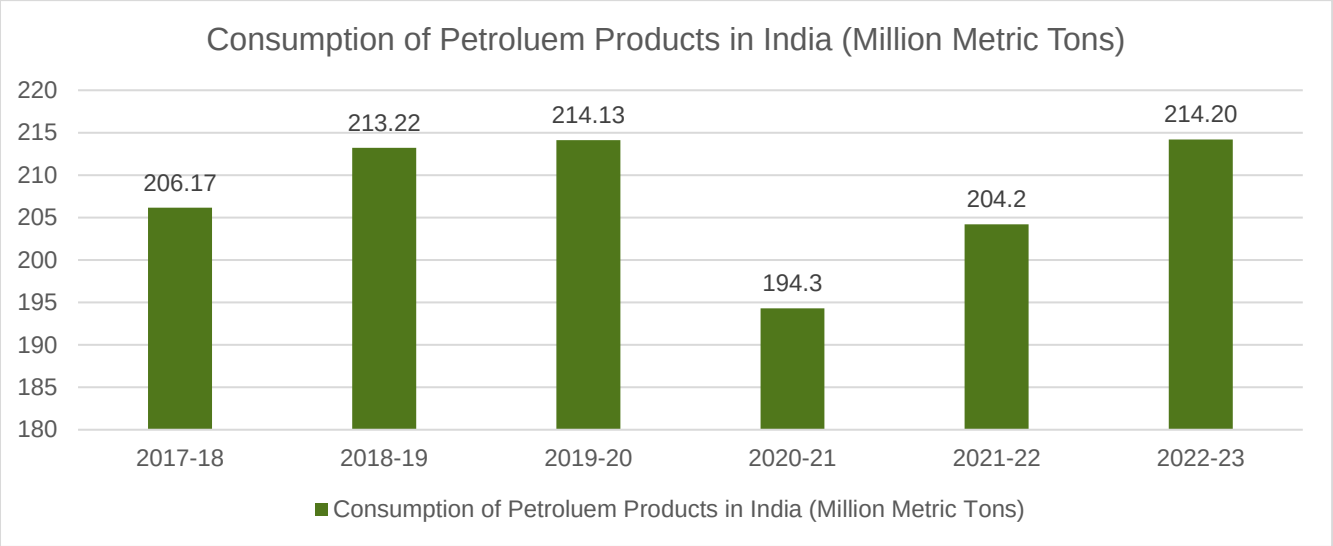


Figure 60: Total Consumption of Petroleum Products in India[84]

Among all the products the High-Speed Diesel (HSD) accounted for 37.55% of total consumption. This was followed by Petrol (15.10%), LPG (13.87%), Pet Coke (7.72%). The consumption of various types of petroleum products is depicted in figure below:

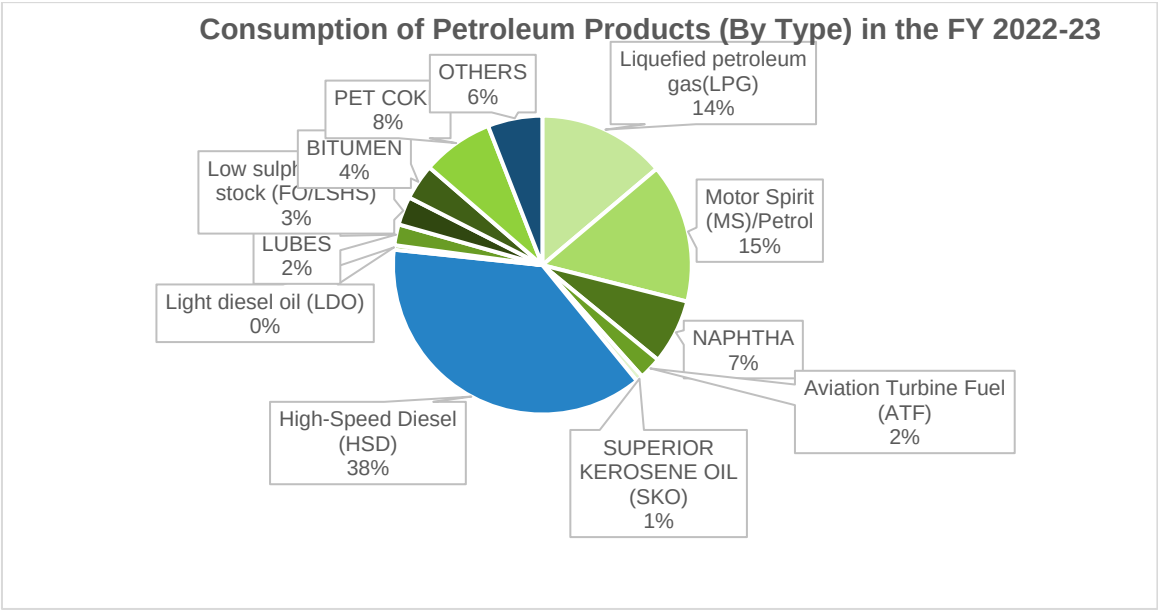


Figure 61: Consumption of Petroleum Products- by type during FY 2022-23

[84] The values are estimated based on Energy Statistics 2023, MoSPI. Final values will be published in the 2024 version of Energy Statistics

Among all the Petroleum Products the HSDO, which has the highest share of consumption (37.55%) during FY 2022-23, experienced a positive growth of 5.47% over last year. The Petrol and Pet-Coke are also having a growth of 10.30% and 1.07% respectively over last year. The LPG has registered a positive growth during FY 2022-23; with a growth of 2.80% over last year it has stood at a figure of 28.33 MTs in 2022-23, as compared to 27.56 MTs during 2020-21[85].

The automotive industry in India is one of the main pillars of the economy. With strong backward and forward linkages, it is a key driver of growth. Liberalization and conscious policy interventions over the past few years created a vibrant, competitive market, and brought several new players, resulting in capacity expansion of the automobile industry and generation of huge employment.

The Automobile sector's contribution to the National GDP has increased to approximately 7.1% today, marking a significant rise from 2.77% in 1992-93. It also offers employment opportunities, both directly and indirectly, to a workforce exceeding 19 million individuals.

The government has introduced the Automotive Mission Plan (AMP) 2016-26, aimed at fostering the growth of the automotive industry, thereby delivering economic advantages to India. The core of objective of AMP 2026 are listed below:

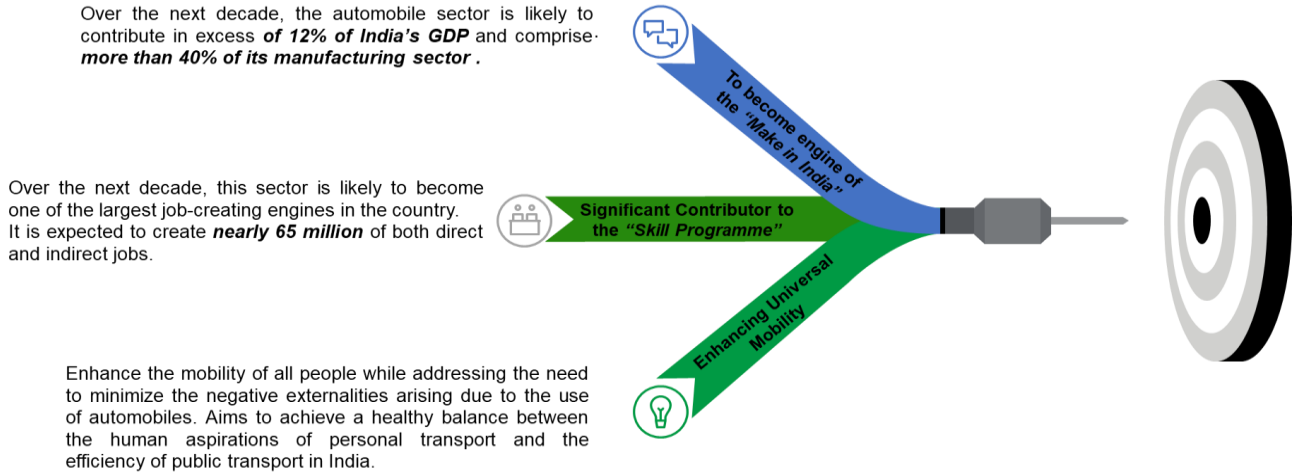


Figure 62: Objective of Automotive Mission Plan (AMP) 2016-26[86]

The automotive industry plays a pivotal role in boosting India's economic growth. Not only does it serve as a substantial source of employment for a diverse workforce, but it also makes a significant contribution to India's Gross Domestic Product (GDP). India is the world's third-largest automobile market, the largest manufacturer of three-wheelers, passenger vehicles, and tractors, and the second-largest manufacturer of two-wheelers. [87].

The Indian automotive industry manufactures a diverse range of vehicles, including passenger cars, commercial vehicles (light, medium, and heavy), multi-utility vehicles like jeeps, two-

[85] The values are estimated based on Energy Statistics 2023, MoSPI. Final values will be published in the 2024 version of Energy Statistics
[86] Source: Automotive Mission Plan:2016-26 (A Curtain Raiser)
[87] Source: An Overview of Automobile Industry in India-IBEF

wheelers (scooters, motorcycles, and mopeds), three-wheelers, tractors, and agricultural equipment. The automobile sector of India is showcased in below figures

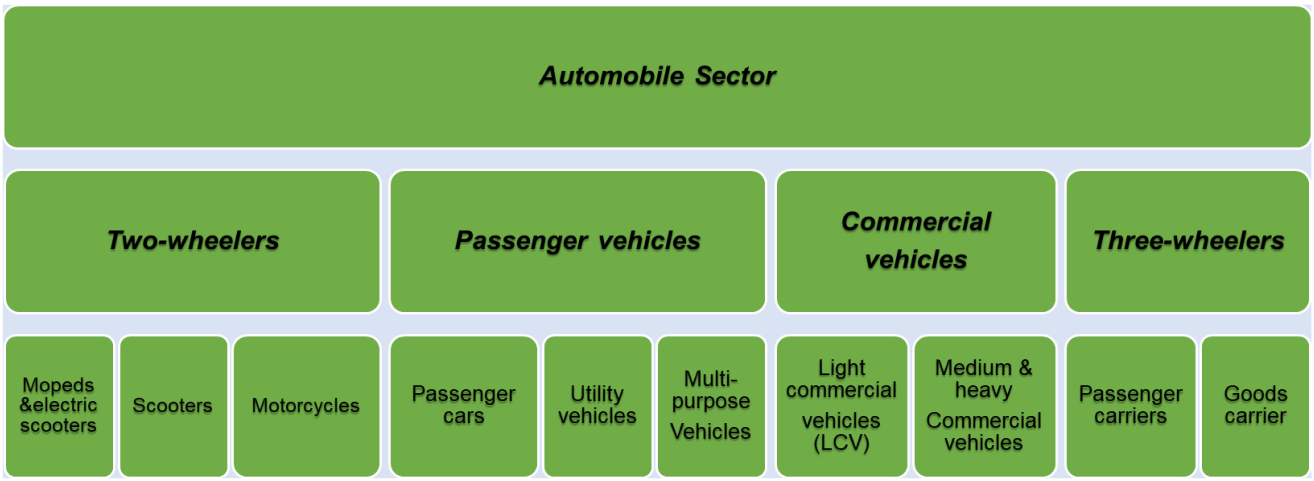


Figure 63:Overview of Indian Automobile Sector

The Indian auto industry is expected to record strong growth in FY23, post recovering from the effects of the COVID-19 pandemic. Electric vehicles, especially two-wheelers, are likely to witness positive sales in FY23. A report by India Energy Storage Alliance estimated that the EV market in India is likely to increase at a CAGR of 36% until 2026. In addition, a projection for the EV battery market is forecast to expand at a CAGR of 30% [88]during the same period The market share by vehicle type and the total vehicle sale in India between FY18- FY 23 is presented in the figure below.[89]

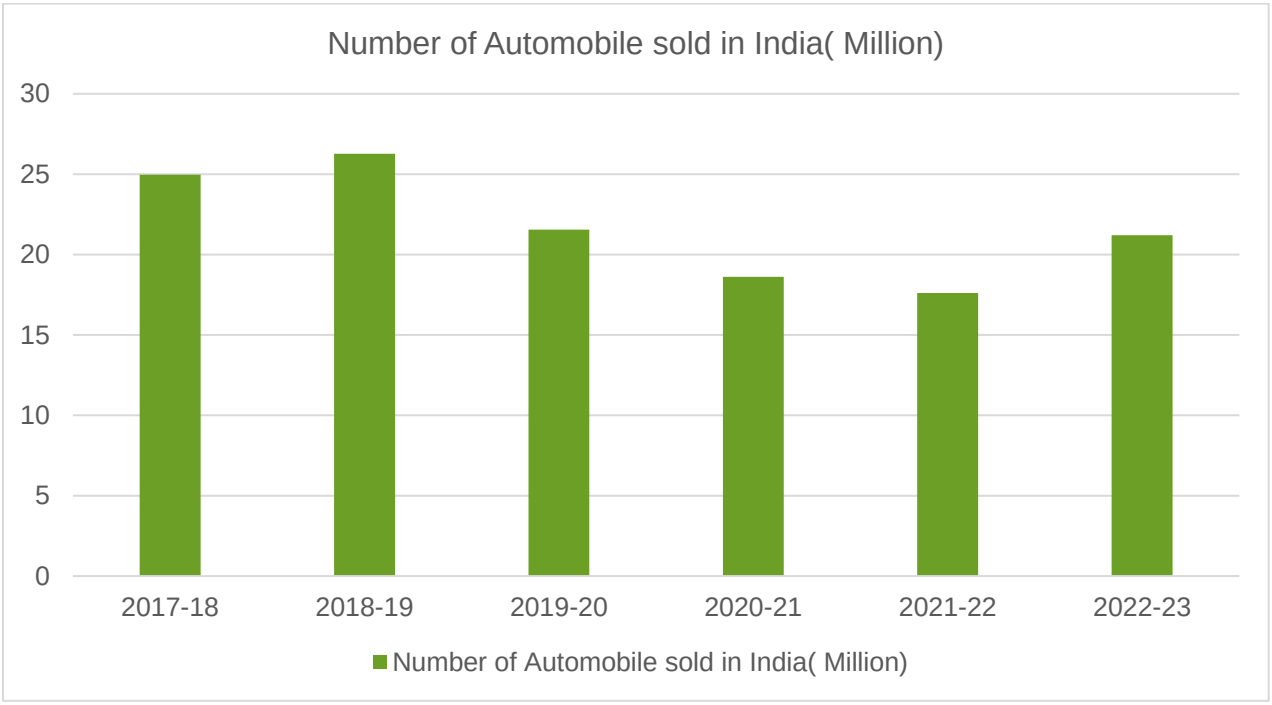


Figure 64:Sales of Automobiles

[88] Source: Automobile sector in India- IBEF August 2023
[89] Source: Automobile sector in India- IBEF August 2023

Two-wheelers and passenger vehicles dominate the domestic Indian auto market. Passenger car sales are dominated by small and midsized cars. Two-wheelers and passenger cars accounted for 74.81% and 18.35% of market shares, respectively, in FY23.[90]

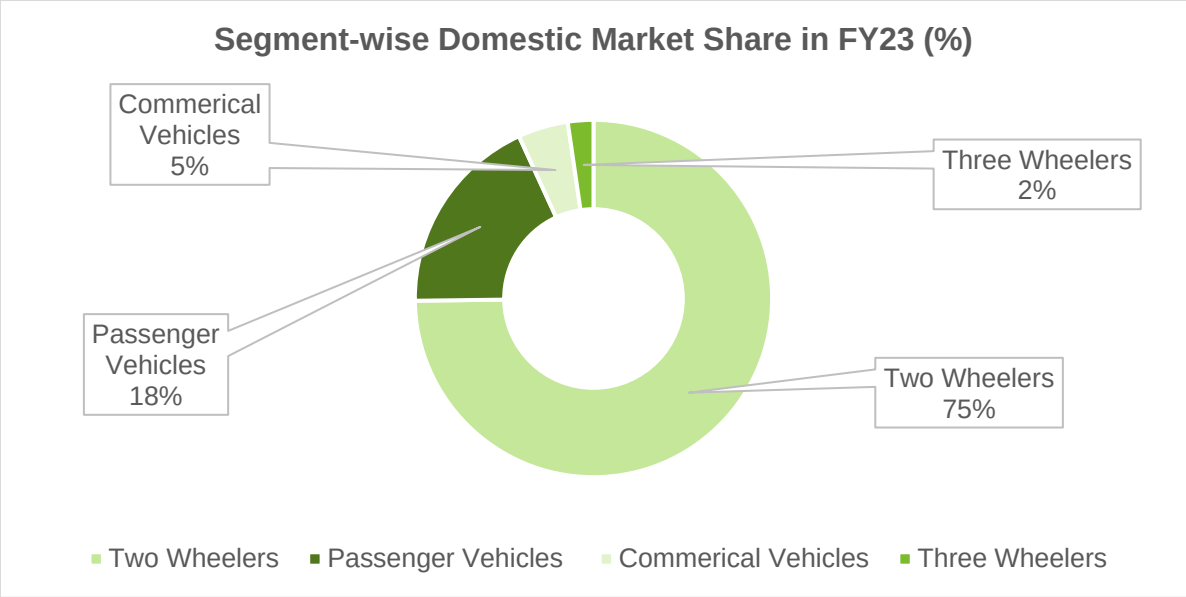


Figure 65:Segment wise % sales of Automobiles

The Indian automobile sector, one of the largest and most dynamic in the world, has undergone significant growth and transformation over the years. Passenger car sales are dominated by small and midsized cars. Export of the total number of automobiles increased from 4,134,047 in 2021-22 to 5,617,246 in 2022-23, registering a growth of 35.9%[91].

The Indian Automotive industry has made great strides over the past two decades, capturing the eye-balls at a global level and is considered as a contender for a top-table position. In terms of global rankings in manufacturing output, it ***is second largest in two-wheelers, seventh largest in commercial vehicles, sixth largest in passenger vehicles and the largest in tractors***.[92] Over the past ten years, India has emerged as one of the most preferred locations in the world for manufacturing high-quality automotive components and vehicles of all kinds, narrowing its gap over several established locations in the process. India's annual production of automobiles in FY 2022-23 was 25.93 million vehicles.

The automotive industry is expected to play a critical role in the transition towards green energy. The domestic electric vehicles (EV) market is expected to grow at a compound annual growth rate (CAGR) of ***49% between 2022 and 2030*** and is expected to hit one crore units' annual sales by 2030. The EV industry will create 5 crore direct and indirect jobs by 2030.

The information provided above outlines the growth statistics[93] for the domestic electric vehicle sector. In the FY 23, total production of passenger vehicles, commercial vehicles, three wheelers, two wheelers, and quadricycles was 25.93 million units. The trend of automobile production in India is shown in the figure below[94].

[90] Source: IBEF
[91] Source: The Automobile Sector in India – PIB Ministry of Information and Broadcasting
[92] Source: The Automobile Sector in India – PIB Ministry of Information and Broadcasting
[93] Source: Economic Survey 2023
[94] Source: Automobile sector in India- IBEF August 2023

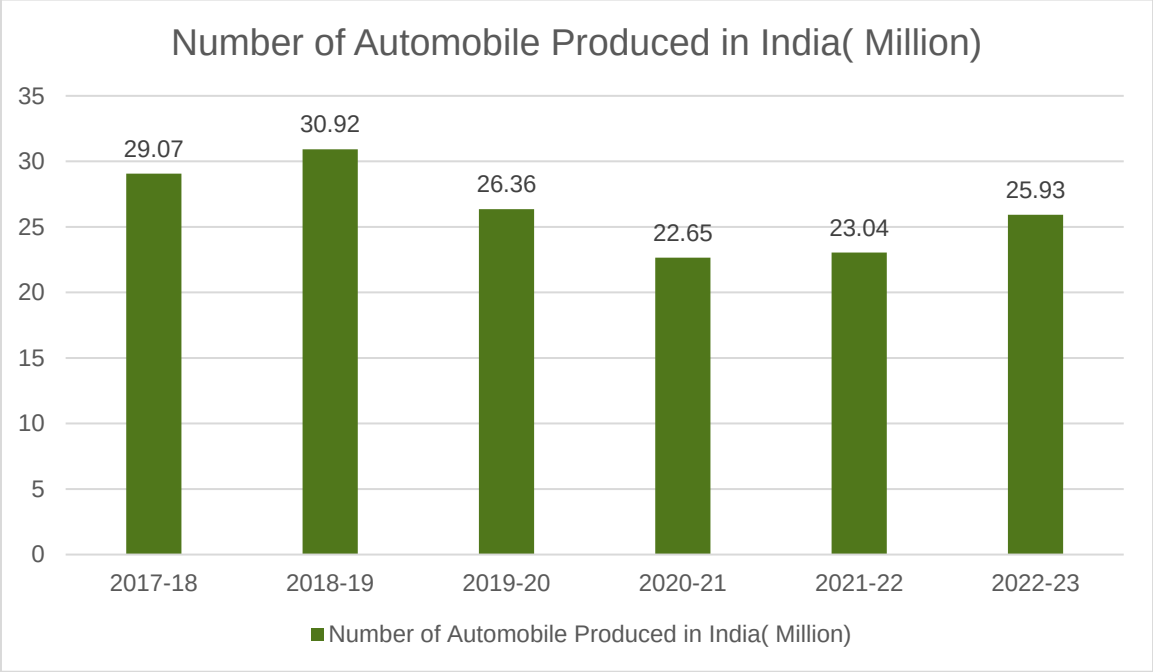


Figure 66:Production details of Automobiles

Indian automotive industry is targeting to increase the export of vehicles by five times during 2016-26. In FY23, total automobile exports from India stood at 4.77 million wherein there is 15% decrease in export of vehicles as compared to FY 22. Indian automobile exports of two-wheelers stood at 36,52,122 in FY23.

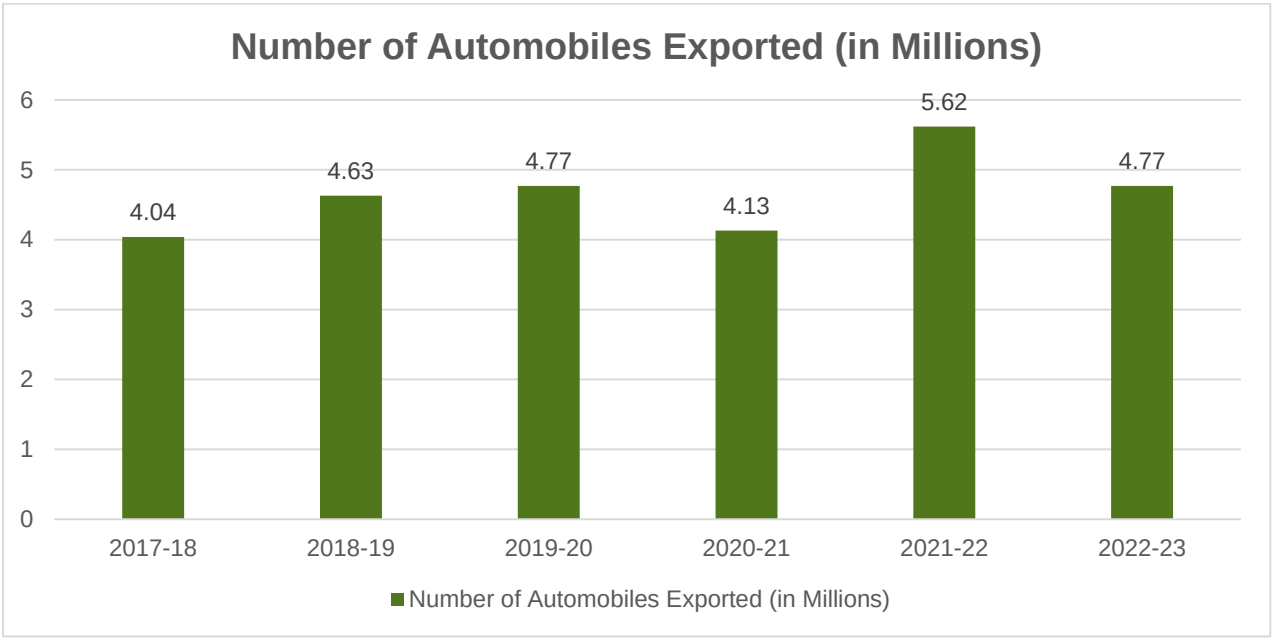


Figure 67:Number of Automobiles Exported from FY 18-23

Over the past few years four specific regions in the country have become large auto manufacturing clusters, each present with a different set of players.

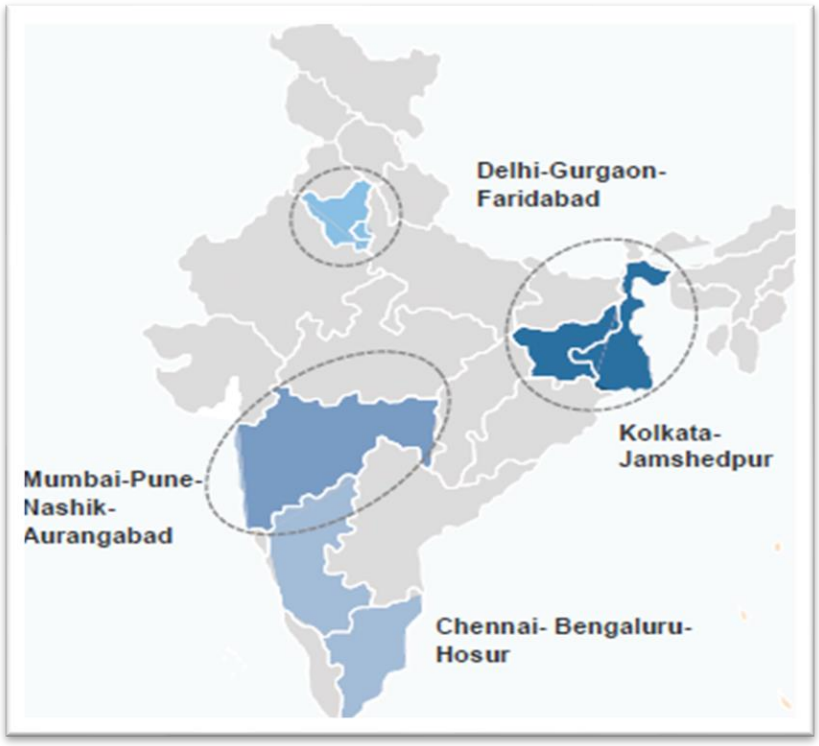


Figure 68:Major automobile manufacturing clusters in India[95]

Each segment in the Indian automobiles sector have few established key players, who hold a major portion of the market. Listed below are the key players in the automotive sector across various zones in India

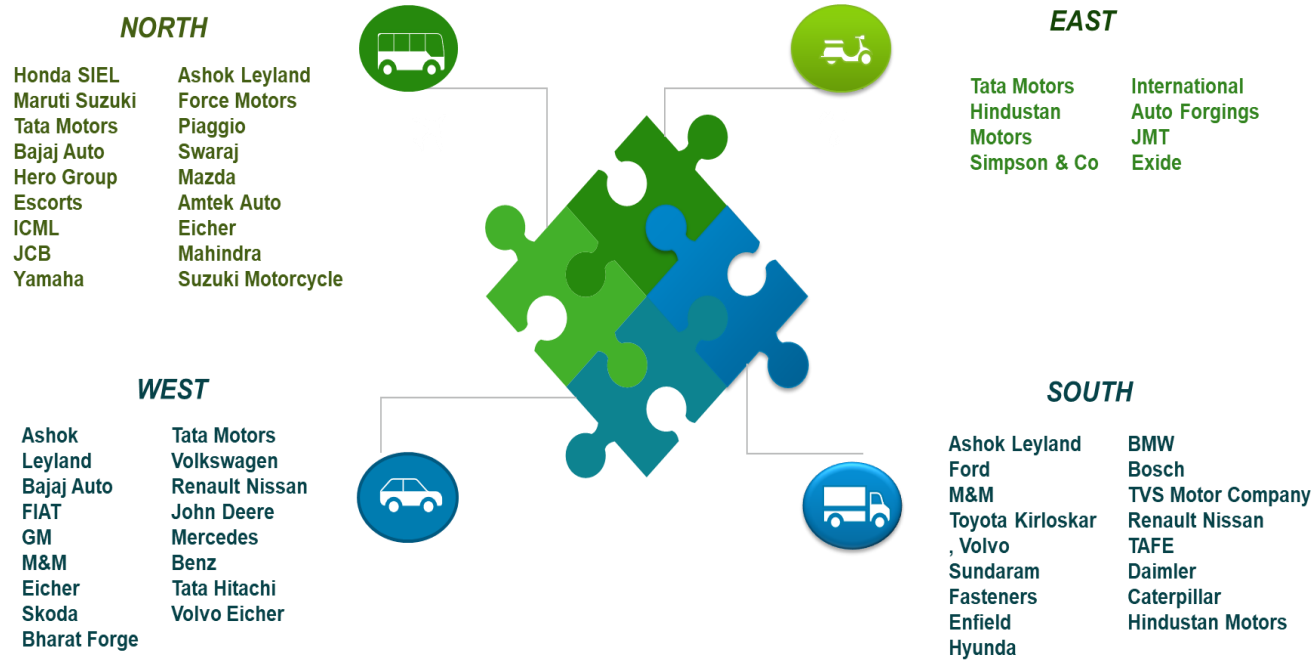


Figure 69:Cluster wise leading companies[96]

[95] Source: Automobile sector in India- IBEF August 2023
[96] Source: Automobile sector in India- IBEF August 2023

9.1. Vehicular pollution in India

Vehicle pollution in India has emerged as a critical environmental issue, posing significant challenges to air quality and public health. The rapid growth of urbanization and industrialization, coupled with a surge in the number of motor vehicles, has led to alarming levels of pollution across the country. One of the primary contributors to air pollution in India is the escalating number of vehicles on the roads. The increasing urban population, coupled with a rising middle class, has fueled a surge in the demand for personal vehicles.

Rapid urbanization is a prevailing trend in most Indian cities, with a significant portion of the population projected to reside in urban areas over the next two decades. Given that diminished air quality is predominantly an urban concern, this shift directly impacts millions of city residents. The substantial surge in motor vehicles, as highlighted earlier, is a consequence of India's swift urbanization. With the ongoing escalation in vehicle numbers and subsequent traffic congestion, automobiles are increasingly emerging as the primary contributors to air pollution in urban India.

The expansion and enhancement of road transport, commonly viewed as a driver of socio-economic progress, have, in the case of India, given rise to various adverse environmental issues. This includes a substantial increase in carbon dioxide (CO2) emissions and the release of air pollutants such as nitrogen oxides (NOX) and fine particulate matter, contributing to environmental challenges.

Road transport presently accounts for 12%[97] of India’s energy-related CO2 emissions and is a key contributor to urban air pollution. As India seeks to meet the increasing demand for private mobility and the transport of goods, energy use and CO2 emissions from road transport could double by 2050. The steadily increasing use of private cars and the expanding truck fleet, with continued reliance on gasoline and diesel, drive the rise. Two-wheelers continue to dominate India’s vehicle fleet, but due to fast electrification, their energy needs, and emissions start to decline in the mid-2020s.

[97] Source: Transitioning India’s Road Transport Sector Realizing climate and air quality benefits- IEA and NITI Aayog

Automotive vehicles emit several pollutants depending upon the quality of the fuel they consume and engine efficiency. The release of pollutants from vehicles also includes fugitive emissions of the fuel and the source and level of these emissions depending upon the vehicle type, its maintenance, etc. The major pollutants released as vehicle/fuel emissions are:

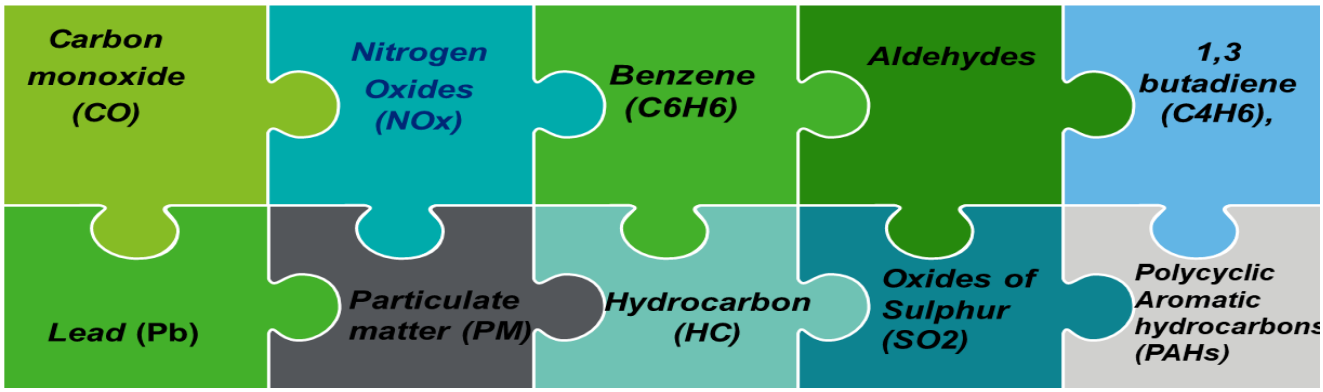


Figure 70: Major Vehicle Pollutants

While the predominant pollutants in petrol/gasoline driven vehicles are hydrocarbons and carbon monoxide, the predominant pollutants from the diesel-based vehicles are Oxides of nitrogen and particulates.[98]

As previously mentioned, the issue of air pollution resulted from motor vehicles stands out as a critical and swiftly escalating challenge in the urban areas of India. The severity of air pollution has reached alarming levels in several major metropolitan cities, with vehicular emissions identified as a significant factor contributing to the decline in air quality. This challenge is intensified by the concentration of many vehicles and relatively high motor vehicle-to-population ratios in these urban centers. The factors contributing to the escalating issues of vehicular pollution in urban India are outlined as follows:

[98] Source: Status of the Vehicular Pollution Control Program in India, CPCB

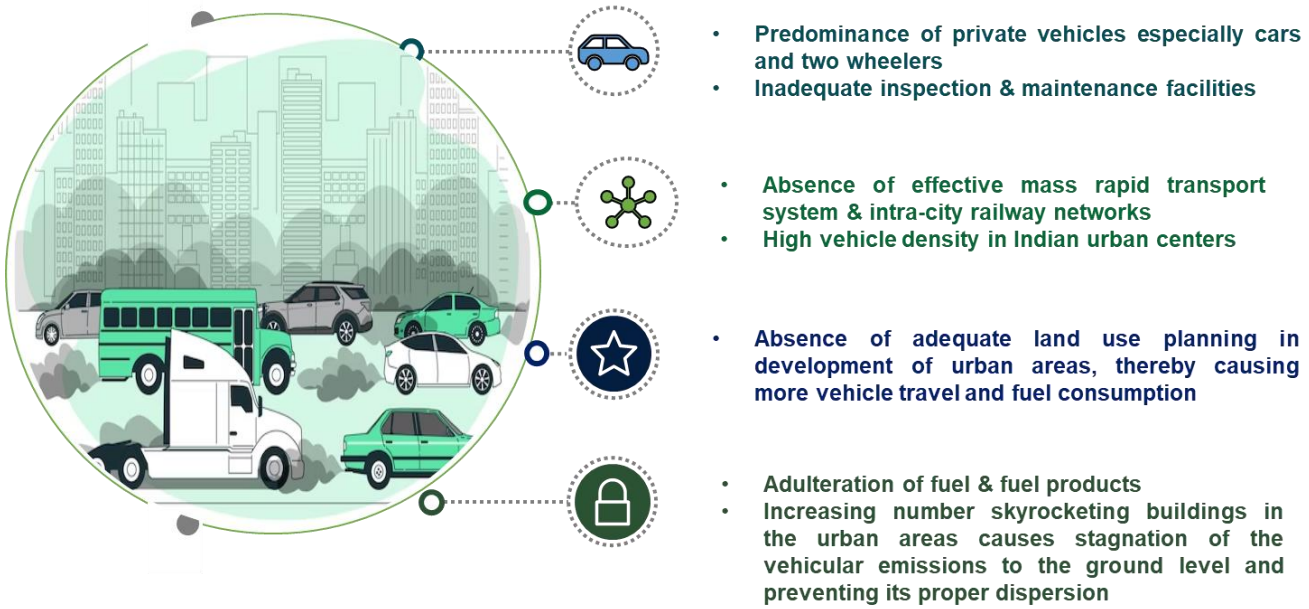


Figure 71: Factors for escalating issues of vehicular pollution in urban India

India is actively addressing this issue through various important measures. The Indian government is considering a revision of its ambient air quality standards and has enhanced both vehicular and industrial emission standards in recent times. The country is placing a considerable focus on the expansion of renewable energy, encouragement of electric vehicles, and widespread distribution of LPG cooking fuel to millions of households, illustrating its commitment to combating air pollution. Additionally, non-technical measures involve raising awareness about the potential economic and health impacts of air pollution, promoting the use of cleaner fuels and the adoption of vehicles equipped with advanced emission control devices, and enhancing the institutional framework and capacity for monitoring vehicle emissions.

The Government of India's National Clean Air Programme (NCAP) is a powerful step in acknowledging and resolving the problem of deteriorating ambient air quality***.*** It is launched as a comprehensive action plan with the goal of reducing air pollution levels across the country. It sets city-specific and time-bound targets for reducing particulate matter (PM10 and PM2.5) concentrations. The program focuses on a collaborative approach involving central, state, and local authorities to implement air quality management plans.

This section encompasses the fuel and emission savings resulting from the Corporate Average Fuel Efficiency (CAFE) norms implemented in India since April 1, 2017, as well as electric vehicles sold under the FAME India scheme by the Department of Heavy Industries. It also provides a concise overview of energy-saving initiatives within the Indian Railways system.

9.2. Savings under Corporate Average Fuel Economy (CAFE) implementation

On April 23rd, 2015, the Government of India's Ministry of Power introduced average fuel consumption benchmarks for cars. These standards apply to motor vehicles utilizing petrol, diesel, liquefied petroleum gas, or compressed natural gas. They encompass vehicles

designed for carrying passengers and their luggage, with a maximum of nine seats, including the driver's seat.

Corporate Average Fuel Efficiency (CAFÉ) norms were first notified by the Government in 2017, under the Energy Conservation Act, 2001 to mitigate fuel consumption by lowering CO_2 emissions; aiming to reduce 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) <3,500 kgs.

It relates the gasoline equivalent corporate average fuel consumption (in litres/100 km) to the corporate average kerb weight of all the cars sold by any original equipment manufacturer (OEM) in a fiscal year. The corporate average fuel consumption is estimated by averaging the standard fuel consumption of all vehicles sold each year. This fuel consumption is measured under standard conditions in nationally accredited labs. There is a limit set on the total emission of CO_2 emitted, as the amount of CO_2 a car emits has a direct correlation with the amount of fuel it consumes.

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.

Table 71:CAFÉ norms for passenger cars[99]

Parameter	CAFÉ norms stage I	CAFÉ norms stage II
Effective year	2017–18 onwards	2022–23 onwards
Average kerb weight (kg)	1,037	1,082
Fuel consumption (litres/ 100 kms)	< 5.5	< 4.78
Average CO_2 emissions (grams of CO_2/km)	< 130	< 113

The regulation provides super credits for battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and strong hybrid electric vehicles (HEVs). For the purpose of calculating the corporate average CO_2 performance, a manufacturer uses a volume derogation factor of 3 for BEVs, 2.5 for PHEVs, and 2 for HEVs. This means that a BEV counts as three vehicles, a PHEV as 2.5 vehicles, and an HEV as two vehicles in calculating fleet average CO_2 emissions. The fuel consumption of the electricity driving portion for BEVs and PHEVs is converted from electricity consumption based on an equation provided in the regulations.

Derogation factors for CO_2-reducing technologies aim to reward innovative technologies that produce real-world CO_2 savings beyond what is measured over a standardized test cycle during vehicle type approval. The compliance provisions allow manufacturers to use derogation factors for four CO_2-reducing technologies in calculating the corporate average CO_2 performance. The defined CO_2-reducing technologies include regenerative braking, start-stop systems, tire pressure monitoring systems, and 6-speed or more transmissions.

[99] Source: Policy Brief Fuel Efficiency Improvement and Emissions in Road Transport-TERI

9.3. Methodology to calculate savings under CAFE norms

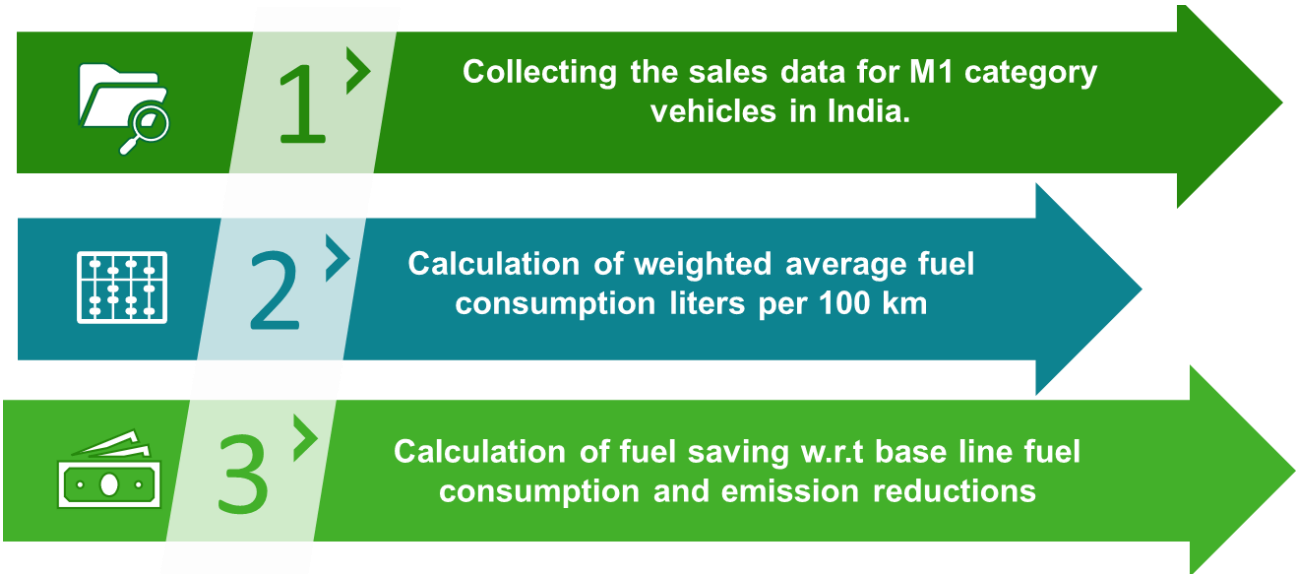


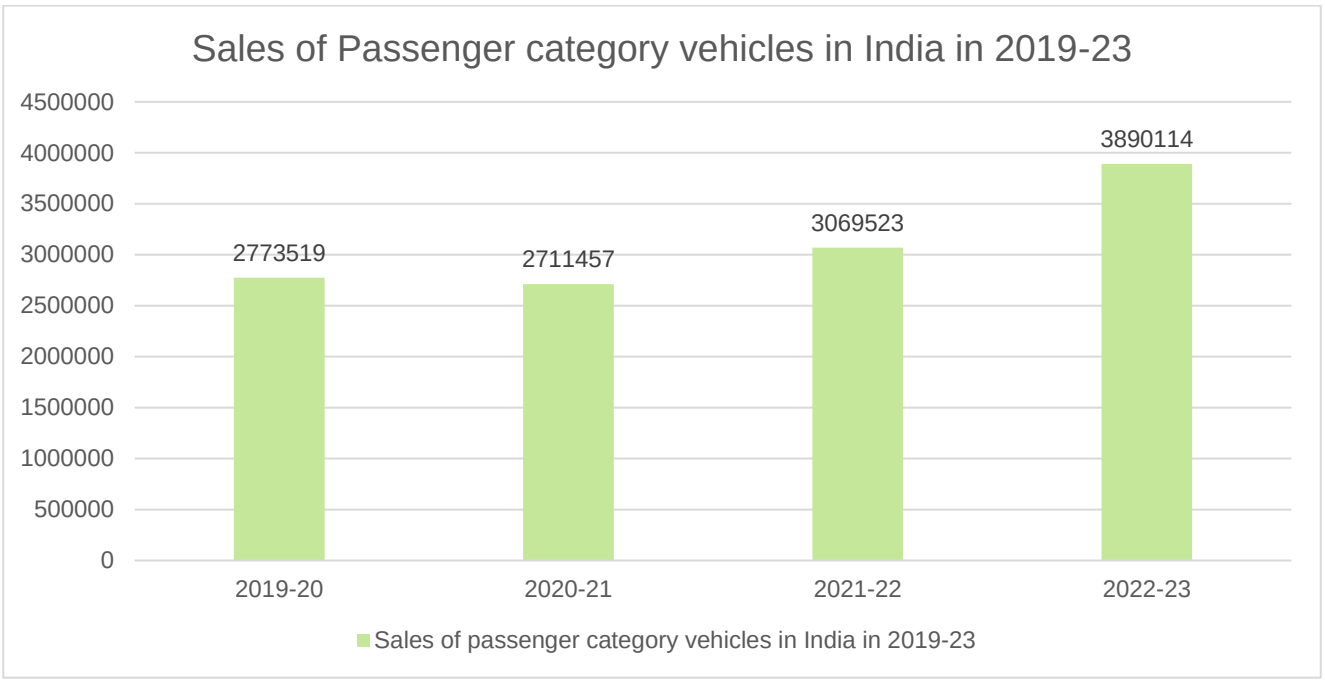
Figure 72:Methodology for saving calculation under CAFE norms

9.4. Energy and emission saving calculations

Sales data for passenger vehicle category was received from ICAT and is presented in Table 72 and Figure 73 (including petrol, diesel, CNG, EVs including includes pure electric, plug in hybrid and strong hybrid models):

Table 72: Sales of M1 category vehicles in India in 2019-23

Year	2019-20	2020-21	2021-22	2022-23
Sales	27,73,519	27,11,457	30,69,523	38,90,114



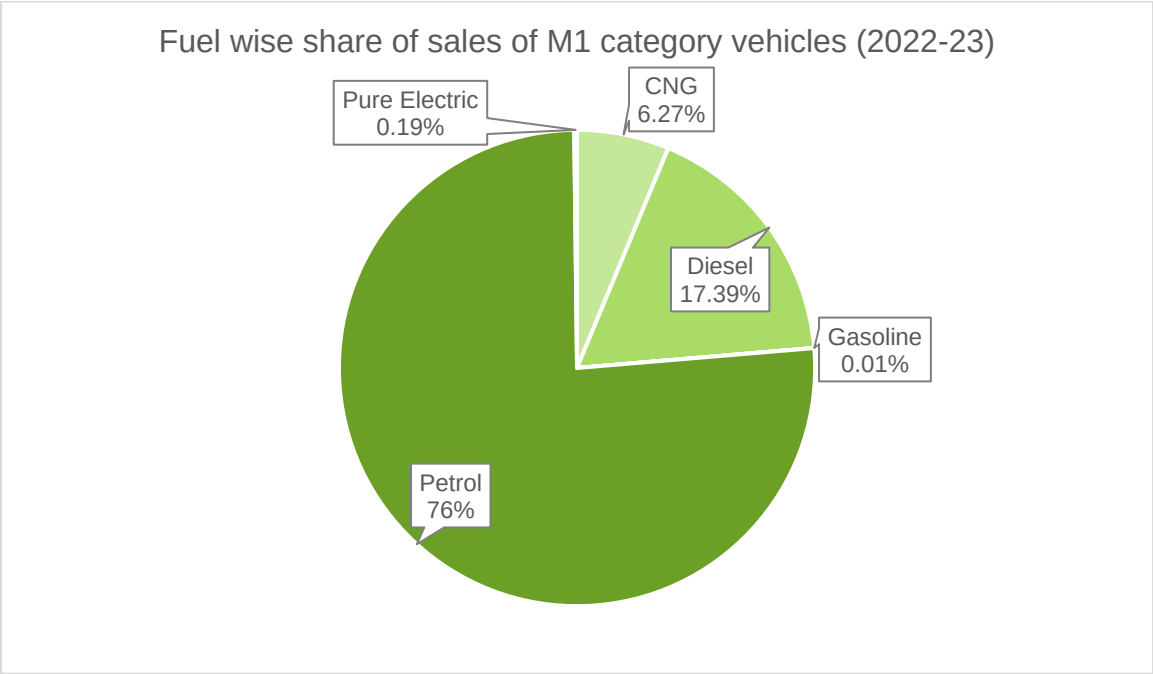


Figure 73: Fuel wise share of sales of M1 category vehicles (FY 2022-23)

Share of the petrol vehicles is highest (76.15%) followed the by the sales of the diesel vehicle (17.39%). Sales of the CNG vehicles were only 6.27% during the FY 2022-23.

Step-2: Calculation of fuel consumption per 100 km

The fuel consumption per 100 km for the vehicles sold during FY 2018-22 is 6.64, 6.65, 5.16 liters per 100. Value of baseline fuel consumption is calculated using the formula *0.0038*weight of vehicle +2.58.*

The actual fuel consumption in petrol equivalent is calculated by considering the fuel conversion factor of 0.04217 liters of petrol per 100 km, 10,000 km run of a passenger vehicle per year and the total number of registered vehicles. The fuel savings in the year 2022-23 in petrol equivalent is shown in Table 73

Table 73: Fuel savings (in Mtoe) for the FY 2022-23

	Sales of M1 category vehicles (22-23)	Petrol saving for 10,000 Kms (Litres)[100]
Grand Total	3080412	482212234.7

The cumulative energy savings in TOE for the FY 2019-23 is showcased in the Table 74:

[100] Assumptions taken for savings calculation:
a) GCV is taken as 11200 kCal/kg
b) Density is taken as 0.7087 kg/Litre
c) 10,000 running kms per annum per vehicle considered
d) Different fuels consumed by M1 category vehicles are converted into petrol equivalent for calculating the fuel savings

Table 74: Total energy savings for FY 2022-23

Year	Savings in Mtoe
Total energy savings in the FY 2022-23	**1.888**

The CO_2 emission savings for 2022-23 is presented in Table 75:

Table 75: CO_2 emission savings (in $MTCO_2$) in the FY 2022-23

Year	CO_2 emission reductions (Million tCO2)
Total emission reduction in the FY 2022-23	**4.41**

9.5. Accelerating E-mobility adoption in India

E-mobility adoption in India is gaining significant momentum as the country strives to address environmental concerns, reduce dependence on fossil fuels, and create a sustainable transportation ecosystem. The shift towards electric vehicles (EVs) is propelled by a combination of government initiatives, technological advancements, and a growing awareness of the environmental impact of traditional combustion engine vehicles.

The transport sector accounts for 18% of total energy consumption in India. This translates to an estimated 94 million tonnes of oil equivalent (MTOE) energy. If India were to follow the current trends of energy consumption, it would require an estimated 200 MTOE of energy supply annually, by the year 2030 to meet the demand of this sector. Now, this demand is being met mostly through imported crude oil, which therefore makes this sector vulnerable to the volatile international crude oil prices. Moreover, the sector also contributes an estimated 142 Million Tonnes of CO2 emissions annually, out of which 123 million tonnes is contributed by the road transport segment alone.[101]

Electric mobility is grabbing attention globally. Leveraging this wave will bring multiple environmental and economic gains for India. These include improved air quality, reduced dependence on imported fuel, reduced emission of greenhouse gases (GHG), improved plant load factor for the electricity grid, and the opportunity to be a leader within a rapidly growing global market.

[101]Source: Electric Mobility- Bureau of Energy Efficiency

The Government of India has identified electric mobility as a practical solution to address existing challenges, especially when complemented by inventive pricing models, suitable technology, and supportive infrastructure. Consequently, it has become a focal point for government attention. The government has announced that the country would shift to an entirely electric public transport along with 30%[1] electric private vehicles by 2030, lending a further push towards the goal of electrification.

As EVs do not have tailpipe emissions, the transition from traditional internal combustion engine vehicles to electric alternatives helps curb the release of pollutants such as nitrogen oxides (NOx) and particulate matter (PM) into the atmosphere, particularly in densely populated urban areas where air quality is a critical concern.

Electric vehicles (EVs) play a crucial role in mitigating greenhouse gas (GHG) emissions and reducing air pollution in India. The transportation sector is a major contributor to air pollution and carbon emissions, primarily due to the reliance on fossil fuel-powered vehicles. The adoption of electric vehicles brings about several environmental benefits.

Electric vehicles in India represent a pivotal solution to combat air pollution and reduce greenhouse gas emissions. Their adoption aligns with the country's commitment to sustainable development, cleaner energy sources, and a healthier living environment for its citizens. As technology advances and infrastructure develops, the role of electric vehicles in India's transportation sector is likely to become even more significant in the coming years.

EV’s capacity of energy storage could help support the uptake of clean energy by enabling seamless integration and use of variable renewable generation. These initiatives combined with smart grid and fostering RE power generation will help in decarbonization of the power sector, electric vehicles would also provide major contributions to keep the world on track to meet its shared climate goals.

The uptake of electric vehicles (EVs) in India has witnessed notable progress in recent years, driven by a combination of government initiatives, increasing environmental awareness, and advancements in EV technology. Major automotive manufacturers have also responded to this shift by introducing a variety of electric models, ranging from two-wheelers to four-wheelers, further diversifying the options available to consumers. As charging infrastructure expands and public awareness campaigns gain momentum, the uptake of EVs is poised to accelerate, positioning India as a key player in the global transition towards sustainable and eco-friendly transportation.

The increasing emphasis on electrifying India's automotive fleet from various sectors is becoming more pronounced, signaling the imminent presence of a significant number of electric vehicles in the country. Importantly, this push for electric vehicles is neither new nor sudden. India has been prioritizing electric mobility for an extended period. Despite prior efforts, the success of these initiatives was limited. However, with the recent and concerted push for electric vehicles by the government, the Indian automotive industry is actively preparing to ensure the success of the electric vehicle mission by 2030.

Considering the emerging market, the central government, in recent years, has boosted momentum through various policies aimed at fostering the adoption of electric mobility. India stands to gain significantly from transitioning to electric mobility, primarily realizing the following advantages:

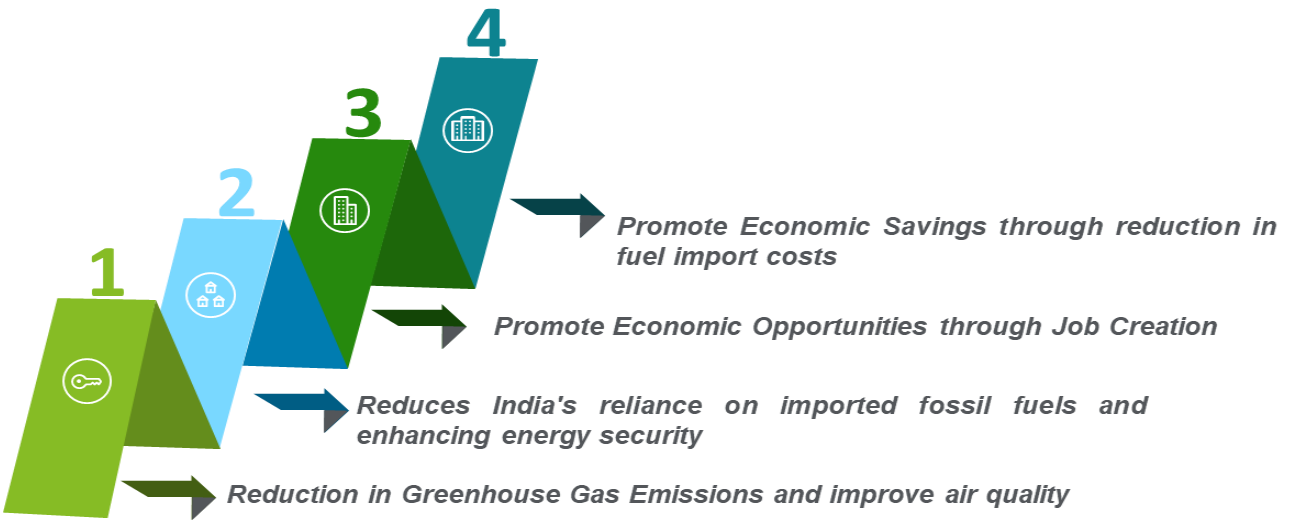


Figure 74: Benefits of transition to electric mobility

To reduce pollution caused by diesel and petrol operated vehicles and to promote electric or hybrid vehicles in India, the Central Government launched the Fame India Scheme in 2015.

Major initiatives undertaken in the last few years to promote EV and EVSE in India are mentioned below:

FAME-I

Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME-India) Scheme is launched under National Mission on Electric Mobility in 2011/ National Electric Mobility Mission Plan 2020, unveiled in 2013. The scheme aims to encourage progressive induction of reliable, affordable, and efficient electric and hybrid vehicles (xEV). The First Phase of the scheme was initially approved for a period of 2 years, commencing from 1st April, 2015.

It is under the framework of Demand Incentive Disbursement Mechanism. Incentive amount has been determined for each category of vehicle like Mild Hybrid, Strong Hybrid, Plug-in Hybrid and Pure Electric technologies and battery specification. It is implemented and monitored by National Automotive Board under D/o Heavy Industry. It is one of the DBT schemes categorized under in-kind mode.

The Scheme has been extended from time to time, with the last extension allowed for a period up to 31st March 2019 . The 1st Phase of FAME India Scheme was implemented through four focus areas namely:

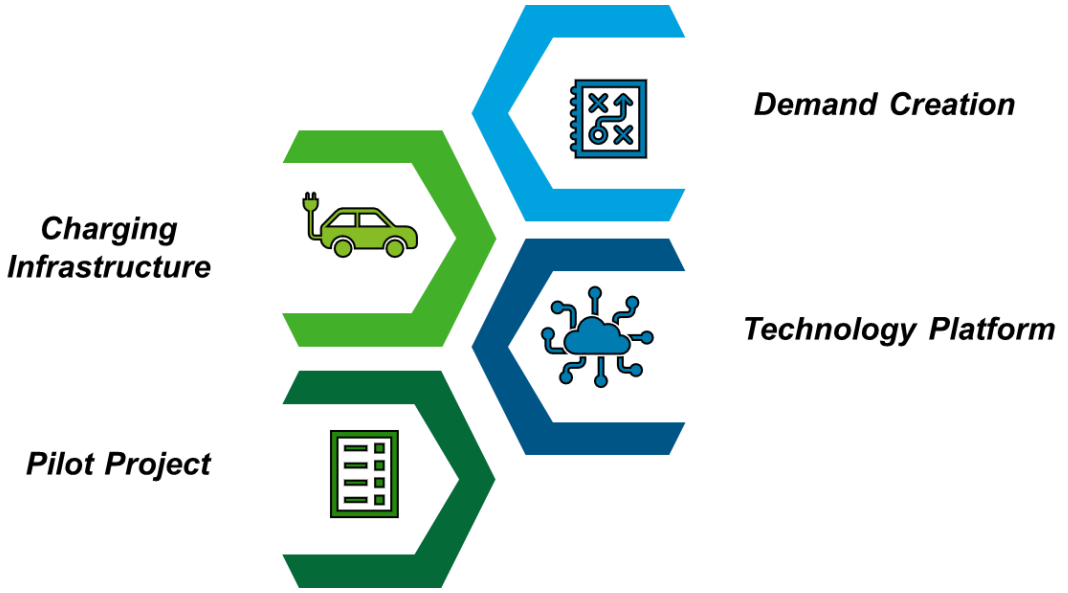


Figure 75:Focus Areas of FAME India

The demand incentive was available to buyers of EV in the form of an upfront reduced purchase price to enable wider adoption. Also, grants were sanctioned for specific projects under Pilot Projects, R&D/Technology Development and Public Charging Infrastructure components under the scheme.

The scheme was one of the most important green initiatives of the Government of India, which will be one of the biggest contributors to reduction of pollution from the road transport sector. Phase-1 of the scheme was approved initially for a period of 2 years, commencing from 1st **April 2015 *i.e.* FY 2015-16 and FY 2016-17, with an outlay of 795 crore**. The duration of Phase-1 of the scheme was extended from time to time and the last extension was allowed up to 31st March 2019, with enhancement of total outlay to **895 crores**.

The funds were used to provide direct subsidy to the EV buyers. Along with direct subsidy, grants for specific projects under pilot projects were sanctioned along-with financial support for R&D/technology development and public charging infrastructure. Under the FAME-I scheme, 465 buses were sanctioned to various cities/states. It promoted some 2,80,000[102] hybrid and EV sales, leading to an estimated 50 million liters of saved fuel and prevented 1,30,000 tCO_2.

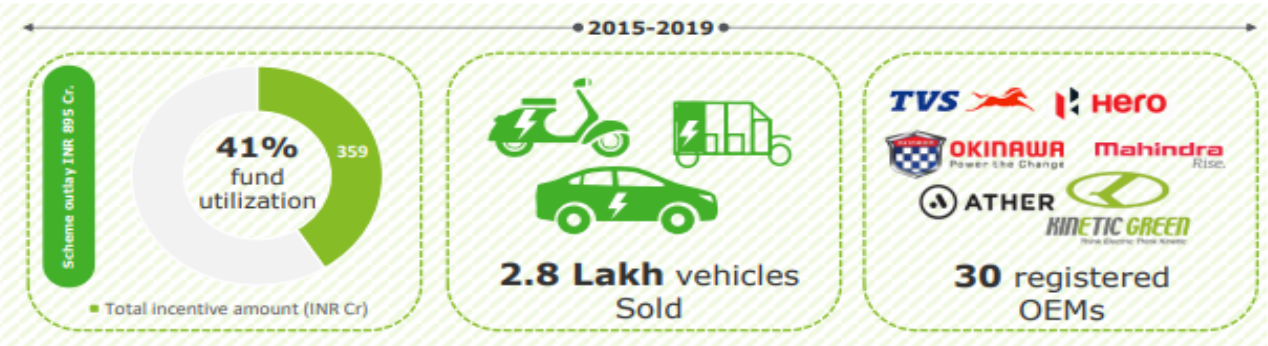


Figure 76: Snapshot of FAME I Scheme

Image Source: Niti Aayog

[102] Source: Transitioning India's Road Transport Sector Realizing climate and air quality benefits- IEA and NITI Aayog

Achievements of Phase-1 of FAME India Scheme:

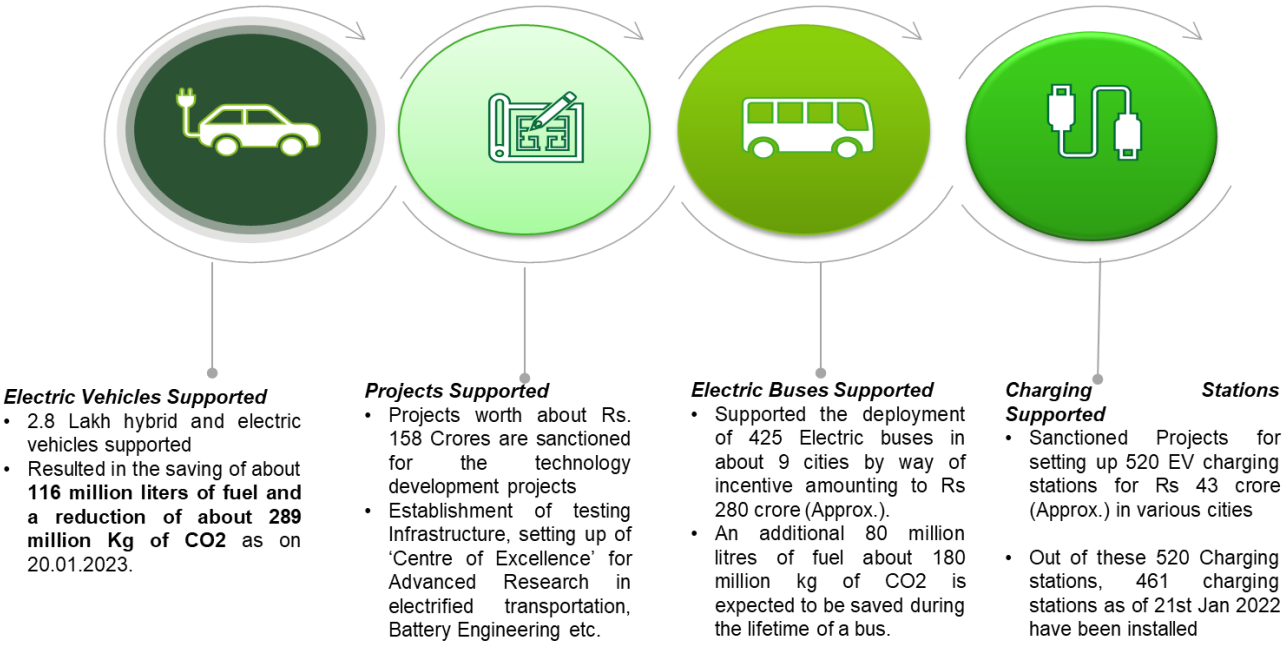


Figure 77: Achievement of Phase-1 of FAME India[103]

FAME-II

Based on the experience gained during Phase 1 of FAME Scheme and suggestions of various stakeholders, the Department of Heavy Industry notified Phase-II of the Scheme, with the approval of Cabinet. Phase-II of the scheme is for a period of 3 years, commencing from 1st April 2019, with an outlay of INR 10,000 crore.

Out of total budgetary support, about 86% of fund has been allocated for Demand Incentive so as to create demand for Electric Vehicles (xEVs) in the country. This phase aims to generate demand by way of supporting ***7210***[104] ***Electric Buses (e-bus), 5 lakh Electric Three Wheelers (e-3W), 55000 Electric Four Wheeler Passenger Cars (including Strong Hybrid) (e-4W) and 10 lakh Electric Two Wheelers (e-2W)*** . The Timeline of FAME India Scheme[105]:

[103] Source: Annual Report of Ministry of Heavy Industries FY 22-23
[104] Source: Annual Report of Ministry of Heavy Industries FY 22-23
[105] Source: https://fame2.heavyindustries.gov.in/content/english/16_1_Timeline.aspx

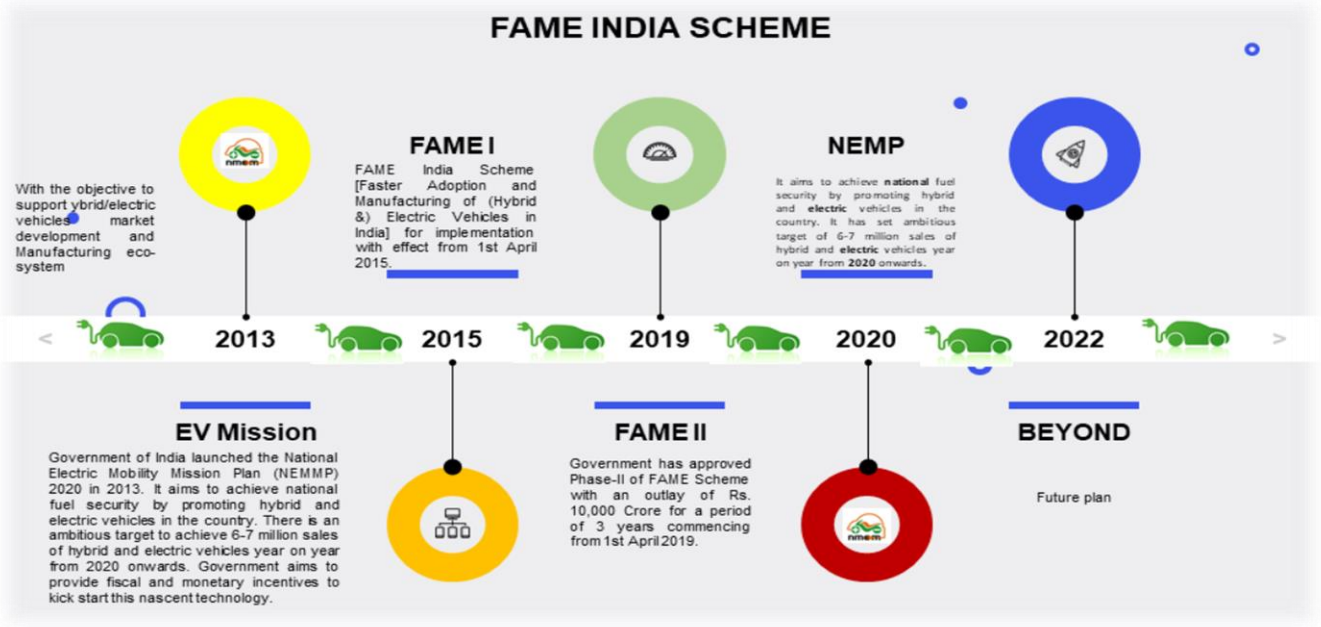


Figure 78: Timeline of FAME Scheme

The primary objective of the scheme evolves around accelerating the nationwide transition towards electric mobility. FAME-II seeks to incentivize the adoption of electric and hybrid vehicles across various segments of the automotive industry. This initiative aims to reduce vehicular emissions, minimize dependence on fossil fuels, and promote cleaner, sustainable modes of transportation. By providing financial incentives, fostering domestic manufacturing of electric vehicles and components, and developing essential infrastructure like charging stations, FAME-II endeavours to create a conducive environment for the widespread acceptance of electric vehicles, aligning India's transportation sector with global sustainability goals while bolstering the country's economic and environmental resilience. The subsidies that have been provided under the scheme are presented in Table 76:

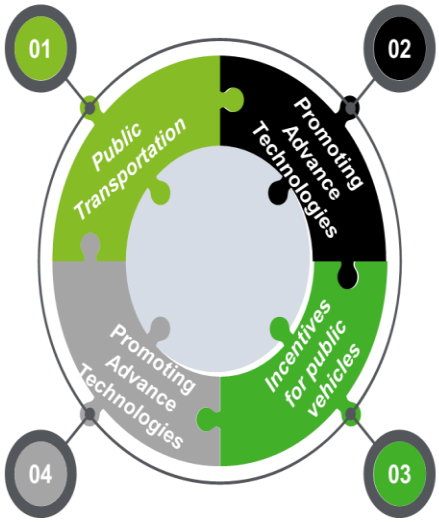
Table 76: Subsidies under FAME-II

Vehicle segment	No. of vehicles supported	Approx. size of battery	Total incentive (INR)	Max. ex-factory price to avail incentive
Electric 2W	10,00,000	2 kWh	20,000	1.5 lakhs
Electric 3W	5,00,000	5 kWh	50,000	5 lakhs
Electric 4W	35,000	15 kWh	1,50,000	15 lakhs
4W strong hybrid	20,000	1.3 kWh	13,000	15 lakhs
Electric Bus	7,090	250 kWh	50,00,000	2 Crores

In the second phase of the FAME scheme, more emphasis will be given on:

- Electrification of public transportation, which includes shared transport
- Demand Incentives on the operational expenditure model for electric buses will be delivered through State/city transport corporations (STUs)

Creation of charging infrastructure will be supported in selected cities and along major highways to address range anxiety among users of electric vehicles under the Scheme



- To promote advanced technologies, incentives will exclusively apply to vehicles equipped with cutting-edge batteries such as Lithium-Ion and other emerging battery technologies.

- In 3W and 4W segments, incentives will be applicable mainly to vehicles used for public transport or registered for commercial purposes. In the e-2Ws segment, the focus will be on private vehicles.
- Create demand by way of supporting 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars and 10 lakh e-2 Wheelers

Figure 79 : Focus Areas of FAME II[106]

The Salient features of FAME India Scheme Phase II is depicted in the figure below:

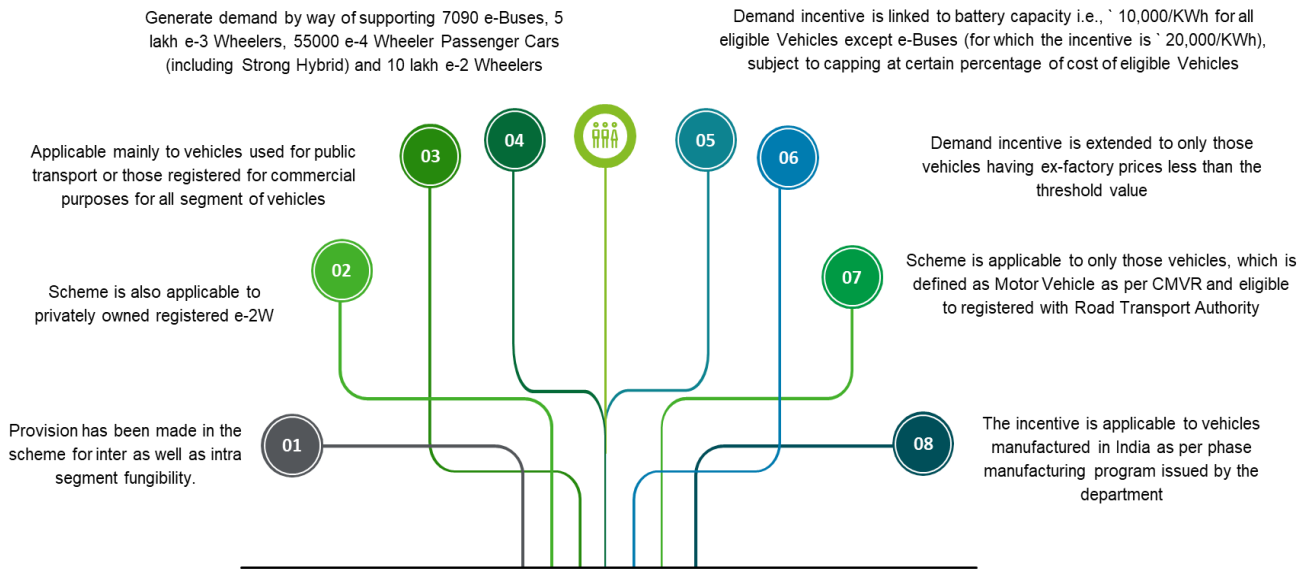


Figure 80: Salient features of FAME India Scheme Phase II

So far, as of 9th December 2022, 64 OEMs have registered their 135 EV Models for availing benefit of demand incentives under Phase-II of FAME Scheme as showcased in Table 77[107]:

Table 77: Registered OEMs in FAME II till 9th December 2022

Registered OEMs			Total Registered OEMs
Electric 2W	Electric 3W	Electric 4W	
26	36	2	**64**

[106] Source: Cabinet approves Scheme for FAME India Phase II-PIB Ministry of Heavy Industries
[107] Source: Ministry of Heavy Industries Annual Report 2022-23

Table 78 : Registered EV Models in FAME II till 9th December 2022

Registered EV models			Total Registered EV models
Electric 2W	Electric 3W	Electric 4W	
43	83	9	**135**

About 7,47,991 EVs have been incentivized to the eligible user of the electric vehicle under the FAME II Scheme as shown in the Table 79[108]:

Table 79: Sale of Electric Vehicles in FAME II till 9th December 2022

Sale of Electric vehicles			Total Sale of EVs for availing benefits
Electric 2W	Electric 3W	Electric 4W	
671644	70912	5,435	747991

Launch of 'EV-YATRA PORTAL' and Mobile App

The Bureau of Energy Efficiency has developed a Mobile Application to facilitate in-vehicle navigation to the nearest public EV charger, a website to disseminate information on various central and state-level initiatives to promote e-mobility in the country, and a web portal to enable CPOs to register their charging details securely into the National Online Database. In December 2022, President Droupadi Murmu unveiled an EV yatra portal and a mobile application that effectively enables in-vehicle navigation to the closest public EV charger.

The Mobile application titled "EV Yatra" has been designed and developed to facilitate in-vehicle navigation to the nearest public EV charger. This Mobile application can be easily downloaded on both iPhone and Android smartphones from Google Play Store and Apple Store and installed conveniently.

Initiative for the development of the Public Charging EV Infrastructure

The availability of user-friendly public charging infrastructure is one of the key requirements for accelerating the adoption of electric vehicles in India. In this regard, the Ministry of Power recently issued the revised consolidated Guidelines and Standards for EV charging infrastructure on January 14, 2022. The Government of India has undertaken multiple initiatives to promote the manufacturing and adoption of electric vehicles in the country. With the considerable expansion in the public EV charging infrastructure, the electric vehicles have started penetrating the Indian market.

Table 80: Electric Vehicle Sale in India[109]

Category	2019-20	2020-21	2021-22	2022-23
E-2 Wheelers	26834	44803	252641	728054
E-3 Wheelers	143051	90898	172543	401882
E-4 Wheelers	2404	5201	19782	48105
E-Buses	369	373	1198	1917
Grand Total	**172658**	**141275**	**446164**	**1179958**

[108] Source: Ministry of Heavy Industries Annual Report 2022-23
[109] Source: https://www.smev.in/statistics

Demand Incentive for E-buses through Grand Challenge (Aggregation Model):

Ministry of Heavy Industries vide Gazette notification dated 11th June 2021, nominated EESL to aggregate demand for E-Buses under FAME -II, in 9 major cities having population of over 4 million (Mumbai, Delhi, Bangalore, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat, and Pune). CESL (wholly owned subsidiary EESL) issued Grand Challenge document on 30th Sep 2021, of the demand for 5,450 e-buses which is received from 5 of the 9 nominated cities out of which 3,472 subsidies allocated under Allocation under FAME-II. Total demand allocation of e-buses city wise under GCC tender is as under:

Table 81: Demand Allocation of E-Buses City Wise[110]

City	Allocation under FAME-II (pro-rata basis)
Delhi	921
Bangalore	921
Hyderabad	300
Surat	150
Kolkata	1180
TOTAL	**3472**

Thus, under FAME-II scheme, a total of 3738+3472=7210 e-buses will be eventually deployed in the various States.

Under Phase II, Ministry has also sanctioned 2877 EV charging stations in 68 cities across 25 States/UTs. Letters of Award are being issued to the selected entities after ensuring the availability of land for Charging Stations, signing of necessary agreements/MoU with concerned partner organizations like City Municipal Corporation/ Discom/ Oil companies etc.

Letters of award for 1822 EV Charging Stations have been issued as on 09th December 2022. Out of these 1822 EV Charging Stations total of 83 EV Charging stations are commissioned and under operational as of 09th December 2022.

Further, 1576 charging stations across 9 Expressways and 16 Highways under phase-II of FAME India Scheme has also been sanctioned. Government has taken several steps for creating the public EV charging infrastructure and building the road map for cleaner transport for the Nation.

Under the Chairmanship of Hon'ble Minister of Heavy ndustries a conference to promote E-Mobility was organized ***on 7th Oct 2022 at Kevadia*** which was attended by the hon'ble Chief minister/Gujarat, Hon'ble MoS/MHI, Secretary Heavy Industries, Transport Ministers of States, senior officials from Central Govt/States/UTs, CEOs/Industry Leaders/Senior officials from the Automobile sector, Start-ups and Technical experts. The highlight of the event was the flagging ***off of Electric buses sanctioned under FAME-II for Gujarat & Karnataka and the exchange of views between the different stakeholders for faster uptake of Electric/Green Vehicles.***

[110] Source: Ministry of Heavy Industries Annual Report 2022-23

9.6. Methodology to calculate fuel savings from adoption of EVs

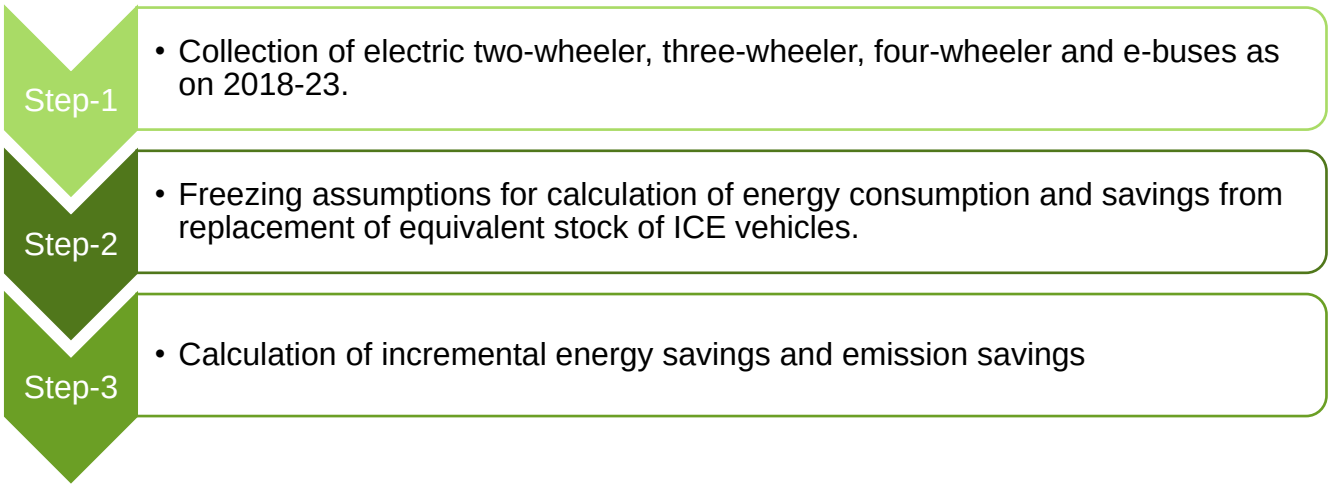


Figure 81 : Methodology for fuel saving estimation due to EVs

9.7. Energy and emission saving calculations

Step-1: Collection of electric 2W, 3W, 4W and Buses data

Under FAME-I scheme 2.8 lakh hybrid and electric vehicles were supported under a total demand incentive disbursement of INR 359 crores. The number of electric vehicles (excluding hybrids) supported under the scheme as on 2022-23 is presented in Table 82:

Table 82: Number of EVs supported under FAME-I and FAME -II (as of March 2023)

Vehicle segment	Number of vehicles supported FAME -I	Number of vehicles supported FAME -II
e- 2-wheeler	1,70,000	1,19,000
e- 3-wheeler	2598	20,420
e- 4-wheeler	12,447	5080
e-buses	400	835
Total	185445	145335

As showcased in the Table 82, a total of 1.4 lakh Electric vehicles (1.19 Lakh electric two-wheelers, 20.42 K electric three-wheelers and 580 electric four-wheelers) have been incentivized in FY 2022-23.

Step 2: Assumptions for various categories of electric vehicles

Following are the assumptions that have been considered for deriving the energy savings and CO_2 emission savings for various category of EVs under FAME-I is presented in Table 83.

Table 83: Assumptions for electric vehicles

Parameters	Electric 2W	Electric 3W	Electric 4W	Electric Buses
Range	50 km	80 km	110 km	200 km
Battery Capacity	2 kWh	7.5 kWh	15 kWh	250 kWh
Total Yearly run	10000 km	36500 km	30000 km	70000 km
CO_2 Emission factor	0.71 tCO_2/MWh[111]			

To compare the energy and emission reductions by adoption of various category of EVs, it is also necessary to calculate the equivalent energy consumption and CO_2 emissions from same number of ICE vehicles. The following are the assumptions that were considered for ICE category of vehicles, details are presented in Table 84 below:

Table 84: Annual running (Kilo meter) for ICE vehicles

Parameters	2-wheeler	3-wheeler	4-wheeler	Buses
Mileage	48 km/l	35 km/l	15 km/l	8 km/l
Fuel type	Petrol	Petrol	Petrol	Diesel
Total Yearly run	10000 km	36500 km	30000 km	70000 km
CO_2 emission factor[112]	44 g/km	92 g/km	231 g/km	1056 g/km

Step-3: Calculation of energy and emission savings

Of the 6,265 electric buses already sanctioned under FAME II, around 928 buses are on the road. These buses are already proving their role in the battle towards reducing carbon emissions.

The energy savings and CO_2 savings were calculated by estimating differential energy consumption and CO_2 emissions, had the same amount of ICE vehicles been purchased instead of EVs. The overall energy and CO_2 emission savings for 2022-23 are given in Table 85

Table 85: Energy and CO_2 savings in 2022-23[113]

Particular	Energy savings in Mtoe	CO_2 emission savings in $MtCO_2$
Total savings in the FY 2022-23	0.145	0.532

[111] Source: https://cea.nic.in/wp-content/uploads/baseline/2023/01/Approved_report_emission__2021_22.pdf
[112] https://shaktifoundation.in/wp-content/uploads/2017/06/WRI-2015-India-Specific-Road-Transport-Emission-Factors.pdf
[113] Fame I savings are reflected

9.8. Achievements under FAME India Scheme Phase II

As on December 2022 under FAME India Scheme Phase II, following has been achieved:

- **OEMs and Vehicle Models:** As on 9th December 2023, 60 OEMs have registered their 135 EV Models for availing benefit of demand incentives under Phase-II of FAME Scheme. About 747991 EVs have been incentivized to the eligible user of the electric vehicle under the Scheme.
- **Sanction of Electric Buses:** In order to promote electric mobility in public transport, the Department has invited the proposal from cities and state transport corporations through an Expression of Interest for deployment of Electric Buses under Operation cost model basis. After examining the proposal, the department sanctioned 6315 no of e-buses to 65 cities for intra-city and intercity operations across 26 states/ UT under the Scheme. Out of these 6315 electric buses, Supply Orders for about 3738 electric buses for intra-city, inter-city operation and last-mile connectivity have been issued as on 09th December, 2022. Out of these 3738 buses, 2435 electric buses have been deployed
- **Sanction of Charging Infrastructure:** To address the issue of range anxiety, the Department of Heavy Industry issued an Expression of Interest (EoI) inviting Proposals from Urban Local Bodies (ULBs)/municipal corporations, PSUs (State/Central) and public/private entities desirous for the deployment of EV charging infrastructure in different states/cities for availing incentives under Fame India Scheme Phase II. Thereafter, the Department sanctioned 2877 Electric Vehicle Charging Stations in 68 cities across 25 States/UTs under the FAME India (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India) scheme phase II. Letters of award for 1822 EV Charging Stations have been issued as of 09th December 2022. Out of these 1822 EV Charging Stations total of 83 EV Charging stations are commissioned and operational as on 09th December 2022.

  Further, 1576 charging stations across 9 Expressways and 16 Highways under phase II of the FAME India Scheme have also been sanctioned.
- **Promotional activities of EVs:** Under the Chairmanship of Hon'ble Minister of Heavy Industries a conference to promote E-Mobility was Organized on 7th October 2022 at Kevadia which was attended by Hon'ble Chief Minister/Gujarat, Hon'ble MoS/MHI, Secretary Heavy Industries, Transport Ministers of States, senior officials from Central Govt/ States/UTs, CEOs/Industry Leaders/Senior officials from the Automobile sector, Start-ups and Technical experts

9.9. Energy efficiency in the Railway Sector

Indian Railways, a government-owned enterprise under the jurisdiction of the Ministry of Railways in India, operates and manages an extensive network that spans thousands of kilometers, effectively encompassing the entire nation. It stands as the fourth-largest railway system globally, following the United States, China, and Russia. The Railways Board, holding a monopoly on rail services provision in India, is responsible for overseeing the entire infrastructure.

Indian Railways (IR) is one of the world's largest rail networks, spread over 68000 route Km. IR is the lifeline of the country carrying nearly 23 million passengers every day making it the largest passenger carrying system in the world. Rail-based transport is the most environment friendly mass transport system due to the inherent gains it provides in terms of energy efficiency and resource optimization. Railways are about 12 times more efficient in freight traffic and 3 times more efficient in passenger traffic as compared to road transport.

Annually, the Indian Railways utilizes more than 20 billion kWh[114] of electricity, accounting for approximately 2% of the nation's overall power consumption. Additionally, it relies on primary energy sources, predominantly diesel. The Indian Railways consumes approximately 2.5 billion units[115] of electricity for non-traction usage, spending about INR 1,700 crores per annum. This points to significant potential in saving energy in the Indian Railway. This has also been recognized by BEE, and various traction units and production units of the Indian Railways have been identified as designated consumers in the second cycle of the Perform Achieve and Trade (PAT) scheme of BEE.

Indian Railways is divided into two categories i.e. Traction and Non-Traction. All traction zonal railways having the annual energy consumption for traction of 70,000 metric tonne of oil equivalent (Mtoe) per year and above are considered as DC and for non-traction system all production by name and above are considered as DC. In PAT Cycle II, 16 Zonal Railways and 6 production units are included[116].

Indian Railways exceeded the targets set under PAT-II and achieved additional energy savings of 1,18,790 TOE, totaling to 1,95,894 TOE. The emission reduction through the implementation of PAT Cycle-II is about 1 million tonnes of CO2[117]. Under PAT-II Cycle, Railways earned 1,18,790 'Escerts' to the tune of approx. Rs.5.3 crore.[118] The continuous efforts of Ministry of Railways and Zonal Railways to embrace various energy efficient technologies and energy conservation measures had resulted in bagging 11 National Energy Conservation Awards (NECA) 2021 year.

[114] Source: IR Annual Environmental Sustainability Report 2020-21
[115] Source: https://shaktifoundation.in/wp-content/uploads/2020/03/Energy-Efficiency-in-Indian-Railways.pdf
[116]Source: https://shaktifoundation.in/wp-content/uploads/2020/03/Energy-Efficiency-in-Indian-Railways.pdf
[117] Source: https://beeindia.gov.in/sites/default/files/Outcomes%20PAT%20cycle%20-II.pdf
[118] Source: IR Annual Environmental Sustainability Report 2020-21

Over the years, Indian Railways, has taken significant measures towards promoting energy efficiency in both traction and non-traction areas. Indian Railways uses a mix of electric and diesel traction. The total electricity and diesel consumption in traction energy in Indian Railways over the years is presented in the figures below:

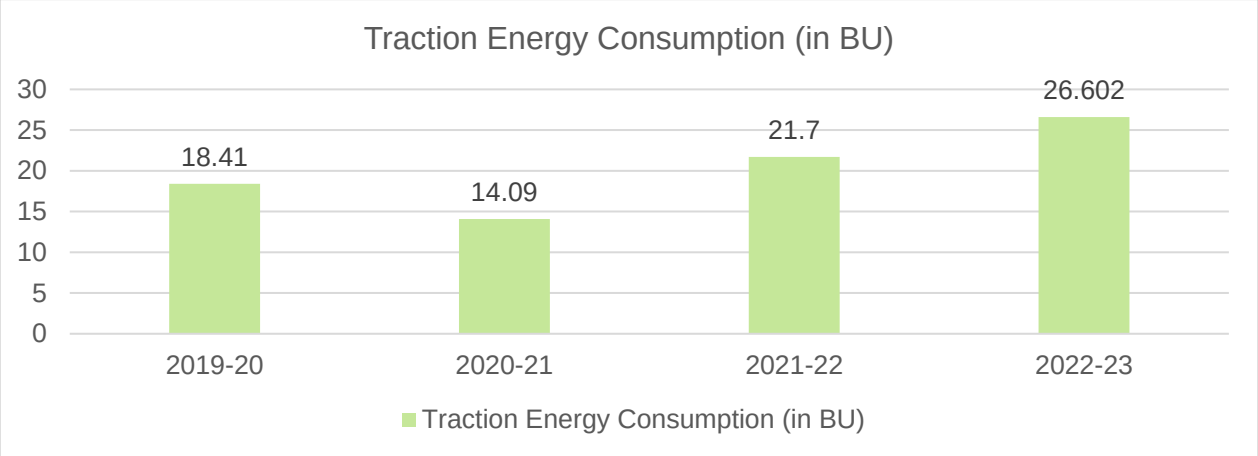


Figure 82: Traction energy consumption by Railways[119]

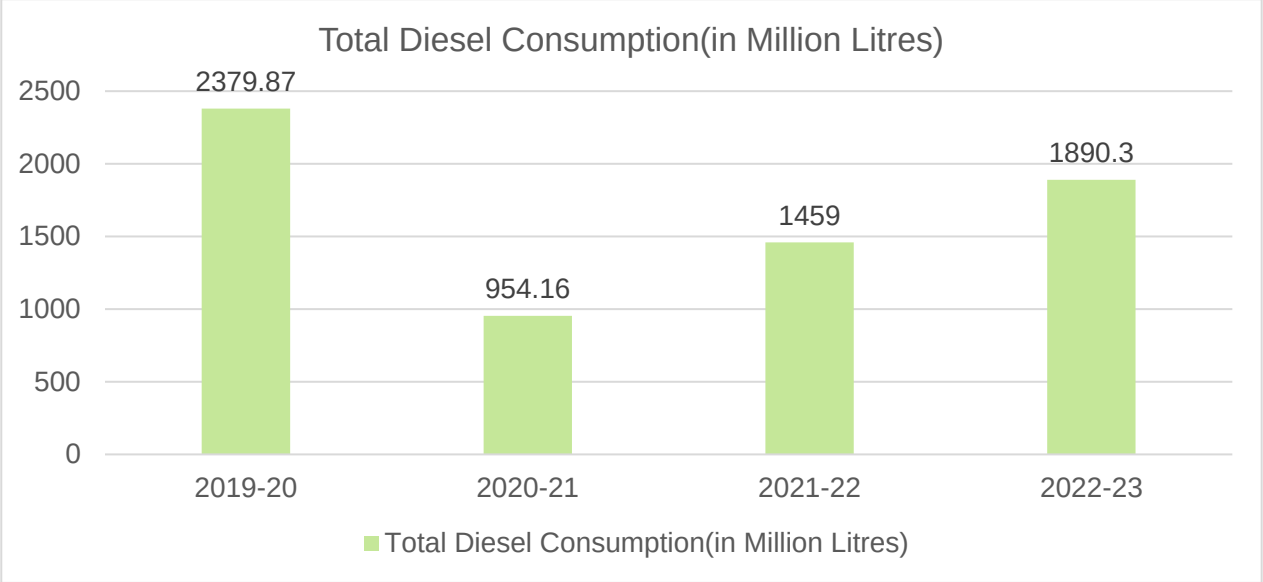


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Figure 83: Consumption of Fuel by Locomotive[120]

The total energy consumption of the locos also went up from 21.7 BU in the year 2021-22 to 26.60 BU in the year 2022-23 as showcased in the Figure 82 above. The percentage increase in the energy consumption of the locos was around 22.06% in the year 2022-23 as compared to the previous year.

Non-traction energy

[119] Indian Railways
[120] Indian Railways

With a view to reduce energy consumption in non-traction area, Indian Railways has initiated various measures. IR consumed around 2.453 BU of electricity for its non-traction usage in the year 2022-23.

The consumption of non-traction energy has largely been static from 2008 onwards, despite increase in electric load (lifts & Escalators) and addition of railway assets on stations buildings such as air-conditioned waiting rooms, new platforms, etc. an indication of efficacy of energy conservation efforts of Indian Railways. However, during the COVID-19 pandemic, the non-transaction energy consumption has also reduced, due to less intake of energy by the manufacturing workshops, maintenance depots, Station area, Platforms, etc. Over the last few years, there has been an increase in the electricity consumption which can be attributed to the significant increase in the route electrification in the same period, as shown in the figure above. To counter this increase, the Indian railways has taken several steps to reduce the energy consumption in the traction segment. Some of these initiatives have been mentioned below:

Mission Electrification:

It is one of the biggest initiatives taken by Indian Railways for switching over energy efficient mode of traction i.e. from diesel to electric. With a view to reduce the Nation's dependence on imported petroleum-based energy and to enhance energy security to the Country as well as to make the Railway System more eco- friendly and to modernize the system, Indian Railways have been progressively electrifying its rail routes. In FY 2022-23, electrification on Indian Railways has been extended to 56,959 RKMs. The progress of electrification of the railway RKM in the last 2 decades is showcased in Table 86[121]:

Table 86: Progress of electrification of railway RKM in the last 2 decades

Year	Cumulative Electrified (RKM)
2001	14,856
2011	19,008
2018	29,228
2019	34,319
2020	39,329
2021	44,802
2022	50,394
2023	56,959

Total 6565KM has been electrified during the year 2022-23. Total electrification of the railway track for the FY 2019-23 is showcased in the figure below:

[121] Indian Railways

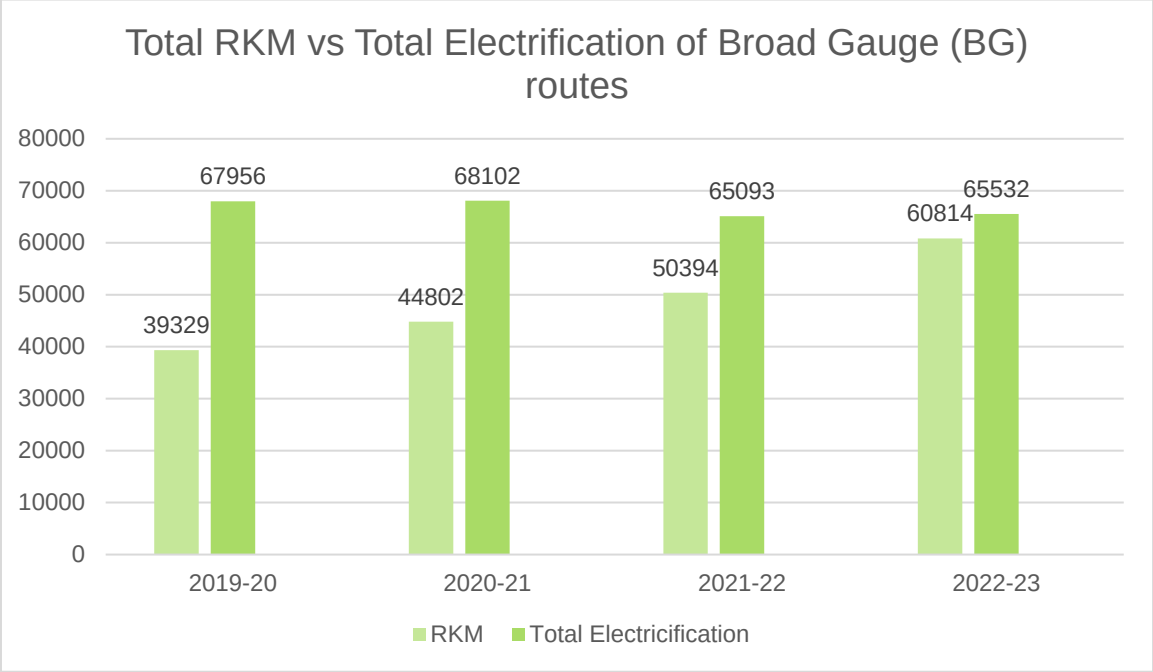

Figure 84: Route electrification in Indian Railways[122]

3-phase regenerative locomotives: The Indian Railways has decided that all new locomotives and EMUs will be manufactured with three phase technologies having regenerative capability. It is envisaged that this measure will save 15% energy on locomotives and 30% in EMUs.

During the Financial Year 2022-23, Indian Railways (IR) achieved milestones in various categories including freight loading, electrification, New Line/ Doubling/ Gauge Conversion, Loco production and also the integration of technology for ensuring safety.

Highlights of Indian Railways (IR) achievements in Financial Year- 2022-23 are mentioned below[123]:

1. ***Freight Loading & Revenue:*** IR has loaded ***1512 MT during 2022-23*** as compared to 1418 MT during FY 2021-22 registering an increase of ***6.63% in terms of loading***. This is the highest-ever loading for IR in a Financial Year. During FY 2022-23, IR has achieved revenue of ***Rs. 2.44 Lakh Crores*** as compared ***to Rs.1.91 Lakh*** Crores during 2021-22 registering an ***increase of 27.75%.*** Following the Mantra, ***"Hungry For Cargo"***, IR has made sustained efforts to improve the ease of doing business as well as improve the service delivery at competitive prices which has resulted in new traffic coming to railways from both conventional and non-conventional commodity streams. The customer-centric approach and work of Business Development Units, backed up by agile policy-making, helped Railways towards this landmark achievement.

[122]Source: Indian Railways (Details till 30.11.2023)
[123] Source: Major achievements of Indian Railways in Financial Year -2022-23-PIB

2. ***Record electrification:*** Indian Railways is rapidly progressing to accomplish Mission 100% Electrification and become the largest green railway network in the world. 6,542RKMs have been achieved in IR history during 2022-23. The previous highest electrification was 6,366 RKM during 2021-22, registering an increase of 2.76%.

3. ***In New Line (New Line/ Doubling/ Gauge Conversion)*** 5243 km was achieved during 2022-23 as compared to 2909 Kms during 2021-22. Thus, average daily track laying comes out to be 14.4 kms per day. It is also the Highest ever commissioning.

4. ***Automatic Signaling:*** In order to increase line capacity to run more trains on existing High Density Routes of Indian Railways, Automatic Block Signaling is a cost effective solution. During 2022-23, IR has upgraded ***530 Kms with automatic signaling as compared to 218 Kms*** *during 2021-22*, registering an increase of ***143.12%.*** It is also the best figures achieved in automatic signaling in the history of IR.

5. ***Digitally Interlocked Stations (Electronic Interlocking):*** Large number of Digitally Interlocked Stations have been created from old lever frame to computer-based operating system. Electronic Interlocking is being adopted on a large scale to derive benefits of digital technologies in train operation and to enhance safety. During 2022-23, 538 Nos. of stations were provided Electronic Interlocking as compared to 421 Nos. of stations during 2021-22, an increase of 27.79%.

6. ***Gati Shakti Freight Terminals***: To increase its model share in freight segment, IR is prioritizing development of Gatishakti Freight Terminals. During 2022-23, ***30 Freight Terminals were created as compared to 21 Freight Terminals*** *in 2021-22.*

7. ***Lifts /Escalators:*** As part of 'Sugamya Bharat Abhiyan', to provide ease of movement for Divyangjans, aged and children on railway platforms, Indian Railways is installing lifts and escalators at railway stations across the country. During 2022-23, ***215 Lifts and 184 Escalators were provided as compared to 208 Lifts and 182 Escalators*** *in 2021-22.*

8. ***Highest ever Scrap Sale achieved:*** Indian Railways makes all out efforts to optimally utilize resources by mobilizing scrap materials and sale through e-auction. Scrap sale of Rs 5736 Cr was achieved during 2022-23 as compared to Rs.5316 Cr during 2021-22, an increase of 7.90%.

9. Yard Remodeling was carried out in 414 stations during 2022-23 over IR.

Innovations and new initiatives of EMU, MEMU and Kolkata Metro

HOG (Head-on-Generation) Trains: Head on Generation system is electrical power supply system where electrical power for catering hotel load of train includes Train Lighting, Air conditioning, fan and other passenger interface requirement working on electrical power supply:

- All LHB coaches have been made HOG complaint.
- All power cars have been made HOG Complaint.

- Due to HOG 0.244 Billion Litre diesel has been saved in the year 2022-23, which results in fuel bill saving of ~2199 Crore and carbon emission reduction of 6.45 lakh metric tonne

Green Environment

- Total renewable power added in the year 2022-23 is 9.75 MW
- More than 700 officials of different Zonal Railways have been trained on Energy efficiency and renewable energy

100% LED initiative:

- All Railway stations have been fitted with 100% LED luminaries. By this, Indian Railway has become a major Railway across the world to have 100% LED lighting at all its stations. All railway installations including offices, maintenance depots etc. are also being provided with 100% LED luminaries and all Residential quarters have also been provided with 100% LED lights.

Through implementing the various energy efficiency measures stated above, the Indian railways has its specific energy and fuel consumption over the past years. The specific energy and fuel consumption for the year 2022-23 as compared to that of year 2021-22 is showcased in the Table 87 and Table 88[124]:

Table 87: Railway specific energy consumption

Specific Energy Consumption (Consumption per 1000 GTKMs) – (BG)	Unit	2021-2022	2022-23(P)
Passenger service- Electricity	kWh/1000 GTKMs	21.6	18.7
Goods services -Electricity	kWh/1000 GTKMs	7.26	6.76

Table 88: Railway specific fuel consumption

Specific Fuel Consumption (Consumption per 1000 GTKMs) – (BG)	Unit	2021-2022	2022-23(P)
Passenger service- Diesel	Litres/ 1000 GTKMs	3.31	3.61
Goods services -Diesel	Litres/ 1000 GTKMs	1.92	1.93

The energy savings and emission reductions in the sector have been accounted for under the PAT and S&L section of the report**.**

[124] Source: INDIAN RAILWAYS ANNUAL REPORT & ACCOUNTS 2021-22

Chapter 10: DISCOMs

10. *DISCOMs*

Demand Side Management (DSM) programs aid utilities in decreasing peak power acquisitions from the wholesale market, consequently reducing overall operational costs. Hence, it is imperative to provide capacity building and other forms of support to Distribution Companies (DISCOMs) to facilitate the effective implementation of DSM measures in their respective regions.

The program's goal is to enhance the capability of DISCOMs in implementing Demand Side Management (DSM) measures within their designated regions. The ensuing accomplishments highlight the significant strides made under this initiative.

That being the goal, it is imperative to provide capacity building and additional assistance to Distribution Companies (DISCOMs) for the successful implementation of Demand Side Management (DSM) programs within their operational domains. Recognizing this need, the Bureau of Energy Efficiency initiated a capacity-building program for DISCOMs in 2014. This program facilitated the training of DISCOM officials and the development of various mechanisms to promote DSM in their respective areas. The initiative encompassed 62 electricity distribution companies, involving the establishment of DSM cells, conducting load research, preparing DSM action plans, and providing manpower/consultancy support. The capacity building of DISCOM officials was successfully accomplished through these comprehensive efforts.

The major achievements under Capacity Building of DISCOMs program on Demand Side Management scheme till date are as follows:

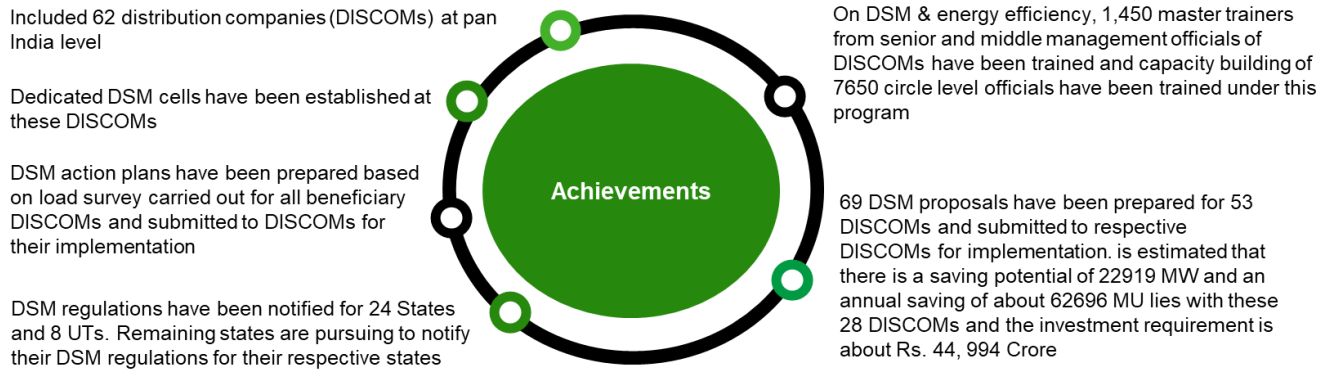

Figure 85: Achievements under DISCOMs program

A. Capacity building of circle-level officials of DISCOMs on DSM and Energy Efficiency

The Bureau conducted a capacity-building training program for circle-level officials of DISCOMs in collaboration with State Designated Agencies (SDAs). The training sessions, facilitated by the partnering agency, focused on the evolving landscape of energy efficiency in the country. The primary aim of the program was to familiarize trainers with the fundamentals of Demand Side Management (DSM) and the financial analyses associated with its implementation. The curriculum aimed to equip participants with a foundational understanding of DSM concepts and the intricacies of its financial aspects.

B. Preparation of DSM action plans based on a load research study conducted at DISCOMs.

The agency carried out load surveys at recipient DISCOMs and formulated specific Demand Side Management (DSM) action plans for each of them. Subsequently, these DSM action plans were submitted to the respective DISCOMs for implementation. It is noteworthy that several DISCOMs have already taken steps to implement demand-side measures within their distribution areas.

About DISCOMs Capacity Building:

In India, 108 distribution utilities (DISCOMs) are currently operating. Out of 108 DISCOMs, 57 are the state DISCOMs followed by 37 deemed DISCOMs and 14 private players. The capacity-building initiatives of BEE is crucial for DISCOMs to adapt the evolving industry trends, regulatory changes, and technological advancements. Capacity-building programme for the DISCOMs officials for participating 62 DISCOMs across 36 states/UTs in India is designed in such a way that it will enhance their skills, knowledge, and capabilities while working in the power distribution sector.

Demand Side Management (DSM) programme

About DSM Programme:

BEE has formulated a comprehensive scheme for “Promoting Energy Efficiency activities in different sectors of Indian Economy”. Ministry of Power, Govt. of India has approved the scheme Demand Side Management (DSM) during 2012-17 and further extended till FY 2021 - 26.

Demand Side Management (DSM) for distribution utilities refers to a set of strategies and programs implemented to influence and manage the patterns and levels of electricity consumption by end-users. The primary goal of DSM is to optimize the use of electricity resources, enhance the efficiency of the power system, and contribute to the overall sustainability of the energy sector. One of the key challenges faced by electricity distribution utilities is the need to balance the supply and demand of electricity in real-time. Traditionally, utilities have focused on increasing the capacity of power generation and improving the reliability of the grid infrastructure to meet growing demand. However, DSM takes a different approach by addressing the demand side of the equation. Instead of solely relying on supply-side solutions, DSM aims to actively manage and shape consumer behaviour to achieve a more balanced and sustainable energy system.

BEE’s DSM measures interventions has already taken in different sectors such as agriculture, public lighting, public water works and sewage pumping which is further helping to reduce the peak electricity demand, thereby helping DISCOMs in reducing their peak power purchases on the wholesale market and lowering their overall cost of operations.

There are various components/measures can be possible for implementing DSM programme at utility periphery. Some of those are as follows:

- **Load Shifting:** DSM encourages consumers to shift their electricity consumption away from peak demand periods. By offering incentives or dynamic pricing structures, utilities can motivate consumers to use electricity during off-peak hours, reducing the strain on the grid during times of high demand.
- **Energy Efficiency Awareness Programs:** Utilities can implement programs that promote energy efficiency measures among consumers. This may include incentives for upgrading appliances, installing energy-efficient lighting, cooling, and adopting smart technologies that enable better control over energy usage.
- **Manual/Automatic Demand Response Programs:** These programs involve actively engaging consumers in adjusting their electricity consumption in response to signals from the utility. This could involve temporarily reducing non-essential loads during peak demand periods or in emergency situations, helping to avoid or mitigate power outages.
- **Time-of-Day (ToD) Tariff:** ToD pricing involves charging different rates for electricity consumption based on the time of day. Higher rates during peak hours and lower rates during off-peak hours provide a financial incentive for consumers to shift their usage to times when electricity is more abundant and cheaper.
- **Smart Grid and Energy-efficient Technologies:** The integration of smart meters and advanced grid management technologies enables real-time monitoring of electricity

consumption patterns. This data can be used to implement more targeted DSM strategies and provide consumers with insights into their energy usage.

- **Incentivizing Consumers:** Utilities may offer financial incentives, rebates, or subsidies to consumers who adopt energy-efficient practices, invest in renewable energy systems, or participate in demand response programs.

Implementing effective DSM measures requires collaboration between utilities, regulators, and consumers. Public awareness campaigns, educational programs, and policy support are essential elements in creating a culture of energy conservation and efficiency. Additionally, advancements in technology, such as the Internet of Things (IoT) and data analytics, also play a crucial role in enabling the monitoring and control of electricity consumption in real-time.

BEE's DSM measures implementation programme consists major activities like carrying out load research, finalization of DSM action plans, conducting the training of trainers (ToT) programmes to create master trainers, capacity building of circle level officials of DISCOMs and providing manpower support to DISCOMs and implementation of DSM measures at DISCOM's periphery.

Identified measures and achievement of DSM programme

Table 89: Identified major sectoral DSM measures at BEE's DSM action plan

Sector	DSM measures
Domestic	Replacement of Conventional bulbs with LED
	Replacement of Conventional tube lights with LED Tube lights
	Installation of BLDC Fans
	Installation of Energy Efficient ACs
	Installation of Solar Water Heater
Commercial	Replacement of Conventional bulbs with LED
	Replacement of Conventional tube lights with LED Tube lights
	Installation of BLDC Fans
	Installation of Energy Efficient ACs
Industrial	Installation of Energy Efficient Motors
Agriculture	Installation of Energy Efficient Pumps

Table 90: Major Achievements in Phase – I and II of DSM programme

Particulars	Performance/Target Achievement	Remarks
No. Of participated DISCOMs	62	Selected as per criteria developed by BEE on pan India Level
Established DSM cell by DISCOMs	61	DoP, Arunachal Pradesh is yet to be established DSM cell.

Particulars	Performance/Target Achievement	Remarks
Notification of DSM regulations	24 States and 8 UTs	Remaining states/UTs are pursuing to notify their regulation (out of 28 States and 8 UTs)
Carrying out load research study and prepared DSM action plan	57	30 in Phase - I & 27 in Phase –II
Development of Master Trainers	1450	senior and middle management officials of DISCOMs
Capacity building of circle level officials of DISCOMs	7650	Circle level officials of DISCOMs on DSM and Energy Efficiency
Providing manpower support to DISCOMs	120	1 technical & 1 financial to 60 DISCOMs
DSM proposal prepared based on action plan	69	Report submitted to DISCOMs for implementation
Estimated energy saving potential (in terms of peak demand GW)	22.9 GW	Across 28 DISCOMs
Estimated energy saving potential (in terms of energy requirement BU)	62.6 BU	Across 28 DISCOMs
Estimated investment potential	₹ 44,994 Cr.	

- Along with the above achievements, in last financial year, the Bureau has already organized a series of 59 one day awareness workshops at beneficiary DISCOMs. DSM action plans were made based on the load research done by BEE through engage agency in association with State Designated Agency.

The key objectives of the workshops are to encourage DISCOMs to implement at least 50% of their identified DSM measures as per DSM action plan based on the load research study, so that the DISCOMs can easily manage the peak load management.

The One-day awareness workshops have been conducted at following DISCOMs namely Andhra Pradesh Eastern Power Dist. Company Ltd., West Bengal State Electricity Dist. Company Ltd., Southern Power Dist. Company of A.P, Chhattisgarh State Power Distribution Company Limited, Kerala State Electricity Board Limited, PED – Mizoram, TP Western Odisha Dist. Ltd., TP Southern Odisha Dist. Ltd., MP Paschim Kshetra Vidyut Vitran Company Ltd, MP Poorvi Kshetra Vitran Company Ltd., Himachal Pradesh State Electricity Board Ltd., etc.

Figure 86: Officials from ERCs, DISCOMs and SDA attending North-east capacity building programme

More than 270 senior officials from SDA, BEE, DISCOMs and SERCs/JERCs attended this workshop for one-to one discussion on the effective implementation of activities under BEE's capacity building of DISCOMs programme.

Figure 87: Officials from NER DISCOMs and SDAs at Phase-III MoU signing and programme kick-start programme at Guwahati

Map 1: Beneficiary DISCOMs under BEE's Capacity Building program:

In-efficient distribution transformers (DTs) replacement study programme:

Objective of the project:

The broad objective of the study is to identify the way and means to improve the operational efficiency and reliability of distribution transformers. Distribution Transformer (DT) is a key asset of the distribution network. Among the installed 12.50 million DTs in India (as per CEA statistics), close to one million DTs fail every year resulting in high financial losses. Besides the network has old DT assets which are either without star label or at Star One /two label causing high distribution loss (part of AT&C loss). Transformers are fundamental for electricity distribution, stepping the voltage up and down as it travels from power plants to load consumption centers. Transformers are among the most efficient electrical devices, with a typical efficiency rating above 97%. The Bureau of Energy Efficiency (BEE) has developed and prescribed, through S&L program, the energy efficiency standards for distribution transformers to reduce energy intensity in the economy. BEE, being the empowered body for EE by the Act, have been recommending EE norms for transformers through star labelling program. Many States are today obligated under national climate action plan and taken proactive stance to opt for mandatory procurement of higher star rated DTs like three Star etc. Few regulatory directions are also seen but poor financial health of DISCOMs is cited as major constraint to procure higher energy efficient DTs. This further gets diluted since DISCOMs are regulated entities who are entitled to pass through the tariff the additional losses those they would not have otherwise incurred if opted for high energy efficient equipment in system. Considering above situations on ground, BEE is looking for carrying out a national level study for acquiring requisite data inputs for performance based (Energy Efficiency and Carbon Footprint) business model in utilities through enhancement or replacement of old assets in electricity distribution network. The study will cover distribution transformers and carry out realistic assessment of various kVA ratings used, DT loading pattern, efficiency label used and actual losses which are essential decision-making points for replacement of the old inefficient distribution transformers of DISCOMs. The primary data like no. of transformers rating wise, their Star labels, their loading pattern, losses are to be sought from respective DISCOMs to initiate the study. According to the report prepared for each of the DISCOMs, the old/inefficient transformer may be undertaken either for performance enhancement through Renovation & Modernization (R&M) effort or replaced with BEE's 5 star rated DT.

About BEE's project on mapping and replacement of in-efficient DT study:

The bureau has already initiated the national level study at 14 DISCOMs across 4 regions i.e., East, North-east, West, and South for acquiring requisite data inputs to study and prepare performance based (Energy Efficiency and Carbon Footprint) business model in utilities through enhancement or replacement of old assets in electricity distribution network. The study will cover distribution transformers and carry out realistic assessment of various kVA ratings used, DT loading pattern, efficiency label used and actual losses which are essential decision-making points for replacement of the old inefficient distribution transformers of DISCOMs. The primary data like no. of transformers rating wise, their Star labels, their loading pattern, losses are to be sought from respective DISCOMs to initiate the study. According to the report

prepared for each of the DISCOMs, the old/inefficient transformer may be undertaken either for performance enhancement through Renovation & Modernization (R&M) effort or replaced with BEE's 5 star rated DT.

Chapter 11: State Designated Agencies (SDAs)

11. *State Designated Agency*

Under the framework of Energy Conservation (EC) Act, a two-tier structure has been established for undertaking energy efficiency activities with Bureau of Energy Efficiency (BEE) at the Centre and State Designated Agencies (SDAs) as nodal agencies at the State level. In exercise of the powers conferred by section 15(d) of the Energy Conservation (EC) Act 2001, all the State Governments / UT Administrations have designated an agency as State Designated Agency (SDA) to coordinate, regulate and enforce the provisions of this Act within the State.

All 36 States/UTs have nominated a SDA in their respective State/UT, out of which, 16 are Renewable Energy Development Agencies, 7 are State Government Power Departments, 7 are Electrical Inspectorates, 4 are Electricity Distribution Companies and 2 are Standalone SDAs. Andhra Pradesh and Kerala are the two states that have established Standalone SDA. Remaining 34 States/UTs have assigned additional responsibility of facilitating and enforcing the provisions of EC Act at State level to one of their existing agencies/departments.

11.1. BEE support extended to SDAs

To build and strengthen the institutional, technical, and financial capacities and capabilities of the SDAs for undertaking energy efficiency activities at State level, BEE provides financial assistance to the SDAs under two major components cited as below.

1. Providing financial assistance to the SDAs to coordinate, regulate and enforce efficient use of energy and its conservation.
2. Contribution to State Energy Conservation Fund (SECF).

The activities covered under each of these components are as follows.

11.1.1. Providing financial assistance to the State Designated Agencies to coordinate, regulate and enforce efficient use of energy and its conservation

1. **State Partnership for Energy Efficiency Demonstrations (SPEED)**

    a. **Implementation of energy efficiency demonstration projects** – These demonstration projects can be implemented by SDAs in the areas of street lighting, water pumping (drinking water supply systems, agricultural water pumping systems, etc.), electric cooking in anganwadis and public buildings, retrofitting of electrical equipment / appliances in buildings, installation of smart-meters in municipalities, Government buildings, etc.

These projects have been successful in facilitating most of the State Governments in replicating the demonstrated technology through various departments / agencies.

b. **Implementation of energy efficiency activities in Government schools** – Replacement of existing conventional appliances with energy efficient appliances in Govt. schools is undertaken by SDAs under this head along with disseminating awareness amongst school children by way of establishing energy clubs, organizing debates, quiz programs, etc.

2. **Model Energy Efficient Village Campaign** – The Model Energy Efficient Village Campaign is initiated to convert villages into model energy efficient villages by replacing existing inefficient electrical equipment / appliances with BEE star rated appliances including household bulbs, streetlights, fans, water pumps, etc.

3. **Manpower Support to SDAs** – This component enables the SDAs to engage manpower to coordinate, administer, regulate, and enforce activities pertaining to energy efficiency within the State smoothly and effectively. The engaged manpower may be made responsible for overall implementation of various programmes viz. Perform Achieve and Trade (PAT), Demand Side Management (DSM), etc.

4. **State Energy Efficiency Research & Outreach Programme** – This component covers the following objectives.

   a. To strengthen partnership between policy makers and educational institutions to forward the energy efficiency drive.

   b. To enhance the outreach activities undertaken by SDAs.

   Through this component, SDAs can draw key experts and can undertake extensive stakeholder engagement, comprehensive analysis, and focused technical assistance to enhance clean energy policy implementation in the State.

5. **Workshops / Capacity Building of energy professionals:** The SDAs may organize workshops at regular interval to disseminate information regarding energy efficiency to energy professionals like Accredited / Certified Energy Auditors, Designated Consumers, Financial Institutions, Energy Service Companies (ESCOs), building professionals, architects, ECBC Master Trainers, equipment / appliance manufacturers and retailers, DISCOM officials, etc. and to address issues faced by them.

6. **Analysis and survey of the impact of energy conservation activities by SDAs** – SDAs document the outcomes of various energy conservation activities undertaken by them and submit the same to BEE.

7. **Maintenance and updation of Internet Platform and other database created–** Under this component, financial support is provided to the SDAs towards establishment of internet platform through creation of a separate website on energy efficiency and regularly updating its contents.

8. **Student Awareness / Student Capacity Building Programme (SCBP)–** Following are the major activities being undertaken by SDAs under this component.
   - Development and incorporation of chapters on EC for School/ State Boards/ ITI/ Dip. Engg. College Curriculum.
   - Training of School Teachers/ Lecturers on new modules/chapters.
   - Debate and Quiz competitions in Schools and at Degree College level, ITI, Diploma Engineering Colleges (polytechnic), Engineering Colleges upon creation of energy clubs.

11.1.2. Contribution to State Energy Conservation Fund (SECF):

Section 16(1) of the EC Act, 2001 requires State Governments / UT Administrations to constitute a fund called State Energy Conservation Fund (SECF) for the purpose of promotion of efficient use of energy and its conservation within the State. The SECF can facilitate to overcome the major barriers for implementation of energy efficiency projects. It is intended to be used as an instrument to facilitate implementation of energy efficiency projects through market transformation.

The scheme is for contribution to all the State/UTs with a maximum ceiling of Rs. 4.00 crore for any State/UT provided in two installments of Rs. 2.00 crore each. The second installment of Rs. 2.00 crore under contribution to SECF is released only after the states have provided a matching contribution to the first installment of Rs. 2.00 crore provided by BEE. As on date, 33 States have constituted SECF out of which about 27 States have also provided matching contribution.

For undertaking energy efficiency projects through SECF, major part of the funds disbursed under SECF is to be earmarked separately as Revolving Investment Fund (RIF). This RIF may be utilized to finance implementation of various energy efficiency projects including those for public buildings of Central Government, State Government and Central or State Government undertakings' / agencies' buildings, energy efficiency street-lighting or common area lighting projects, energy efficiency projects in public drinking water pumping stations and in agricultural pumping, energy efficiency projects in various industrial sectors and MSME clusters, etc.

11.2. Key highlights of activities of SDAs during FY 2022-23

11.2.1. Andaman & Nicobar Islands

The A&N Islands SDA has completed the implementation of Model Energy Efficient Village Campaign in Harminder Bay village by retrofitting of energy efficient appliances/ equipment therein.

11.2.2. Andhra Pradesh

Andhra Pradesh State Energy Conservation Mission (APSECM), the SDA of Andhra Pradesh completed replacement of all existing ceiling fans of Tirumala Tirupati Devasthanams (TTD) Buildings with Energy Efficient Brushless Direct Current (BLDC) fans, through Andhra Pradesh State Energy Efficiency Development Corporation (APSEEDCO) Limited.

Andhra Pradesh SDA has completed the replacement of conventional electrical equipment viz. lights and fans with energy efficient ones in 76 Nos. of Govt. School.

Through retrofitting of conventional electrical appliances viz. lights, fans, etc. with energy efficient ones, APSECM has developed 3 Nos. Model Villages under Model Energy Efficient Village Campaign.

11.2.3. Arunachal Pradesh

Arunachal Pradesh Energy Development Agency (APEDA), the SDA of Arunachal Pradesh completed replacement of 5 Nos. Agricultural Water pump sets (2 Nos. 5HP Pump at Papumpare, 1 No. 7.5HP Pump at Pakke Kessang and 2 Nos. 10HP Pump at Roing & Pasighat) with Energy Efficient Water pump sets.

Arunachal Pradesh SDA has completed the replacement of conventional electrical equipment viz. lights and fans with energy efficient ones in Indian Reserve Battalion (IRBN), Seijosa.

APEDA undertook the replacement of all Energy Efficient motors and pumps along with installation of variable frequency drive (VFD) for Public Health Engineering (PHE) Department at water pumping system in Senkiview, Itanagar.

APEDA has completed implementation of Model Energy Efficient Village Campaign in 6 Nos. villages, converting them into model energy efficient villages by replacing existing conventional lamps, streetlights, and fans with energy efficient ones at common public places including panchayat bhawan, community center, etc.

11.2.4. Assam

The Assam SDA implemented EE demonstration project at “Akaya Mahapurusia Satra” and “Powa Meca, Hajo” by replacement of existing lights and fans with energy efficient lights and fans.

The SDA of Assam has completed implementation of energy efficiency measures including replacement of inefficient appliances viz. bulbs, fans and Tube lights with energy efficient ones in 9 Nos. of Villages to showcase the villages as Model Energy Efficient Villages.

11.2.5. Bihar

Bihar Renewable Energy Development Agency (Bihar SDA) has completed the retrofitting of existing conventional lighting system and fans with energy efficient luminaries and fans at Mangal Talab Auditorium, Patna.

Bihar SDA implemented energy efficiency demonstration projects at 62 Nos. Govt. schools by replacing therein, the existing conventional lights and ceiling fans with energy efficient ones.

BREDA undertook the Model Energy Efficient Village Campaign in 10 Nos. villages.

11.2.6. Chandigarh

SDA has completed replacement of Existing CFL/ HPSV lamps with energy efficient LED Fixtures in the following Public Buildings:
a) Government Medical College & Hospital Sector 32 – Blocks A&D
b) Home Science College Sector 10
c) Govt. High School Sector 31
d) Govt. Model Senior Secondary School Sector 45C
e) Govt. Middle School Sector 46

11.2.7. Chhattisgarh

Chhattisgarh State Renewable Energy Development Agency (CREDA), the SDA of Chhattisgarh executed replacement of indoor lights with LED lights in its office building at Raipur.

Chhattisgarh SDA has completed installation of energy efficient electrical appliances viz. LED lights and ceiling fans in Village Tarasgaon, Dist-Kanker.

The SDA of Chhattisgarh has completed implementation of energy efficiency measures including replacement of inefficient appliances viz. bulbs, fans and Tube lights with energy efficient ones in 200 Nos. of Govt. Schools.

11.2.8. Daman and Diu

Daman & Diu SDA has implemented Energy Efficiency measures in 5 Nos. Govt. schools.

SDA Daman undertook the replacement of conventional street lights in Pariyari village and Daman Fort Area with LEDs.

11.2.9. Goa

Goa SDA undertook the renovation of all drinking water-pumps of the PHE Department by replacing inefficient old pumps by the efficient ones.

Goa SDA carried out replacement of 506 Nos. of HPSV fixtures of 250W at NH-17 from Panaji to Cortalim to Margao (33 Kms) with the LED fixtures of 96W.

11.2.10. Gujarat

Gujarat Energy Development Agency (GEDA) implemented Model Energy Efficient Village Campaign in 2 Nos. villages, by replacing existing conventional household lamps, streetlights, and fans with energy efficient ones.

11.2.11. Haryana

Haryana SDA has completed the implementation of energy efficiency demonstration projects involving replacement of conventional electrical equipment with energy efficient ones at:
a) Karnal Jail

b) 27 Nos. Govt. Hospitals across the State
c) Brahmsarovar and associated places at Kurukshetra

LED bulbs were deployed at Households of more than 300 Nos. of villages covering entire Karnal Block, Hithin Block District Palwal, Nangal Chaudhry Block, Mahendragarh and Bawaland by SDA Haryana.

11.2.12. Himachal Pradesh

Himachal Pradesh SDA has completed the replacement of existing inefficient equipment with energy efficient (EE) equipment i.e., with LED Bulbs, LED Tubelights, EE Fans etc. in the Godowns of H.P. State Civil Supplies Corporation (HPSCSC), Gas Agencies & Petrol Pumps.

11.2.13. Karnataka

Karnataka SDA completed the replacement of the existing conventional water pumps by Energy Efficient Star Rated pumps at all Govt. hospitals in Mysuru & Chamarajanagar Districts (Taluk/Hobli).

KREDL completed replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in 130 Nos. Govt. schools during 2022-23.

11.2.14. Kerala

Energy Management Centre (EMC) – Kerala, the SDA of Kerala undertook the retrofitting of inefficient tube lights with energy efficient LED tube lights, inefficient ceiling fans with energy efficient star labelled ceiling fans, inefficient bulbs/ CFLs with energy efficient LED bulbs and inefficient street lights with energy efficient LED street lights at Guruvayur Temple and its associated buildings.

Implementation of EE activities in selected 8 Nos. Govt. hospitals by replacement of inefficient electrical appliances viz. lights and fans with energy efficient ones has been completed by Kerala SDA.

11.2.15. Ladakh

Ladakh SDA initiated the implementation of clean cooking programme through distribution of 2,000 Nos. Induction Cookstoves to electrified consumers in the UT (1000 Nos. each at Leh & Kargil).

Ladakh SDA initiated the deployment of 40,000 nos. 10W Rechargeable Emergency LED Bulbs to off grid village consumers of Ladakh.

11.2.16. Madhya Pradesh

Madhya Pradesh Urja Vikas Nigam (MPUVN) Limited, the SDA of Madhya Pradesh completed replacement of all existing conventional luminaries and fans with energy efficient ones in 5 Nos. Govt. hospitals.

MP SDA completed the implementation of Model Energy Efficient Village Campaign for converting the entire villages namely Kajlas, Badjhiri, Chandpur, Dobra, Kekda, Chimankhapa, Rasena & Kevlari Kalan into model energy efficient villages by carrying out replacement of existing inefficient appliances like household bulbs, tubelights, fans and street lights with energy efficient electrical equipment.

11.2.17. Maharashtra

Maharashtra Energy Development Agency (MEDA), the SDA of Maharashtra has completed implementation of energy efficiency measures including replacement of existing appliances viz. lights, fans and ACs with energy efficient ones in 10 Nos. Govt. buildings.

Implementation of EE activities under Model EE Village Campaign in 11 Nos. villages has been completed.

11.2.18. Meghalaya

Meghalaya SDA completed the replacement of all existing conventional luminaries and fans with energy efficient ones in 5 Nos. Govt. hospitals.

The SDA undertook replacement of existing inefficient luminaries with Energy Efficient appliances such as LED lights, tube-lights and fans in 4 Nos. Orphanages of Meghalaya.

11.2.19. Mizoram

Mizoram SDA completed the replacement of all existing conventional luminaries and fans with energy efficient ones at 8 Nos. Govt. hospitals.

The SDA undertook Model Energy Efficient Village Campaign by implementing energy efficiency measures in 13 Nos. selected villages.

11.2.20. Nagaland

Nagaland SDA implemented demonstration projects on space heating and replacement of conventional bulbs/ street lights by LED bulbs and street lights. Some of the prominent places of implementation of these projects are Kohima War Memorial, Green Park- Dimapur, etc.

Nagaland SDA undertook Model Energy Efficient Village Campaign by implementing energy efficiency measures in 11 Nos. selected villages.

11.2.21. Odisha

Odisha SDA undertook the replacement of all existing conventional luminaries and fans with energy efficient appliances in 5 Nos. Govt. hospitals.

11.2.22. Puducherry

Renewable Energy Agency Puducherry (REAP), i.e., Puducherry SDA has completed installation of LED lights in identified 14 Nos. Villages,10 Nos. PLF offices, 2 Nos. Municipalities' buildings and 2 Nos. Govt. community halls.

Puducherry SDA has completed the installation of electric cooking system in 3 Nos. Govt. hospitals and 2 Nos. Community Health Centres.

11.2.23. Punjab

Punjab Energy Development Agency (Punjab SDA) has completed the installation of energy efficient electrical appliances viz. LED lights and ceiling fans in 10 Nos. Govt. Schools in Amritsar district.

Punjab SDA undertook the replacement of all existing conventional luminaries, fans, and ACs with energy efficient appliances in 6 Nos. Govt. hospitals.

11.2.24. Rajasthan

Rajasthan Renewable Energy Corporation Limited (RRECL), the SDA of Rajasthan carried out the replacement of conventional appliances with energy efficient appliances at Govt. Circuit Houses.

11.2.25. Sikkim

Sikkim SDA completed the implementation of phase change material-based space heating project at Power Secretariat building, Gangtok.

Sikkim SDA undertook the replacement of conventional Lights with LED Bulbs and Tube-lights at common property resources in 12 Nos. villages.

11.2.26. Tamil Nadu

Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO), the SDA of Tamil Nadu completed implementation of EE measures including replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in two villages namely Othaiyal and Karenthal.

11.2.27. Telangana

Telangana State Renewable Energy Development Corporation (TSREDCO) Limited, the SDA of Telangana implemented energy efficiency measures including retrofitting of energy efficient equipment/appliances in selected 74 Nos. Fire stations, 202 Nos. Post offices, 4 Nos. Police Stations and 7 Nos. Public Health Centres.

Replacement of existing inefficient appliances with EE appliances in common areas at 10 Nos. villages in Telangana has been implemented by Telangana SDA.

11.2.28. Uttar Pradesh

Uttar Pradesh New & Renewable Energy Development Agency (UPNEDA), the SDA of Uttar Pradesh completed the replacement of all existing conventional luminaries and fans with energy efficient ones in more than 700 Nos. Kasturba Gandhi Balika Vidyalayas (KGBVs).

11.2.29. Uttarakhand

Uttarakhand Renewable Energy Development Agency (UREDA), the SDA of Uttarakhand undertook replacement of conventional luminaries and fans with energy efficient luminaries and fans in 26 Nos. villages across the State.

11.2.30. West Bengal

West Bengal State Electricity Distribution Company Limited (WBSEDCL), i.e., West Bengal SDA has completed implementation of energy efficiency measures in 41 nos. Govt. schools across six (6) districts namely Darjeeling, Jalpaiguri, Dakshin Dinajpur, Howrah, South 24 Pgs, and North 24 Pgs.

West Bengal SDA undertook replacement of conventional luminaries and fans with energy efficient luminaries and fans in 5 Nos. hospitals across the State.

Chapter 12: Conclusion

12. *Conclusion*

India holds a prominent position in the global energy landscape, and its ongoing industrialization and urbanization are poised to exert significant pressure on both its energy sector and policymakers. Despite the substantial strides made, the per capita energy consumption in India remains considerably below the global average. Notably, there exist pronounced variations in energy utilization and service quality across different states and between rural and urban areas.

The exponential growth witnessed in the energy sector over the past decades is a testament to the rising demands fueled by escalating urbanization, enhanced electricity access, electrification efforts, and expanded economic activities. As India strives for sustained economic growth, there is a simultaneous acknowledgment of the imperative for sustainable development. The government, recognizing the environmental impact, has proactively implemented comprehensive policies and regulations to promote energy efficiency. These initiatives are not only aligned with national developmental objectives but also contribute to fulfilling commitments under key multilateral environmental agreements, thereby addressing the pressing issues of greenhouse gas emissions and climate change.

The tentative findings of the report reflect that the adoption of energy efficiency schemes/programs presented in Table 91 has led to the overall thermal energy savings in the order of 24.44 Mtoe, while overall electricity savings are to the tune of 306.55 BU. Total, these energy savings translated into monetary savings of worth INR 1,91,810 crores and contributed to reduce 306.02 Million Tonnes of CO2 emission.

Table 91: Summary of Energy Saving (2022-23)

Program/ Scheme	Sector	Electricity Savings (BU)	Thermal Savings (MTOE)	Total Energy Savings (MTOE)	GHG Reduction (MtCO2)	Monetary Savings (INR Crore)
PAT- V	Large Industry	0.008	0.6802	0.6809	2.68	1256.66
PAT- IV		0.009	0.7501	0.7508	2.96	1385.75
PAT- III		0.62	1.59	1.59	5.59	3223.20
PAT- II		36.47	10.95	14.08	68.43	43078.10
PAT- I		3.01	8.41	8.67	31.00	9500.00
PRSF	MSME	0.02	-	0.0019	0.02	14.17
4E		0.28	0.00089	0.0246	0.23	175.15
BEE-GEF-EESL		0.0015	0.0018	0.0019	0.009	4.49
BEE-UNIDO-SME		0.00	0.00	0.0057	0.038	36.72
FLCTD	Large/MSME	0.00009	0.000657	0.0007	0.002	1.22
ECBC	Commercial Buildings	0.1609	-	0.0138	0.1303	25.46
BEE Star Rating		0.2492	-	0.0214	0.2019	39.43

Green Building Rating Program (GRIHA)		0.0882	-	0.0076	0.0714	13.96
ENS	Residential Buildings	0.0048	-	0.00041	0.0034	0.76
S&L	Appliances	80.86	0.018	6.97	57.46	50894.84
UJALA	LED Lamps	176.19	-	15.15	125.09	70476
SLNP	Municipal	8.59	-	0.74	5.92	5688.00
FAME	Transport	-	0.14	0.14	0.53	1559.88
CAFÉ		-	1.89	1.89	5.69	4436.35
Total		**306.55**	**24.44**	**50.75**	**306.02**	**191810.16**

The Impact Assessment of Energy Efficiency for the FY 2022-23 report of Bureau of Energy Efficiency (BEE) presents a comprehensive view of the instrumental role played by the bureau in fostering energy efficiency across diverse sectors of the Indian economy. The report underscores how BEE, through its various schemes and programs, has become a pivotal force driving the implementation and penetration of energy efficiency measures, ultimately leading to a significant reduction in energy consumption.

One of the key mechanisms through which BEE facilitates energy efficiency is the Perform Achieve and Trade (PAT) scheme. By setting energy consumption norms and encouraging industries to surpass them, PAT incentivizes efficiency improvements and ensures that energy consumption in these sectors is continuously optimized. The Standards & Labelling Program is another noteworthy initiative that guides consumers towards energy-efficient products, contributing to reduced energy consumption in households and businesses alike.

The BEE SME program stands out as an impactful measure tailored for small and medium enterprises, recognizing their unique challenges. This program not only aids these enterprises in adopting energy-efficient technologies but also promotes sustainable practices that enhance their overall competitiveness. Furthermore, BEE's collaboration with various ministries and departments of the Indian government has led to the implementation of crucial initiatives like UJALA, PRSF, FAME, and CAFE in the Municipal, MSME, and transport sectors.

The UJALA program, known for its widespread distribution of energy-efficient LED bulbs, has not only reduced energy consumption but has also contributed to significant cost savings for consumers. The partial risk sharing facility (PRSF) has played a crucial role in mitigating financial risks for the MSME industries investing in energy-efficient technologies, fostering a conducive environment for widespread adoption. Similarly, initiatives like FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) and CAFE (Corporate Average Fuel Efficiency) have been instrumental in promoting energy efficiency in the transport sector, aligning with global sustainability goals.Demand Side Management (DSM) program help utilities to lower peak power purchases from the wholesale market, leading to decreased overall operational costs.

Agricultural Demand Side Management (AgDSM) initiatives aims to reduce the energy intensity of agriculture pumping sector by carrying out efficiency up gradation of agricultural pump sets and reducing overall power consumption.In collaboration with State Designated Agencies (SDAs), BEE is organizing a range of training and awareness initiatives targeting farmers and equipment technicians.

In India, building sector (residental and commercial) accounts for 33% of total electricity consumption . BEE has introdudced various initiatives such as EBC which aims to reduce the energy consumption and foster low-carbon growth in the building sector.

In conclusion, the Impact Assessment Report highlights BEE's pivotal role in steering India towards a more energy-efficient future. Through a combination of innovative schemes and collaborative efforts with various stakeholders, BEE has not only laid the groundwork for sustainable practices but has also positioned itself as a catalyst for change in the national energy landscape. As the bureau continues to evolve and implement progressive measures, it is poised to play an increasingly crucial role in achieving and surpassing the energy efficiency targets set for the nation.

12.1. Way Forward

The significance of energy in driving a company's economic growth is extensive and diverse. Energy stands as the essential force driving every operational aspect within a company, powering manufacturing, production processes, logistics, and service delivery. It is important to introduce new policies aimed at reducing unnecessary energy consumption across all sectors. India in its updated Nationally Determined Contributions (NDCs) has committed that it will reduce the emission intensity of its GDP by 45% by 2030 from 2005 level. Further, it has proposed to install 50% of the power capacity from non-fossil energy sources and aim to achieve net zero emissions by 2070.

With a population of 1.4 billion, India has a massive demand for energy to fuel its rapidly growing economy. India’s had developed various missions to combat the impact of Climate Action through implementation of eight National Missions. Today, India is a power surplus nation with a total installed capacity of over 400 GW[125].

Keeping in mind the sustainable development goals, India’s power generation mix is rapidly shifting towards renewable energy. India is the world’s third largest producer of renewable energy, with over 40% of its installed electricity capacity coming from non-fossil fuel sources. India has steadily invested in renewable energy sources, generating employment opportunities within this sector. However, the nation faces with significant challenges and remains heavily reliant on coal for energy. Moving forward, the Government has charted an ambitious roadmap to provide secure, affordable, and sustainable energy access to all its citizens.

The Bureau of Energy Efficiency (BEE) plays a crucial role in expediting the rate of energy efficiency across the nation. Through initiatives like Standards and Labelling, Perform, Achieve, and Trade (PAT) scheme, BEE has strategically formulated policies and programs aimed at the primary goal of reducing the country's energy intensity.

[125] Source: National Energy Data: Survey and Analysis Year 2021-22

Given the importance of energy access, energy security and energy transition at the global and national level, a robust, consistent and reliable energy data can help understand the energy profile of a country. In this regard, a dedicated unit is required to assess the impact of various policies and programmes. In today's context, as energy transition takes priority, comprehensive energy data becomes instrumental in enabling policymakers to formulate evidence-based policies. This data-driven approach supports countries in fulfilling their environmental and developmental commitments in the forthcoming years.

In view of above, BEE has established a dedicated Energy Data Management Unit (EDMU) to compile and publish data regarding the supply and consumption of energy in various sectors of economy. The work carried out under the EDMU is a collaborative effort of different line Ministries/Departments, Think Tanks, NITI Aayog, and other stakeholders. EDMU aims to prepare data collection methodologies, standardization definitions, terminologies and calculation methodology of all the key parameters in the energy sector in line with international standards so that reporting of data is uniform across all sectors and sources. Further, EDMU will develop comprehensive and unified approach for energy statistics and enhance their dissemination to facilitate advancements in energy policy.

Annexure

A.1 Savings achieved under 4E Scheme in the FY 2022-23

The table below showcases the energy and emission savings obtained under SIDBI's 4E scheme for the FY 2022-23:

Table 92: Cluster-wise energy savings obtained under SIDBI- 4E Scheme in FY 22-23

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
Adityapur							
	METAL PRODUCTS	2	77400000	265849	0	23	215
	TRANSPORT EQUIPMENT	4	63871000	219380	0	19	178
Ahmedabad							
	CHEMICAL & CHEMICAL PRODUCTS	1	60970000	465263	0	40	377
	MACHINERY	1	3714000	28342	0	2	23
	RUBBER & PLASTIC PRODUCTS	3	106994000	816472	0	70	661
Ambattur							
	ELECTRONIC EQUIPMENT	3	13496000	259534	0	22	210
	IRON & STEEL	1	4985000	95864	0	8	78
	LEATHER & LEATHER PRODUCTS	1	17880000	343840	0	30	279
	METAL PRODUCTS	16	198615000	3819455	0	328	3094
	NON-FERROUS METALS	1	1963000	37749	0	3	31
	OTHER SERVICES	6	35137000	675700	0	58	547
	PAPER & PAPER PRODUCTS	2	8884000	170843	0	15	138
	RUBBER & PLASTIC PRODUCTS	1	24449000	470165	0	40	381
	TRANSPORT EQUIPMENT	28	365054000	7020151	0	604	5686
	WOOD & WOOD PRODUCTS	1	6278000	120729	0	10	98
Andheri							

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	MACHINERY	3	22161000	173567	0	15	141
	METAL PRODUCTS	2	26360000	206454	0	18	167
	OTHERS	1	66200000	518485	0	45	420
	PAPER & PAPER PRODUCTS	2	64000000	501254	0	43	406
	RUBBER & PLASTIC PRODUCTS	1	7042000	55154	0	5	45
Aurangabad							
	ELECTRONIC EQUIPMENT	2	34492000	369790	0	32	300
	METAL PRODUCTS	7	166935000	1789715	0	154	1450
	NON-FERROUS METALS	1	17029000	182568	0	16	148
	PAPER & PAPER PRODUCTS	3	51819000	555553	0	48	450
	RUBBER & PLASTIC PRODUCTS	2	26778000	287088	0	25	233
	TRANSPORT EQUIPMENT	7	64516000	691678	0	59	560
	WOOD & WOOD PRODUCTS	1	22042000	236313	0	20	191
Bahadurgarh							
	ELECTRICAL EQUIPMENT	1	18700000	80526	0	7	65
	MACHINERY	1	75000000	322964	0	28	262
	METAL PRODUCTS	3	39330000	169362	0	15	137
	TEXTILES (INCLUDING JUTE)	1	12400000	53397	0	5	43
	TRANSPORT EQUIPMENT	3	77500000	333729	0	29	270
Bengaluru							
	ELECTRICAL EQUIPMENT	2	50000000	3394672	0	292	2750
	ELECTRONIC EQUIPMENT	1	49000000	3326778	0	286	2695
	FOOD & FOOD PRODUCTS	3	87900000	5967833	420	933	8519
	MACHINERY	6	91154000	6188758	0	532	5013
	METAL PRODUCTS	8	136901000	9294679	0	799	7529
	NON-FERROUS METALS	1	7874000	534593	0	46	433
	OTHER SERVICES	4	43156000	2930009	0	252	2373

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	OTHERS	3	33293000	2260376	0	194	1831
	PAPER & PAPER PRODUCTS	1	5664000	384548	0	33	311
	RUBBER & PLASTIC PRODUCTS	5	51443000	3492642	0	300	2829
	TRANSPORT EQUIPMENT	5	119866000	8138114	0	700	6592
	WOOD & WOOD PRODUCTS	1	29000000	1968910	0	169	1595
Bhilwara							
	TEXTILES (INCLUDING JUTE)	8	124866000	1021338	0	88	827
Bhopal							
	ELECTRICAL EQUIPMENT	1	11000000	121418	0	10	98
	ELECTRONIC EQUIPMENT	1	6501000	71758	0	6	58
	METAL PRODUCTS	2	12956000	143009	0	12	116
	OTHER SERVICES	1	6670000	73624	0	6	60
	OTHERS	2	29685000	327664	0	28	265
Bhubaneswar							
	FOOD & FOOD PRODUCTS	1	18220000	182415	0	16	148
	MACHINERY	1	30000000	300354	0	26	243
	OTHERS	1	13350000	133658	0	11	108
	PAPER & PAPER PRODUCTS	4	19934000	199575	0	17	162
	RUBBER & PLASTIC PRODUCTS	3	50794000	508540	0	44	412
Chandigarh							
	CHEMICAL & CHEMICAL PRODUCTS	3	35900000	403771	0	35	327
	ELECTRICAL EQUIPMENT	1	8500000	95600	0	8	77
	FOOD & FOOD PRODUCTS	2	34000000	382402	0	33	310
	IRON & STEEL	19	593831000	6678880	0	574	5410
	MACHINERY	5	50700000	570228	0	49	462
	METAL PRODUCTS	12	274414000	3086363	0	265	2500
	OTHERS	2	53400000	600595	0	52	486

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	PAPER & PAPER PRODUCTS	3	32620000	366881	0	32	297
	RUBBER & PLASTIC PRODUCTS	1	3244000	36486	0	3	30
	TEXTILES (INCLUDING JUTE)	3	107000000	1203440	0	103	975
	TRANSPORT EQUIPMENT	4	65381000	735347	0	63	596
	WOOD & WOOD PRODUCTS	1	15295000	172024	0	15	139
Changodar							
	METAL PRODUCTS	3	43966000	494490	47	89	814
	OTHER SERVICES	2	54000000	607344	0	52	492
	PAPER & PAPER PRODUCTS	1	4757000	53502	0	5	43
	RUBBER & PLASTIC PRODUCTS	2	31230000	351247	0	30	285
	TEXTILES (INCLUDING JUTE)	2	30180000	339438	0	29	275
Chennai							
	CEMENT	1	11300000	103198	0	9	84
	CHEMICAL & CHEMICAL PRODUCTS	3	64045000	584894	38	89	809
	ELECTRICAL EQUIPMENT	1	10480000	95709	0	8	78
	ELECTRONIC EQUIPMENT	3	95015000	867730	0	75	703
	FOOD & FOOD PRODUCTS	1	12312000	112440	0	10	91
	HOSPITALS	1	30000000	273977	0	24	222
	IRON & STEEL	1	12260000	111965	26	35	321
	MACHINERY	11	142681000	1303042	0	112	1055
	METAL PRODUCTS	17	201668000	1841744	0	158	1492
	NON-FERROUS METALS	1	30000000	273977	0	24	222
	OTHER SERVICES	14	175670000	1604316	0	138	1299
	OTHERS	3	152646000	1394048	0	120	1129
	PAPER & PAPER PRODUCTS	1	1221000	11151	0	1	9
	RUBBER & PLASTIC PRODUCTS	5	47633000	435011	0	37	352
	TEXTILES (INCLUDING JUTE)	1	11741000	107225	0	9	87

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	TRANSPORT EQUIPMENT	15	308008000	2812900	0	242	2278
Chinchwad							
	ELECTRICAL EQUIPMENT	1	4850000	32031	0	3	26
	IRON & STEEL	1	2360000	15586	24	25	227
	MACHINERY	3	57000000	376441	0	32	305
	METAL PRODUCTS	5	165368000	1092128	0	94	885
	OTHER SERVICES	6	61610000	406886	0	35	330
	RUBBER & PLASTIC PRODUCTS	3	49018000	323726	0	28	262
	TEXTILES (INCLUDING JUTE)	1	5175000	34177	0	3	28
	TRANSPORT EQUIPMENT	5	119805000	791220	0	68	641
Coimbatore							
	MACHINERY	1	42200000	318937	0	27	258
	METAL PRODUCTS	7	152456000	1152223	0	99	933
	OTHER SERVICES	3	54566000	412396	0	35	334
	OTHERS	2	80000000	604619	0	52	490
	PAPER & PAPER PRODUCTS	1	55535000	419719	0	36	340
	RUBBER & PLASTIC PRODUCTS	3	73510000	555570	0	48	450
	TEXTILES (INCLUDING JUTE)	13	467166000	3530721	0	304	2860
	TRANSPORT EQUIPMENT	2	38468000	290731	0	25	235
Dehradoon							
	LEATHER & LEATHER PRODUCTS	1	18198000	137536	0	12	111
	RUBBER & PLASTIC PRODUCTS	1	5923000	44765	0	4	36
	TRANSPORT EQUIPMENT	2	27488000	207747	0	18	168
Erode							
	ELECTRICAL EQUIPMENT	1	66000000	1113418	0	96	902
	IRON & STEEL	1	35000000	590449	0	51	478
	METAL PRODUCTS	3	120500000	2032831	0	175	1647

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	RUBBER & PLASTIC PRODUCTS	1	17600000	296911	0	26	240
	TEXTILES (INCLUDING JUTE)	15	479700000	8092524	0	696	6555
	TRANSPORT EQUIPMENT	1	3900000	65793	0	6	53
Faridabad							
	ELECTRONIC EQUIPMENT	1	7060000	119102	0	10	96
	IRON & STEEL	1	15104000	254804	0	22	206
	LEATHER & LEATHER PRODUCTS	1	8903000	150193	0	13	122
	MACHINERY	5	78122000	1317916	0	113	1068
	METAL PRODUCTS	13	198816000	3354020	0	288	2717
	OTHERS	2	47244000	797005	0	69	646
	PAPER & PAPER PRODUCTS	1	60300000	1017259	0	87	824
	RUBBER & PLASTIC PRODUCTS	5	62743000	1058472	0	91	857
	TEXTILES (INCLUDING JUTE)	4	33322000	562141	0	48	455
	TRANSPORT EQUIPMENT	9	263118000	4438793	0	382	3595
Gandhidham							
	FOOD & FOOD PRODUCTS	5	120615000	3979440	0	342	3223
	MINING	1	10340000	341147	0	29	276
	NON-METALLIC MINERAL PRODUCTS	2	81100000	2675725	0	230	2167
	OTHER SERVICES	1	5100000	168264	0	14	136
	OTHERS	1	10715000	353519	0	30	286
	PAPER & PAPER PRODUCTS	1	19000000	626865	0	54	508
	RUBBER & PLASTIC PRODUCTS	1	75000000	2474468	0	213	2004
	TEXTILES (INCLUDING JUTE)	1	10560000	348405	0	30	282
	WOOD & WOOD PRODUCTS	5	52420000	1729488	0	149	1401
Gurugram							
	FOOD & FOOD PRODUCTS	2	99549000	596659	0	51	483
	MACHINERY	3	32620000	195512	0	17	158

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	METAL PRODUCTS	5	54056000	323991	0	28	262
	OTHER SERVICES	2	76700000	459711	0	40	372
	OTHERS	1	7000000	41955	0	4	34
	RUBBER & PLASTIC PRODUCTS	2	19862000	119045	0	10	96
	TEXTILES (INCLUDING JUTE)	1	28380000	170099	0	15	138
	TRANSPORT EQUIPMENT	2	8500000	50946	0	4	41
Guwahati							
	FOOD & FOOD PRODUCTS	2	20298000	282120	0	24	229
	OTHERS	1	22400000	311335	2	29	264
	PAPER & PAPER PRODUCTS	2	49000000	681045	0	59	552
	RUBBER & PLASTIC PRODUCTS	1	50000000	694944	0	60	563
Haridwar							
	CHEMICAL & CHEMICAL PRODUCTS	2	54528000	757878	0	65	614
	ELECTRONIC EQUIPMENT	1	48100000	668536	0	57	542
	OTHER SERVICES	1	38200000	530937	0	46	430
	PAPER & PAPER PRODUCTS	4	185470000	2577826	0	222	2088
Hosur							
	ELECTRICAL EQUIPMENT	1	10306000	81669	0	7	66
	ELECTRONIC EQUIPMENT	2	13463000	106686	0	9	86
	MACHINERY	3	12083000	95751	0	8	78
	METAL PRODUCTS	6	46491000	368414	16	48	438
	MINING	1	10856000	86027	0	7	70
	OTHER SERVICES	24	238029000	1886240	0	162	1528
	OTHERS	1	6333000	50185	0	4	41
	RUBBER & PLASTIC PRODUCTS	3	79014000	626140	0	54	507
	TRANSPORT EQUIPMENT	15	109947000	871265	0	75	706
Hyderabad							

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	CHEMICAL & CHEMICAL PRODUCTS	1	70000000	467815	0	40	379
	ELECTRICAL EQUIPMENT	2	29600000	197819	0	17	160
	ELECTRONIC EQUIPMENT	2	53700000	358881	0	31	291
	IRON & STEEL	1	4000000	26732	0	2	22
	MACHINERY	4	78600000	525289	0	45	425
	METAL PRODUCTS	5	95325000	637063	0	55	516
	OTHER SERVICES	3	9572000	63970	0	6	52
	PAPER & PAPER PRODUCTS	2	45035000	300972	0	26	244
	RUBBER & PLASTIC PRODUCTS	7	143984000	962254	0	83	779
Indore							
	FOOD & FOOD PRODUCTS	1	5348000	51647	0	4	42
	IRON & STEEL	1	50000000	482865	0	42	391
	MACHINERY	2	62732000	605822	0	52	491
	OTHER SERVICES	2	74000000	714640	0	61	579
	OTHERS	1	60700000	586198	0	50	475
	RUBBER & PLASTIC PRODUCTS	2	23500000	226947	0	20	184
	TRANSPORT EQUIPMENT	4	58710000	566980	0	49	459
Jaipur							
	CHEMICAL & CHEMICAL PRODUCTS	2	5243000	78643	0	7	64
	ELECTRICAL EQUIPMENT	1	19100000	286494	0	25	232
	ELECTRONIC EQUIPMENT	1	4045000	60674	0	5	49
	FOOD & FOOD PRODUCTS	4	23200000	347993	0	30	282
	MACHINERY	1	5214000	78208	0	7	63
	METAL PRODUCTS	2	10997000	164952	0	14	134
	MINING	4	38531000	577953	0	50	468
	NON-METALLIC MINERAL PRODUCTS	2	12900000	193496	0	17	157
	OTHER SERVICES	3	80100000	1201476	0	103	973

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	OTHERS	1	19000000	284994	0	25	231
	RUBBER & PLASTIC PRODUCTS	3	40884000	613248	0	53	497
	TEXTILES (INCLUDING JUTE)	1	9600000	143997	0	12	117
	WOOD & WOOD PRODUCTS	1	10000000	149997	0	13	121
Jallandhar							
	IRON & STEEL	1	57946000	641687	135	190	1736
	MACHINERY	4	11001000	121824	0	10	99
	METAL PRODUCTS	6	94689000	1048575	0	90	849
	OTHER SERVICES	2	19050000	210958	0	18	171
	OTHERS	4	48022000	531790	0	46	431
	RUBBER & PLASTIC PRODUCTS	1	50000000	553694	42	90	820
	TRANSPORT EQUIPMENT	1	26600000	294565	0	25	239
	WOOD & WOOD PRODUCTS	2	42427000	469832	0	40	381
Jodhpur							
	FOOD & FOOD PRODUCTS	3	49474000	1244094	0	107	1008
	NON-METALLIC MINERAL PRODUCTS	2	15157000	381144	0	33	309
	TEXTILES (INCLUDING JUTE)	2	12325000	309930	0	27	251
	WOOD & WOOD PRODUCTS	2	23530000	591695	0	51	479
Kanchipuram							
	FOOD & FOOD PRODUCTS	1	4543000	28374	0	2	23
	LEATHER & LEATHER PRODUCTS	1	30000000	187367	0	16	152
	MACHINERY	1	6020000	37598	0	3	30
	METAL PRODUCTS	3	45268000	282725	0	24	229
	RUBBER & PLASTIC PRODUCTS	1	2822000	17625	0	2	14
Kanpur							
	ELECTRICAL EQUIPMENT	1	11352000	157101	0	14	127
	FOOD & FOOD PRODUCTS	1	3353000	46402	0	4	38

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	METAL PRODUCTS	1	3540000	48990	0	4	40
	RUBBER & PLASTIC PRODUCTS	3	18971000	262541	0	23	213
Kishangarh							
	CONSTRUCTION	1	11237000	302444	0	26	245
	ELECTRICAL EQUIPMENT	1	7394000	199010	0	17	161
	IRON & STEEL	1	8105000	218146	0	19	177
	NON-METALLIC MINERAL PRODUCTS	4	42795000	1151829	0	99	933
Kochi							
	CHEMICAL & CHEMICAL PRODUCTS	1	48500000	404849	0	35	328
	FOOD & FOOD PRODUCTS	1	28000000	233727	0	20	189
	IRON & STEEL	1	16159000	134886	0	12	109
	MACHINERY	1	34500000	287985	0	25	233
	METAL PRODUCTS	6	46546000	388538	51	84	768
	OTHERS	1	50000000	417370	0	36	338
	PAPER & PAPER PRODUCTS	4	17798000	148567	0	13	120
	RUBBER & PLASTIC PRODUCTS	3	97300000	812202	0	70	658
	TEXTILES (INCLUDING JUTE)	1	10327000	86204	0	7	70
	WOOD & WOOD PRODUCTS	2	11500000	95995	0	8	78
Kolhapur							
	IRON & STEEL	2	85006000	790350	0	68	640
	METAL PRODUCTS	2	18165000	168891	0	15	137
	OTHER SERVICES	6	135303000	1257991	0	108	1019
	TRANSPORT EQUIPMENT	3	89610000	833157	0	72	675
Kolkata							
	CHEMICAL & CHEMICAL PRODUCTS	1	22917000	728147	0	63	590
	FOOD & FOOD PRODUCTS	1	41237000	1310233	0	113	1061
	MACHINERY	1	3613000	114797	0	10	93

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	METAL PRODUCTS	1	10162000	322880	0	28	262
	OTHERS	2	2780000	88330	0	8	72
	RUBBER & PLASTIC PRODUCTS	1	3500000	111206	0	10	90
	TEXTILES (INCLUDING JUTE)	1	15363000	488132	0	42	395
Kundli							
	CHEMICAL & CHEMICAL PRODUCTS	1	11600000	43234	0	4	35
	ELECTRICAL EQUIPMENT	1	12728000	47438	0	4	38
	ELECTRONIC EQUIPMENT	1	26510000	98805	0	8	80
	MACHINERY	2	7237000	26973	0	2	22
	METAL PRODUCTS	4	19216000	71619	0	6	58
	OTHER SERVICES	2	8824000	32888	0	3	27
	OTHERS	1	46810000	174464	0	15	141
	PAPER & PAPER PRODUCTS	1	24756000	92267	0	8	75
	RUBBER & PLASTIC PRODUCTS	5	54114000	201687	0	17	163
	TEXTILES (INCLUDING JUTE)	1	28678000	106885	0	9	87
	TRANSPORT EQUIPMENT	1	2449000	9128	0	1	7
Lucknow-Bo							
	RUBBER & PLASTIC PRODUCTS	1	13000000	48452	0	4	39
	WOOD & WOOD PRODUCTS	1	12536000	46723	0	4	38
Ludhiana							
	FOOD & FOOD PRODUCTS	1	8914000	127511	0	11	103
	IRON & STEEL	1	12100000	173086	0	15	140
	METAL PRODUCTS	3	75789168	1084136	0	93	878
	OTHERS	1	16900000	241748	0	21	196
	RUBBER & PLASTIC PRODUCTS	2	31505000	450667	0	39	365
	TEXTILES (INCLUDING JUTE)	20	293288516	4195383	0	361	3398
	TRANSPORT EQUIPMENT	4	153572883	2196803	0	189	1779

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
Madurai							
	NON-METALLIC MINERAL PRODUCTS	1	5000000	51843	0	4	42
	TEXTILES (INCLUDING JUTE)	2	28453000	295017	0	25	239
Mahesana							
	MACHINERY	1	2800000	64200	0	6	52
	OTHERS	3	8983000	205967	0	18	167
	RUBBER & PLASTIC PRODUCTS	1	27657000	634136	0	55	514
	TEXTILES (INCLUDING JUTE)	1	3132000	71812	0	6	58
	WOOD & WOOD PRODUCTS	1	1917000	43954	0	4	36
Mysore							
	FOOD & FOOD PRODUCTS	2	29512000	139771	0	12	113
	OTHER SERVICES	1	74930000	354875	0	31	287
	OTHERS	2	45000000	213124	0	18	173
	PAPER & PAPER PRODUCTS	6	203550000	964029	0	83	781
	RUBBER & PLASTIC PRODUCTS	2	34871000	165152	0	14	134
	TRANSPORT EQUIPMENT	1	24507000	116067	0	10	94
Nagpur							
	CHEMICAL & CHEMICAL PRODUCTS	2	69667000	754300	0	65	611
	ELECTRICAL EQUIPMENT	1	5467000	59192	0	5	48
	FOOD & FOOD PRODUCTS	4	162631000	1760843	0	151	1426
	IRON & STEEL	1	15579000	168677	0	15	137
	MACHINERY	1	4558000	49350	0	4	40
	METAL PRODUCTS	10	80871000	875609	0	75	709
	OTHER SERVICES	5	101731000	1101465	0	95	892
	RUBBER & PLASTIC PRODUCTS	8	113826000	1232420	0	106	998
	TEXTILES (INCLUDING JUTE)	2	38922000	421417	0	36	341
	TRANSPORT EQUIPMENT	2	6580000	71243	0	6	58

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	WOOD & WOOD PRODUCTS	1	29900000	323734	0	28	262
Nasik							
	ELECTRICITY GENERATION	1	1980000	13196	0	1	11
	MACHINERY	1	11100000	73975	0	6	60
	METAL PRODUCTS	5	51235000	341452	0	29	277
	OTHER SERVICES	2	15496000	103272	0	9	84
	OTHERS	1	6309000	42046	0	4	34
	RUBBER & PLASTIC PRODUCTS	2	19620000	130756	0	11	106
	TRANSPORT EQUIPMENT	1	40000000	266577	0	23	216
New Delhi							
	CHEMICAL & CHEMICAL PRODUCTS	1	11200000	81632	0	7	66
	ELECTRONIC EQUIPMENT	3	64992000	473697	0	41	384
	IRON & STEEL	2	18288000	133293	3	15	136
	LEATHER & LEATHER PRODUCTS	1	17700000	129007	0	11	104
	MACHINERY	1	6433000	46887	0	4	38
	METAL PRODUCTS	6	53887000	392757	0	34	318
	OTHER SERVICES	1	3000000	21866	0	2	18
	OTHERS	2	5788000	42186	0	4	34
	PAPER & PAPER PRODUCTS	3	60539000	441241	0	38	357
	RUBBER & PLASTIC PRODUCTS	8	84220000	613841	0	53	497
	TEXTILES (INCLUDING JUTE)	1	4650000	33892	0	3	27
	TRANSPORT EQUIPMENT	4	48913000	356504	0	31	289
Noida							
	CHEMICAL & CHEMICAL PRODUCTS	1	3163000	54170	0	5	44
	ELECTRICAL EQUIPMENT	1	4500000	77067	0	7	62
	ELECTRONIC EQUIPMENT	2	40524000	694015	0	60	562
	FOOD & FOOD PRODUCTS	1	4900000	83918	0	7	68

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	LEATHER & LEATHER PRODUCTS	1	10598000	181502	0	16	147
	METAL PRODUCTS	1	20817000	356513	0	31	289
	OTHER SERVICES	1	27200000	465828	0	40	377
	PAPER & PAPER PRODUCTS	2	68400000	1171420	0	101	949
	RUBBER & PLASTIC PRODUCTS	2	63300000	1084078	0	93	878
	TEXTILES (INCLUDING JUTE)	1	14800000	253465	0	22	205
Odhav							
	CHEMICAL & CHEMICAL PRODUCTS	1	18876000	754454	0	65	611
	FOOD & FOOD PRODUCTS	1	3187000	127381	0	11	103
	OTHER SERVICES	2	32817000	1311661	0	113	1062
	OTHERS	1	6300000	251804	0	22	204
	RUBBER & PLASTIC PRODUCTS	1	5121000	204681	0	18	166
	TEXTILES (INCLUDING JUTE)	2	22902000	915369	0	79	741
Panaji							
	MINING	1	61900000	922679	0	79	747
	OTHER SERVICES	1	27000000	402461	28	63	573
	RUBBER & PLASTIC PRODUCTS	1	20060000	299013	0	26	242
Patna							
	RUBBER & PLASTIC PRODUCTS	2	32054000	51851	0	4	42
Peenya							
	MACHINERY	2	16576000	92128	0	8	75
	METAL PRODUCTS	8	90275000	501740	38	81	739
	OTHER SERVICES	5	76182000	423412	0	36	343
	RUBBER & PLASTIC PRODUCTS	2	12277000	68234	0	6	55
Puducherry							
	MACHINERY	1	5450000	89302	0	8	72
	METAL PRODUCTS	4	85082000	1394121	0	120	1129

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	OTHER SERVICES	1	5420000	88810	0	8	72
	OTHERS	2	10158000	166445	0	14	135
	PAPER & PAPER PRODUCTS	1	70000000	1146993	0	99	929
	RUBBER & PLASTIC PRODUCTS	6	113807000	1864798	0	160	1510
	TEXTILES (INCLUDING JUTE)	1	41332000	677250	0	58	549
Pune							
	IRON & STEEL	2	79409000	155631	0	13	126
	MACHINERY	4	91067000	178479	0	15	145
	METAL PRODUCTS	16	291105000	570527	0	49	462
	NON-FERROUS METALS	1	18000000	35278	0	3	29
	OTHER SERVICES	4	61925000	121365	0	10	98
	OTHERS	2	54900000	107597	0	9	87
	PAPER & PAPER PRODUCTS	1	50000000	97993	0	8	79
	RUBBER & PLASTIC PRODUCTS	3	77374000	151643	0	13	123
	TRANSPORT EQUIPMENT	6	141388000	277102	0	24	224
Raipur							
	IRON & STEEL	1	29900000	777400	0	67	630
	METAL PRODUCTS	2	79000000	2054000	0	177	1664
	TRANSPORT EQUIPMENT	1	60100000	1562600	0	134	1266
Rajkot							
	FOOD & FOOD PRODUCTS	1	25036000	650936	0	56	527
	IRON & STEEL	3	65894000	1713244	0	147	1388
	MACHINERY	1	20532000	533832	0	46	432
	METAL PRODUCTS	7	135522000	3523572	0	303	2854
	NON-FERROUS METALS	4	38171000	992446	0	85	804
	OTHER SERVICES	4	82284000	2139384	0	184	1733
	OTHERS	1	37700000	980200	0	84	794

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	PAPER & PAPER PRODUCTS	1	17133000	445458	0	38	361
	RUBBER & PLASTIC PRODUCTS	6	109878000	2856828	0	246	2314
Sitapura Industrial Area							
	RUBBER & PLASTIC PRODUCTS	2	12880000	334880	0	29	271
	WOOD & WOOD PRODUCTS	1	2867000	74542	0	6	60
Surat							
	CHEMICAL & CHEMICAL PRODUCTS	1	3216000	83616	0	7	68
	OTHER SERVICES	1	14100000	366600	0	32	297
	TEXTILES (INCLUDING JUTE)	2	34253000	890578	0	77	721
Thane							
	CHEMICAL & CHEMICAL PRODUCTS	2	70000000	503250	0	43	408
	ELECTRONIC EQUIPMENT	1	2050000	14738	0	1	12
	FOOD & FOOD PRODUCTS	1	10400000	74769	0	6	61
	MACHINERY	3	54100000	388940	0	33	315
	METAL PRODUCTS	4	79130000	568888	20	69	627
	NON-METALLIC MINERAL PRODUCTS	1	13629000	97983	0	8	79
	OTHER SERVICES	2	21620000	155432	0	13	126
	PAPER & PAPER PRODUCTS	1	1534000	11028	0	1	9
	RUBBER & PLASTIC PRODUCTS	5	146470000	1053015	0	91	853
Tirupur							
	RUBBER & PLASTIC PRODUCTS	1	7900000	224225	0	19	182
	TEXTILES (INCLUDING JUTE)	5	118653000	3367714	0	290	2728
Udaipur							
	MINING	1	7000000	106275	0	9	86
	NON-METALLIC MINERAL PRODUCTS	1	11900000	180668	0	16	146
	WOOD & WOOD PRODUCTS	1	50000000	759108	0	65	615

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
Vadodara							
	CHEMICAL & CHEMICAL PRODUCTS	3	41576000	504987	0	43	409
	ELECTRICITY GENERATION	1	6268000	76132	0	7	62
	METAL PRODUCTS	2	35251000	428163	0	37	347
	TEXTILES (INCLUDING JUTE)	1	20790000	252518	0	22	205
	TRANSPORT EQUIPMENT	1	50000000	607306	0	52	492
Varanasi							
	CHEMICAL & CHEMICAL PRODUCTS	1	23900000	290292	0	25	235
	FOOD & FOOD PRODUCTS	4	37798000	459099	0	39	372
	OTHER SERVICES	2	29129000	353804	0	30	287
Vasai							
	ELECTRONIC EQUIPMENT	1	8400000	72449	0	6	59
	IRON & STEEL	1	5782000	49869	0	4	40
	METAL PRODUCTS	1	21667000	186875	0	16	151
	OTHER SERVICES	1	11949000	103059	0	9	83
	RUBBER & PLASTIC PRODUCTS	1	22237000	191792	0	16	155
Vatva							
	FOOD & FOOD PRODUCTS	1	17000000	334631	0	29	271
	IRON & STEEL	2	99936000	1967158	0	169	1593
	METAL PRODUCTS	1	75000000	1476313	0	127	1196
	OTHER SERVICES	2	53850000	1059993	0	91	859
	RUBBER & PLASTIC PRODUCTS	1	45000000	885788	0	76	717
	TEXTILES (INCLUDING JUTE)	1	46256000	910511	0	78	738
Vijayawada							
	HOTELS	1	7400000	31329	0	3	25
	METAL PRODUCTS	2	35475000	150189	0	13	122
	NON-METALLIC MINERAL PRODUCTS	1	7670000	32472	0	3	26

Cluster	Sector	No. of Units	Total Investment (INR)	kWh Saved	Thermal Energy Saved	Total Energy Saved (TOE)	Emission Reduction (tCO2)
	OTHER SERVICES	1	8808000	37290	0	3	30
Visakapatnam							
	FOOD & FOOD PRODUCTS	2	63600000	1229989	0	106	996
	TEXTILES (INCLUDING JUTE)	3	110000000	2127340	0	183	1723
Vishwakarma							
	PAPER & PAPER PRODUCTS	1	12900000	249479	0	21	202
Yamuna_Nagar							
	CHEMICAL & CHEMICAL PRODUCTS	1	16860000	187613	0	16	152
	HOSPITALS	1	4731000	52645	0	5	43
	HOTELS	1	9963000	110865	0	10	90
	MACHINERY	1	9537000	106125	0	9	86
	METAL PRODUCTS	2	18499000	205851	0	18	167
	TEXTILES (INCLUDING JUTE)	2	41616000	463090	0	40	375
	WOOD & WOOD PRODUCTS	3	61703000	686611	0	59	556
Total (Investment in Crore and Electrical Savings in MWh)		1088	1962.74	275863.1	889.44	24613.67	231294.86

A.2 Sample Energy Savings Calculation of appliances covered under S&L Program

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard	Energy saving formula	Sample Energy Savings Calculation of an appliance based on the formula
1.	Frost Free Refrigerator	Annual Energy Consumption (kWh)	759 + adjusted volume*0.8716	(Baseline Annual Energy consumption by appliance as defined by (kWh) – Annual energy consumption of star rated appliance)	(759+271.6*0.8716) – 275 = 720.73 kWh/yr
2.	Tubular Fluorescent Lamps	Lumen /Watt	61	(Rated Lumen per watt for star rated – Baseline Lumen Per watt) * Lumens	(69 – 61) * 2484 = 4.72 W
3.	Room Air Conditioners (RAC)	ISEER	2.3	(CSTL /Baseline ISEER) – (CSTL/Rated ISEER for star rated appliance)	(3870.5 / 3.31) – (3870.5 / 2.3) = 513 kWh/yr
4.	RAC (Cassette, Floor Standing Tower, Ceiling, Corner AC)	ISEER	2.3	(CSTL /Baseline ISEER) – (CSTL/Rated ISEER for star rated appliance)	(4683.3 / 3) – (4683.3 /2.3) = 475 kWh/yr
5.	Distribution Transformer (DT)	Maximum loss at 50% and 100% of the loading	Base energy consumption is measured by the % loss corresponding to specific rating (in kVA) of transformers and operational voltage (V of primary incomer)	Base loss at 50% loading – Rated loss at 50% loading for star rated appliance	240 – 135 = 105 W
6.	Direct Cool Refrigerator	Annual Energy Consumption (kWh)	561 + adjusted volume*0.645	[Baseline Annual Energy consumption by appliance as defined by (kWh) – Annual energy consumption of star rated appliance)	(561 + 176.39*0.645) – 674.8 = 461.8
7.	Stationary Storage Type Electric Water Heater (Geyser)	Standing energy loss in 24 hours (%)	Baseline energy consumption Matrix	Baseline Standing loss (kWh/24 hr) – Rated standing loss for star rated appliance (kWh/24 hr)	1.138 – 0.454 = 0.684

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard	Energy saving formula	Sample Energy Savings Calculation of an appliance based on the formula
8.	Color Television	Annual Energy consumption (kWh)	0.1494 * screen area in cm^2 + 4.38	(Baseline Annual Energy consumption by appliance as defined by (kWh/yr) – Annual energy consumption of star rated)	(0.1494*2734.72 + 4.38) – 412.95 = 338.82 kWh/yr.
9.	Room Air Conditioners (Variable Speed)	ISEER	3.1 for Split AC 2.5 for Window AC	(CSTL /Baseline ISEER) – (CSTL/Rated ISEER for star rated appliance)	(4838.07 / 3.74) – (4838.07 / 3.1) = 267 kWh/yr
10.	LED Lamps	Lumen /Watt	79	(Rated Lumen per watt for star rated – Baseline Lumen Per watt) * Lumens	(91 – 79) * 819 = 1.37 W
11.	Agricultural Pump sets	Performance factor	IS 14220 for Open well, IS8034 for Submersible pump set, IS9079 for moonset pump sets	[Baseline Annual Energy consumption by appliance as defined by (kWh) – Annual energy consumption of star rated]	
12.	Ceiling Fans	Service value	3.1	(Minimum air delivery / Baseline service factor) – Rated consumption of star rated appliance	(215 / 3.1) – 53 = 16.4 W
13.	Domestic Liquefied Petroleum Gas (LPG) Stoves	Thermal Efficiency (%)	68%	(Total gas consumption * rated thermal efficiency/ baseline thermal efficiency) – Total gas consumption	(469* 69 / 68) – 469 = 7 g/hr
14.	**c)** Washing Machine (Front loaders (drum type))	kWh/kg/cycle	0.18	(Baseline energy consumption per cycle – Rated energy consumption) * Rated Capacity * Number of cycles	(0.18 – 0.11) * 15 * 220 = 231 kW
	d) Washing Machine (Top loaders & semi-automatic machines)	kWh/kg/cycle	0.0185	(Baseline energy consumption per cycle – Rated energy consumption) * Rated Capacity * Number of cycles	(0.0185 – 0.0133) * 7 * 220 = 8 kW

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard	Energy saving formula	Sample Energy Savings Calculation of an appliance based on the formula
15.	Microwave Oven	Energy consumption per cycle (Wh)	60 Wh/cycle	(Baseline energy consumption – Rated energy consumption) * No of cycles per year	(60 – 57.8) * 365 = 8.03 kWh/yr
16.	c) Chillers (Air cooled)	ISEER	3 - 3.1 (Matrix)	(Baseline kW/Tr – Rated kW/Tr) * 100% Cooling Capacity	(1.13 – 0.86) *117.57 = 31.7 kW
	d) Chillers (Water cooled)	ISEER	4.8 - 6 (Matrix)	(Baseline kW/Tr – Rated kW/Tr) * 100% Cooling Capacity	(0.73 – 0.6) * 50.47 = 6.56 kW
17.	Light Commercial Air conditioners	ISEER	2.7 (Fixed Speed) 3.1 (variable Speed)	(CSTL /Baseline ISEER) – (CSTL/Rated ISEER for star rated appliance)	(10063.2 / 3.1) – (10063.2 / 3.23) = 131 kWh/yr
18.	Deep freezers	Annual Energy Consumption(k Wh)	5.07*V + 151.98 (Hard Top) 9.21*V+613.4 (Glass Top)	Baseline energy consumption – rated energy consumption	(9.21 * 288 + 613.4) – 1045 = 1759.46 kWh/yr

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