सत्यमेव जयते
Government of India

आज़ादी का अमृत महोत्सव

IMPACT OF ENERGY EFFICIENCY MEASURES

FOR THE YEAR 2020-21

BUREAU OF ENERGY EFFICIENCY

Imprint

Study by
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Commissioned on behalf of
Bureau of Energy Efficiency
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Version
New Delhi, May 2022
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Preface

Energy efficiency provides the considerable potential to promote low carbon transformation in the Indian context. India had realized this importance of energy optimization long back, evident from the launch of the Energy Conservation Act in 2001. It had further directed its policies to focus specifically on energy efficiency by setting up the Bureau of Energy Efficiency (BEE) and subsequently initiating the National Mission for Enhanced Energy Efficiency (NMEEE).

While rolling out schemes and programmes to conserve energy is an important aspect, assessing their impact on the ground is essential to gauge their effectiveness, and derive learnings for future interventions. Therefore, an impact assessment of all the schemes related to energy efficiency is required.

Along with BEE, there are other organizations at the national level that are also supporting in energy efficiency by launching their own set of schemes. These schemes are spanning across major energy consuming sectors in India such as Industry, Commercial, Residential, Transport, Agriculture, Municipal etc., along with cross cutting mechanisms for the realization of energy savings.

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 (KPMG India) to conduct this study for the FY 2020-21. The overall objective of this study was to assess the impact of all energy efficiency schemes/programmes in India in terms of total energy saved and reduction in the CO_2 emissions in 2020-21.

The objective of this study is to assess the overall impact of all energy efficiency schemes at the national as well as state level for the FY 2020-21 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, Residential Building 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 estimated findings of the report reflect that the adoption of energy efficiency schemes/programs has led to the overall energy savings of 42.0 Million Tonnes of oil Equivalent for the year 2020-21. This study has estimated that various energy efficiency measures have led to the overall thermal energy savings in the order of 22.24 Million Tonnes of oil Equivalent, while overall electricity savings are to the tune of 239.78 Billion Units in the year 2020-21

Overall, these energy savings translated into monetary savings worth INR 152,241 crores per annum. The equivalent reduction in CO_2 emissions is around 267.98 Million Tonnes annually.

May 2022
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 energy consumption in India has grown from about 332.93 million tons of oil equivalent (TOE) in 2012 to about 553.97 million TOE in 2021.[1]

Energy demand and consumption in the country has increased rapidly and is expected to rise further in the years to come. In order to meet the increasing demand for energy in the country, energy efficiency would play a major and crucial role in every sector of the Indian economy.

India has remained progressive and one of the front runners in achieving its energy efficiency potential, through innovative programmes such as the Perform Act 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. However, the rhythm and momentum of this energy transition have been curbed by the COVID-19 pandemic during FY 20-21.

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 at least limit the energy imports and perpetual headlong rush towards new production capacities which still require heavy investment and significant financing.

The COVID 19 pandemic has also taught a lesson to the world that globalization is important but being self-reliant is also necessary. The Government of India is implementing reforms toward a secure, sustainable, and affordable energy system to power robust economic growth. The Government has also notified policies and regulations for the promotion of energy efficiency in India.

The Bureau of Energy Efficiency (BEE) has been engaged in several initiatives to design and implement energy efficiency programs, as well as there are complimenting programs by other agencies, a direct consequence of which can be observed in the declining trend of India's energy intensity.

[1] Source: Energy Statistics 2021, MoSPI

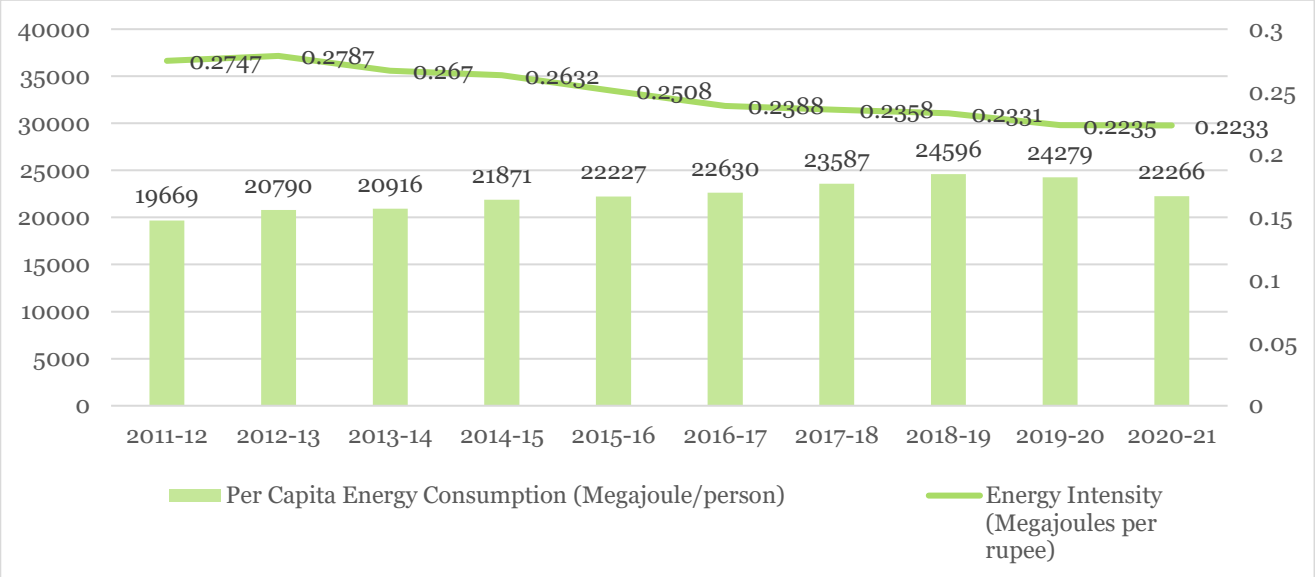


Figure 1: Energy intensity and Per capita Consumption trend

During the years 2011-12 to 2020-21, India's energy intensity decreased from 0.27 MJ per INR to 0.22 MJ per INR (Figure 1[2]), which is a significant decrement of 18.51%. 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 Figure 2.

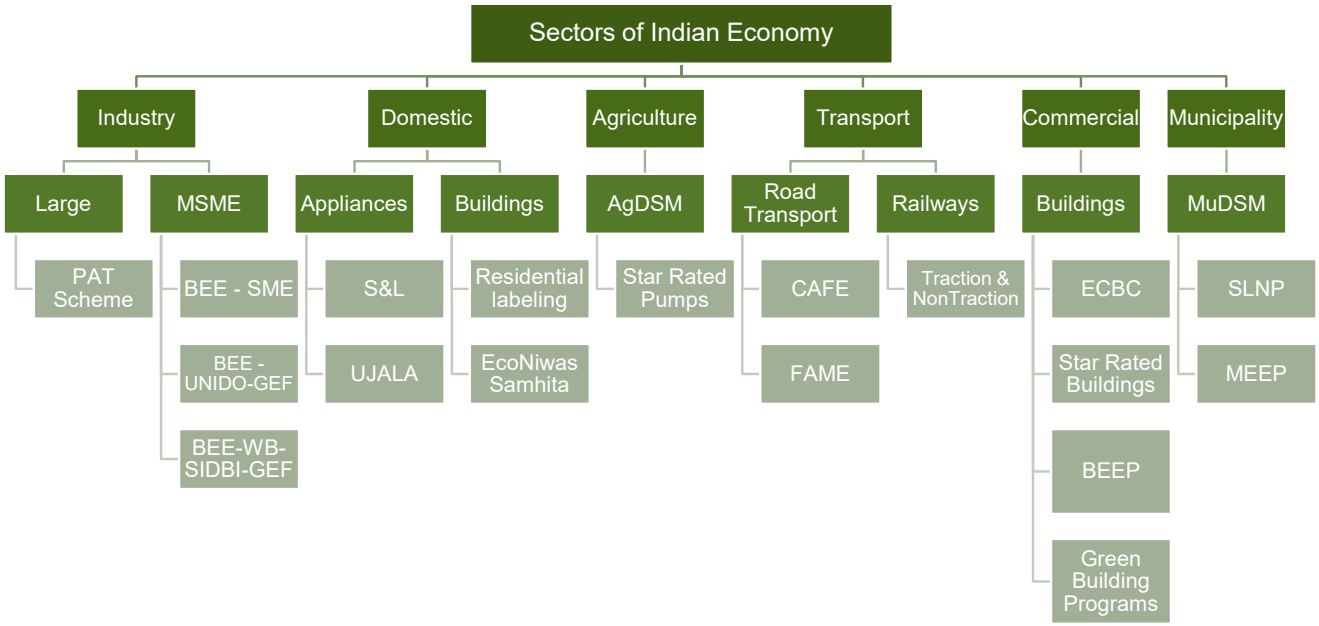


Figure 2: Energy Efficiency Schemes in India

[2] Energy Statistics 2022

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 2020-21. 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 2020-21

The adoption of energy efficiency schemes/programmes has led to the overall energy savings of 42.0 Mtoe, i.e., 4.73% of the total primary energy supply of the country for the year 2020-21.

A summary of savings from various schemes and interventions is presented in Table 1.

Table 1: Summary of energy savings (2020-21)[3]

Program/Scheme	Sector	Electricity Savings (BU)	Thermal Savings (MTOE)	Total Energy Savings (MTOE)	GHG Reduction (MtCO2)	Monetary Savings (INR Crore)
PAT- III	Large Industry	0.61	1.69	1.75	6.43	3,483.59
PAT- II		36.47	10.95	14.08	68.43	42,020.59
PAT- I		3.01	8.41	8.67	31.00	9,500.00
PRSF	MSME	0.08	-	0.01	0.06	48.25
BEE-GEF-EESL				0.0019	0.009	3.45
BEE-UNIDO				0.010	0.064	17.84
BEE-FLCTD		0.00015	0.00001	0.000026	0.00080	0.11
ECBC	Commercial Buildings	0.1410	-	0.0121	0.1114	22.31
BEE Star Rating		0.2492	-	0.0214	0.1969	39.43
ENS	Residential Buildings	0.0024	-	0.00021	0.0019	0.38
S&L	Multiple (Appliances)	61.57	0.02	5.29	50.16	36,942.00
	Others (AgDSM, SEAC, etc.)	0.46		0.04	0.36	275.01
UJALA	LED Lamps	47.78	-	4.10	38.70	19,112.00
	LED (Private Market)	82.00	-	7.05	67.00	32,800.00
SLNP	Municipal	7.40	-	0.64	6.00	5,069.27
FAME	Transport		0.02	0.02	0.05	183.50
CAFE			0.31	0.31	0.92	2,723.13
Total		**239.77**	**21.40**	**42.00**	**267.98**	**1,52,240.8**

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 21.40 Mtoe** amounting to **INR 40,918 Crores** and a reduction of **78.56 Million tonne of CO_2 emission**. While overall electricity savings are to the tune of **239.77 BU annually**. These savings resulted in cost savings worth **INR 1,52,240 Crores and a reduction of 267.98 Million tonnes of CO2 emissions**.

Overall, these energy savings translated into monetary savings worth INR 152,240.8 crores in the year 2020-21. The equivalent reduction in CO_2 emissions is around 267.98 million Tonnes annually.

PAT scheme contributed to 55.44% of the total energy savings, while S&L and UJALA accounted for 42.26% of the total energy saving from all major interventions carried out during FY 20-21. The share of various schemes in the total Energy savings is presented in Figure 3.

[3]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.

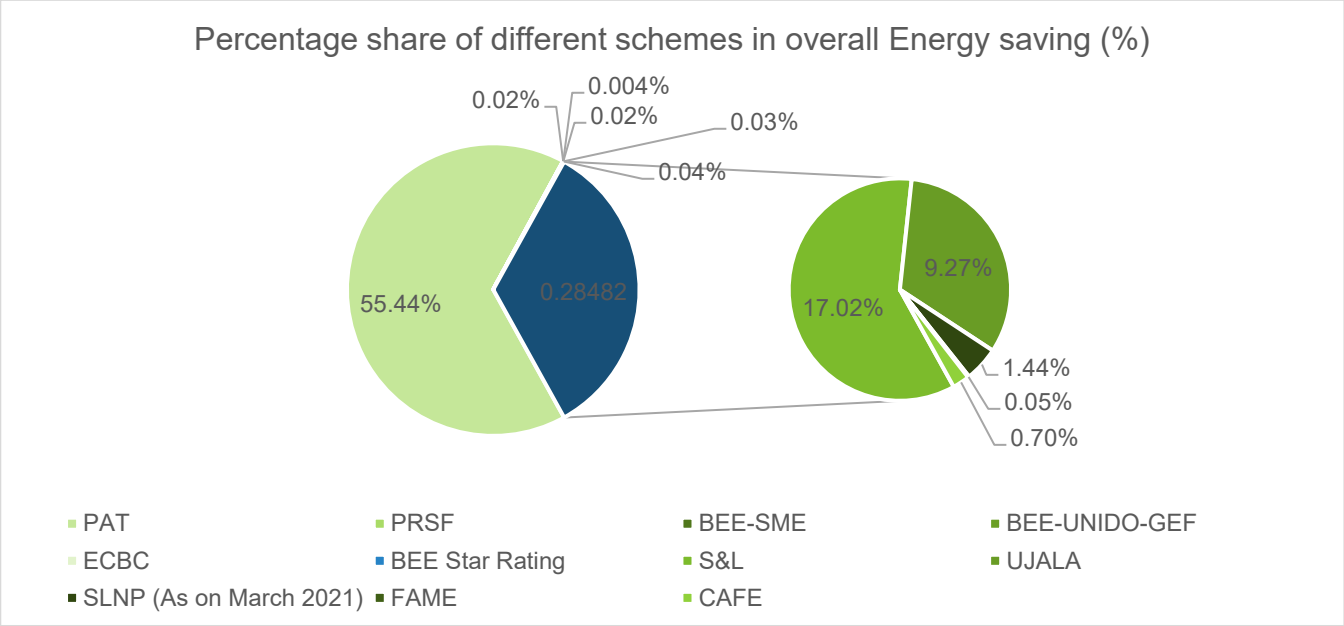


Figure 3: Total energy savings (Mtoe) by Scheme / Programme (2019-20)

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 30.75 Mtoe in the demand side energy consumption, amounting to 5.26% of the energy demand (585 Mtoe[4]) during the year 2020-21. The total energy savings achieved (including both Supply Side and Demand Side sectors of the economy) is of the order of 42.0 Mtoe. These energy savings amount to 4.73% of the total primary energy supply (888.52 Mtoe[4]) during 2020-21.

Thermal and Electrical Energy savings contribution from various economic sectors is presented in Table 2.

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[5]	21.89	40.09	24.51	105.99	55,073.72
Domestic[6]	0.02	191.35	16.48	156.22	89,129.39
Commercial Buildings[7]	-	0.39	0.03	0.31	61.74
Transport (including Railways)	0.33	-	1.23	0.97	2,906.63
Others (including Municipal)	-	7.86	0.64	6	5,069.27
Agriculture (including Star Rated pumps)	-	0.01	0.006	0.36	313.01
Total	**22.24**	**239.77**	**42.0**	**267.98**	**1,52,240.8**

[4] Energy Statistics 2022, MoSPI report.
[5] Industry Sector includes the savings from PAT (Excluding – DISCOM, Buildings, Railways) and MSMEs
[6] Domestic Sector includes the savings from S&L (except pump sets and DTs) and savings from UJALA programme
[7] Including saving from DTs

The industry sector has the highest contribution with a share of 57.14% of the total energy savings while the domestic sector has contributed 38.24% of the total savings achieved during FY 20-21.

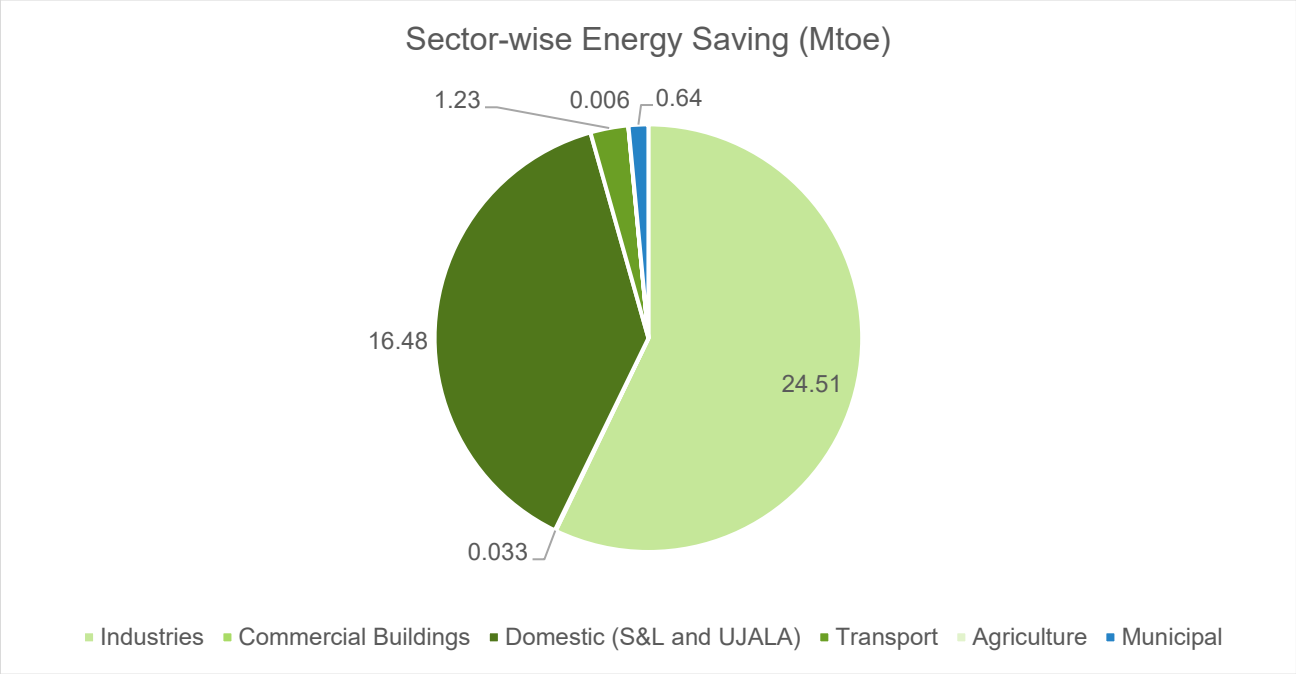


Figure 4: Total Energy Savings by Economic Sectors (2020-21)

Overall, these energy savings translated into monetary savings worth INR 1,52,241 crores and contributed to reducing 267.98 million Tonnes of CO_2 emission. Emission reductions from the various schemes are presented in Figure 5.

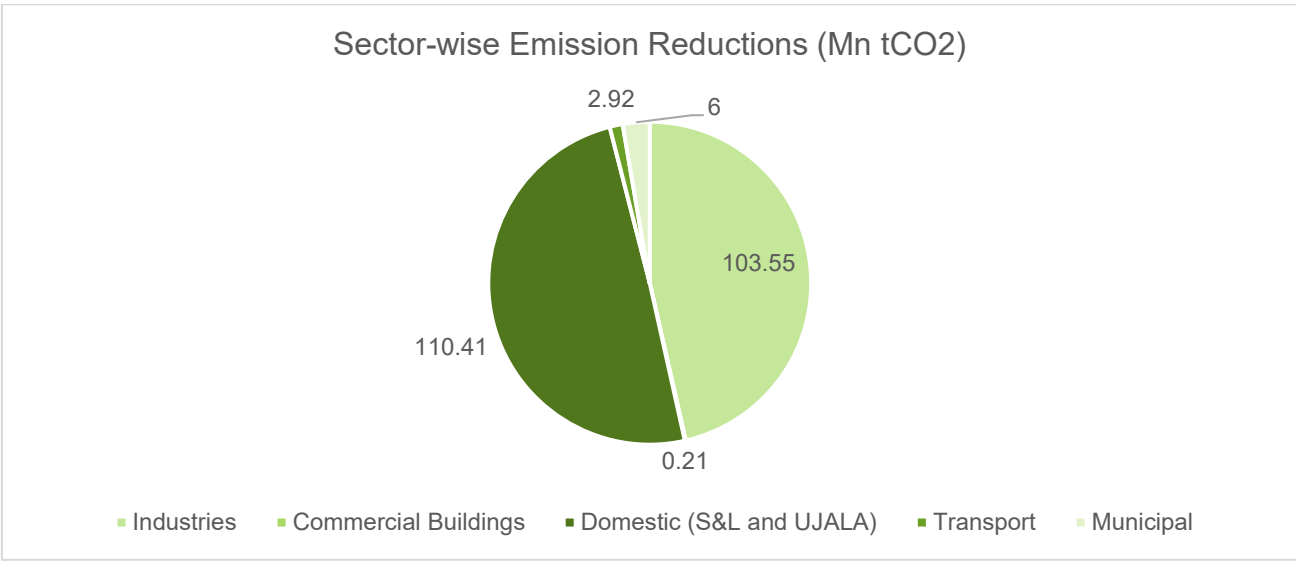


Figure 5: CO_2 Emission Reductions by Economic Sectors (2020-21)

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 2020-21 across various sectors viz. Industry, building (domestic and commercial), municipal, agriculture, transport, and miscellaneous are calculated and the impact of various schemes have been computed.

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, energy savings achieved during the years by implementing EE technologies/ solutions have been compared with the total energy consumption of the country for the respective years, as seen in Figure 6.

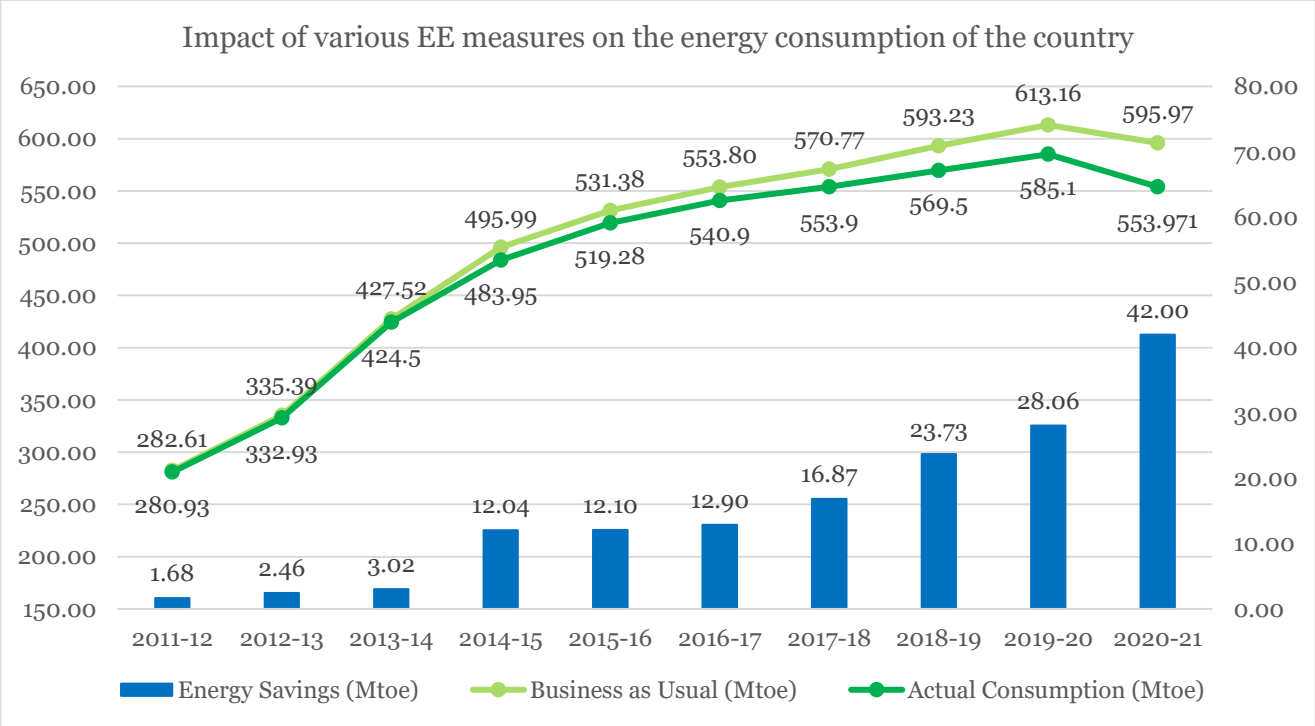


Figure 6: Impact of various EE measures (Mtoe)

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

Speaking at the 26th Conference of Parties (COP-26) in Glasgow, our Honorable Prime Minister Narendra Modi has announced that India will achieve net-zero emissions by 2070. India has also committed to reducing 1 billion tonnes of projected emissions from now till 2030 and achieving a carbon intensity reduction of 45 percent over 2005 levels by 2030.

Improved energy efficiency across all the sectors of the Indian economy will help us achieve the enormous and ambitious targets that our Prime Minister has set at COP 26.

The Government of India has made impressive progress in recent years in increasing citizens' access to electricity and clean cooking. Looking ahead, the Government has laid out an ambitious vision to bring secure, affordable, and sustainable energy to all its citizens.

As energy has always been recognized as one of the most important inputs to determine the economic growth of a country, it is prudent to initiate new and innovative policies to curb unnecessary energy consumption across all sectors.

The current policy and program implementation landscape of the country shapes the energy consumption of the demand sectors. Current schemes/programs were largely successful in achieving significant energy savings across various sectors viz. Industry, building (domestic and commercial), municipal, agriculture, and transport. However, in 2020, the coronavirus pandemic has exacerbated many of the existing challenges the energy sector faces to its financial and physical resilience.

India has suffered the devastating impacts of COVID-19, raising health, economic and social challenges. However, when the Indian economy will come back to pre-COVID levels, the resilience of the power sector has become critical. It is this crisis and the Government's response that could create the strongest momentum for energy efficiency reforms in coming years.

It is possible that the future landscape would be driven by disruptive technologies due to changes in behavior post COVID such as remote production, process automation, economic megatrends such as Industry 4.0, and e-Mobility which will change the dynamics of energy sector.

The BEE's National Strategic Plan on Energy Efficiency includes these relatively new technologies such as e-Mobility, fuel cell vehicles (FCVs), integration of renewables & storage, net-zero buildings, district cooling, smart meters, internet of things, active appliance feedback, blockchain technologies, etc. for decarbonizing various sectors of the economy.

At the COP26 summit, our honorable Prime Minister also delivered a new motto for long-term sustainable growth. He stated that 'LIFE,' or Lifestyle for the Environment, might serve as a basis for climate change. This can become a mass movement of Environmental Conscious Lifestyle. What is needed today is Mindful and Deliberate Utilization, instead of Mindless and Destructive Consumption. These movements together can set goals that can revolutionize many sectors in diverse areas including Energy.

Outcomes of the COP26 summit are expected to benefit the country in the long-term with new technologies in energy efficiency, carbon reduction, green fuels, etc. The said targets will setup massive investment opportunities across segments like renewables, the EV ecosystem, ethanol blending, improvement in energy efficiencies, and carbon capture technologies

Energy saving through the adoption of the above-mentioned technologies, increasing the scope of the wide gamut of energy related policies and programs, and sensitizing the consumers towards the importance of saving energy in their day-to-day lives would go a long way in making India energy secure, self-reliant and resource efficient.

Chapter 1: Introduction

1. *Introduction*

Today, India has become a major force in the global energy economy. The country's energy demand and consumption has doubled since 2000, primarily driven by urbanization, industrialization and a period of rapid economic growth. Over the past three decades, India's primary energy demand has tripled, whereas economic growth, measured by GDP has increased fourfold over the same period, signaling that a decoupling of energy consumption and economic growth is already underway[8].

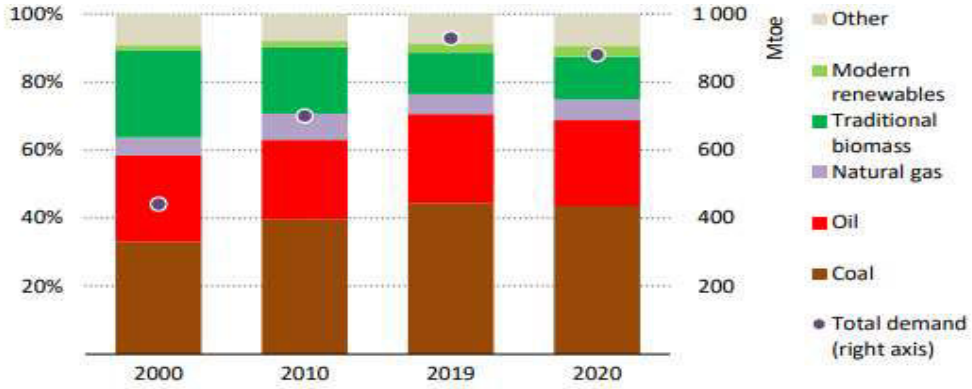


Figure 7: Total Primary Energy Demand in India

Image Source: IEA

Despite the shock from COVID-19, India's total energy demand is still projected to grow by almost 5% per year to 2040[9], which is nearly double the rate of energy demand as a whole.

In 2020-21, the total final Energy Consumption (End Use) in India was 5,53,971 kTOE[10]. The industrial sector was the largest consumer of energy in the country with this sector itself using more than half, i.e., 56.22% of the total final energy consumption. The consumption of the residential, agriculture, commercial & public sectors, non-energy purpose and other sectors represented 34.96% of the total final consumption in the country, whereas transport sector accounted for 8.82% of Total Final Consumption[11].

The total final energy consumption by the major sectors of the Indian economy is depicted in Figure 8.

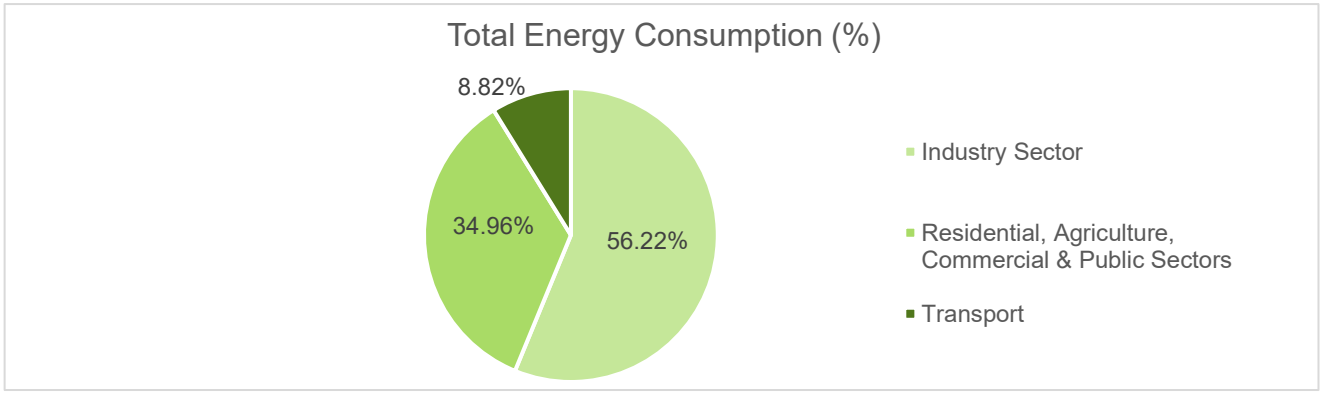


Figure 8: Total final energy consumption by major sectors in India Economy

[8] Source: IEA
[9] Source: https://iea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fdd6283b22/India_Energy_Outlook_2021.pdf
[10] Source: http://www.mospi.nic.in/sites/default/files/reports_and_publication/ES/Energy%20Statistics%20India%202021.pdf
[11] Source: MOSPI

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 Performance Achieve and Trade (PAT) scheme, ECBC for residential & commercial sector, Standards & Labeling programme for appliances, and conducive policies for clean transport (EVs) etc.

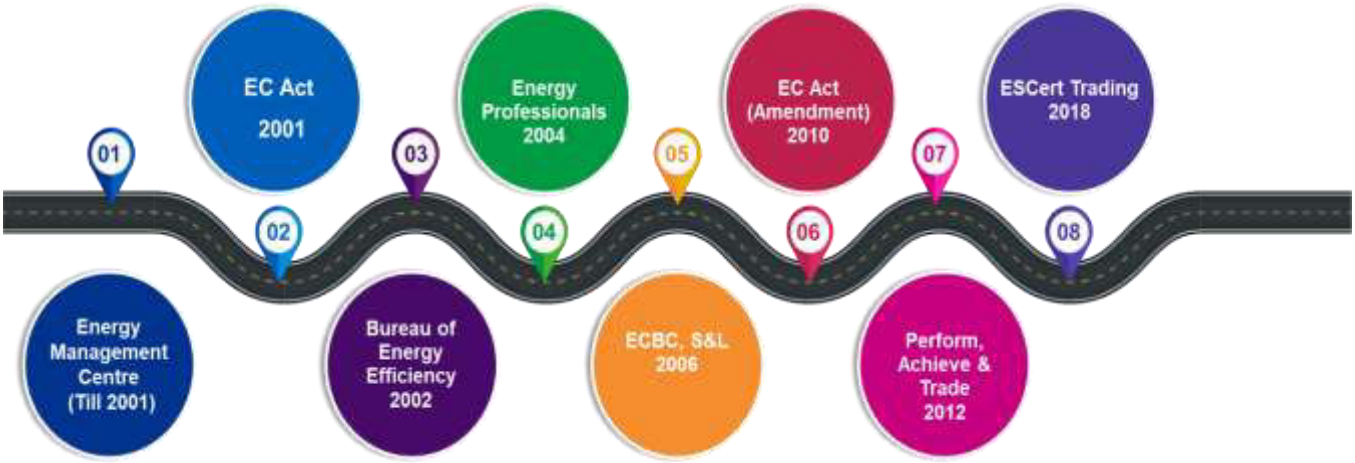


Figure 9: Chronograph of EE policies and programs in India

During the 30th National Energy Conservation Awards (NECA) held in January 2021, the Standards and Labelling Programme for Air Compressors and Ultra High Definition (UHD) TV on voluntary basis was launched and the energy consumption standards were effective from 1st January 2021.This initiative is expected to save around 8.41 Billion Units of electricity for Air Compressors and 9.75 Billion Units for UHD TV till 2030.

BEE has also developed a Management Information System (MIS) portal namely State-wise Actions on Annual Targets and Headways on Energy Efficiency (SAATHEE), portal for State Designated Agency for state level activities, which would facilitate real-time monitoring of the progress of implementation of various Energy Conservation endeavors at State level was also launched at the NECA event.

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 2020-21.

Table 3: Status of major EE schemes and programmes

Sector/ Sub-sector	Schemes/ Programs	Status as on FY 2020-21
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 2 was launched in 2016 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 100 DCs have been completed. • PAT Cycle IV, V & VI added 109, 110 and 117 DCs respectively, which makes the total number of DCs till PAT Cycle VI = 1073.
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 efficiency projects implemented in the clusters as on 31st March 2021
	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 28 appliances in this programme covered as on 31st March 2021. • 10 appliances under Mandatory regime. • 18 appliances under voluntary regime.
	UJALA	• 37 Crore LED bulbs were distributed till 31st March 2021. • 73 lakhs LED tube-lights and 25.92 EE fans were also distributed under UJALA programme till March 2021.
Domestic-Buildings	Eco Niwas Samhita	• As on 31st March 2021, Over 1.55 million sqm of the residential built-up area has been compliant with ENS

Sector/ Sub-sector	Schemes/ Programs	Status as on FY 2020-21
		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 2021, 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 2021.
Agriculture-Appliances (Star Rated Pumps)	AgDSM- (Star Rated Pumps)	• As on 31st March 2021, 77,400 nos. of energy efficient pumps have been installed.
Municipality - Lighting & Appliances	MuDSM- (SLNP)	• Around 120 Lakh LED Street Lights in 28 States/UTs across India has been installed till 31st March 2021.
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 • Under FAME-I, a total 2.8 lakhs vehicles were supported • Upgradation of Public EV charging infrastructure for faster adoption of EV. • FAME II was launched in 2019. As on 31st March 2021, 260099 EVs were sold under FAME II, 50 number of OEMs have been registered under FAME-II. 164 EV models have been approved for the subsidy under FAME-II. • India had installed 1800 public charging points including fleet segment by end of FY 2020-21.

Sector/ Sub-sector	Schemes/ Programs	Status as on FY 2020-21
		• 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 2020-21. • The Ministry of Housing and Urban Affairs (MoHUA) has also made amendment in Model Building Byelaws (MBBL) 2016 to include the provision of EV charging in buildings
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 an agency to undertake a comprehensive review of national and state level schemes initiated for the adoption of energy efficiency in 2020-21 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 2020-21. 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.

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 2018
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
1 kWh saving = 0.79 kg of carbon dioxide emission reduction[12]
Cost/toe[13] = INR 18,402
Cost/kWh[14] = INR 6.00
Net energy (Total) [15] consumption in 2020-21 = 553.97 Mtoe
Net energy supply [15] in 2020-21 = 888.52 Mtoe
Electricity (Total) [16] consumption in 2020-21= 1227 TWh
Emission factor for LPG[17] – 63.1 tonne of CO_2/ TJ

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 2020-21.

[12] https://cea.nic.in/wp-content/uploads/tpe___cc/2022/02/User_Guide__ver_17_2021.pdfhttp://www.cea.nic.in/reports/others/planning/pdm/growth_2018.pdf

[13] 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

[14] https://pfcindia.com/Home/VS/29 (PFC report 2018-19)

[15] Energy Statistics 2022, MoSPI Report.

[16] Energy Statistics 2022, MoSPI Report.

Chapter 10 covers various initiatives undertaken in states by SDAs and other agencies. Finally, Chapter 11 concludes the entire report along with the way forward.

Chapter 2: Industries

2. *Industries*

The final Energy Consumption (End Use) of India was 5,53,971ktoe[18] in the last FY 2020-21. The industrial sector was the largest consumer of energy in the country with this sector itself using more than half, i.e., 56.22% of the total final energy consumption. Within the industry sector, the most energy intensive industries were iron and steel, which accounted for 15.37% of the industrial energy use followed by Chemicals and petrochemicals 4.43 % and construction 1.96%.[19]

At the 26th Conference of Parties (COP-26) in Glasgow, honorable Prime Minister has announced that India will achieve net-zero emissions by 2070 and has also committed to reduce 1 billion tonnes of projected emissions from now till 2030 and achieving carbon intensity reduction of 45 per cent over 2005 levels by 2030. Achieving these ambitious emissions reduction targets needs inclusive efforts by industrial consumers, which also happen to be the largest consumers of primary energy in India (56% energy demand).

Needless to say, Industrial consumers will also be the front-runners 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.

BEE has developed a National Strategy Plan titled 'Unlocking National Energy Efficiency Potential' (UNNATEE), as per the report India's energy saving potential is estimated to be 86.9 Mtoe under "moderate" implementation of EE programs by year 2031. As per this report, industrial sector will contribute an estimated 60% of the estimated energy savings potential.

[18] Source: Energy Statistics 2022, MoSPI
[19] Source: Energy Statistics 2022, MoSPI

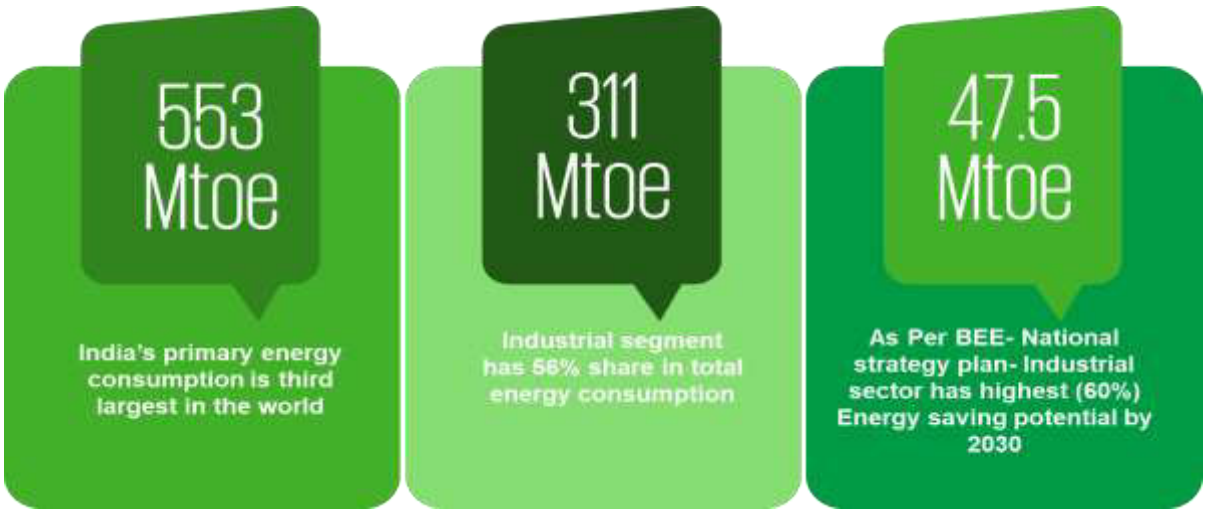


Figure 10: Energy Consumption Scenario

Bureau of Energy Efficiency (BEE) has notified broad policies for promotion of Energy Efficiency (EE) in India. Industrial segment is one of the focus sectors of the BEE to enhance energy efficiency. In a bid to combat increasing energy consumption and related carbon emissions, the Government of India released the National Action Plan on Climate Change (NAPCC) in 2008 to promote and enable sustainable development of the country by promoting a low carbon and high resilience development path.

The Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE) is a broader version of the National Mission for Enhanced Energy Efficiency (NMEEE) and includes current and potential areas of energy efficiency in each sector. The revised Mission includes existing activities of BEE as well as new activities which have been identified. Includes proposing amendment to EC Act of 2001 to enhance scope, expanding coverage of PAT, developing a PAT for SMEs, expanding S & L coverage, promote ESCOs, mobilize investment, enhanced data collection and analysis, enhancing state-level capacity (regional Bureaus of Energy Efficiency) and capacity building.

Today, Energy Efficiency in industrial sector has gained significant momentum with policy focus coming-in through schemes like Perform, Achieve and Trade (PAT). While energy efficiency in the MSME sector has remained on the programme agenda of several institutions, including BEE, World Bank, UNIDO and UNDP etc. for a significant time now.

2.1. Perform, Achieve and Trade (PAT) framework

The PAT scheme was designed with the goal of improving the energy efficiency of industrial units in a cost-effective manner. Even though the industrial sector is the largest energy consumer segment in the country, it was realized that the sector had not taken advantage of the benefits of increased energy efficiency due to problems in getting access to necessary capital to fund energy efficiency investments, and often a lack of necessary incentives towards such investments, and problems of long payback periods of such investments, coupled with inadequate information about the benefits of energy efficiency investments. The PAT scheme was designed to mitigate such inherent anomalies and offer a transparent, robust, and cost-effective mechanism to attain the desired energy efficiency goals in the large industrial sector.

As broadly brought out in the framework document on "National Mission on Enhanced Energy Efficiency", the Energy Conservation Act, 2001 has identified 20 large Energy Intensive Sectors namely Aluminum, Buildings, Cement, Ceramics, Chlor-Alkali, Chemicals, Copper, DISCOMs, Fertilizer, Glass, Iron & Steel, Mines, Petroleum Refinery, Petrochemicals, Pulp & Paper, Railways, Sugar, Textile, Thermal Power Plants and Zinc for energy efficiency improvements.

PAT is a market-based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. In this mechanism, an individual target will be set for the industries by the Government to reduce their Specific Energy Consumption (SEC).

These targets can be achieved over a period of 3 years. The industries can achieve this target by implementing best practices in their industries, change the old technology to the latest one, by using energy efficient equipment and by any other suitable innovative method or they can use their R&D facilities to develop efficient processes.

Those industries that achieve and exceed the target would be issued Energy Saving Certificates (ESCerts) and those industries who could not achieve the target have to either pay penalties or buy the ESCerts from the industries who have secured ESCerts by exceeding the target assigned to them. Some of the broad steps involved in commissioning and operationalizing typical PAT cycles in industries / industry sectors are presented in Figure 11.

Figure 11: Design of the PAT framework

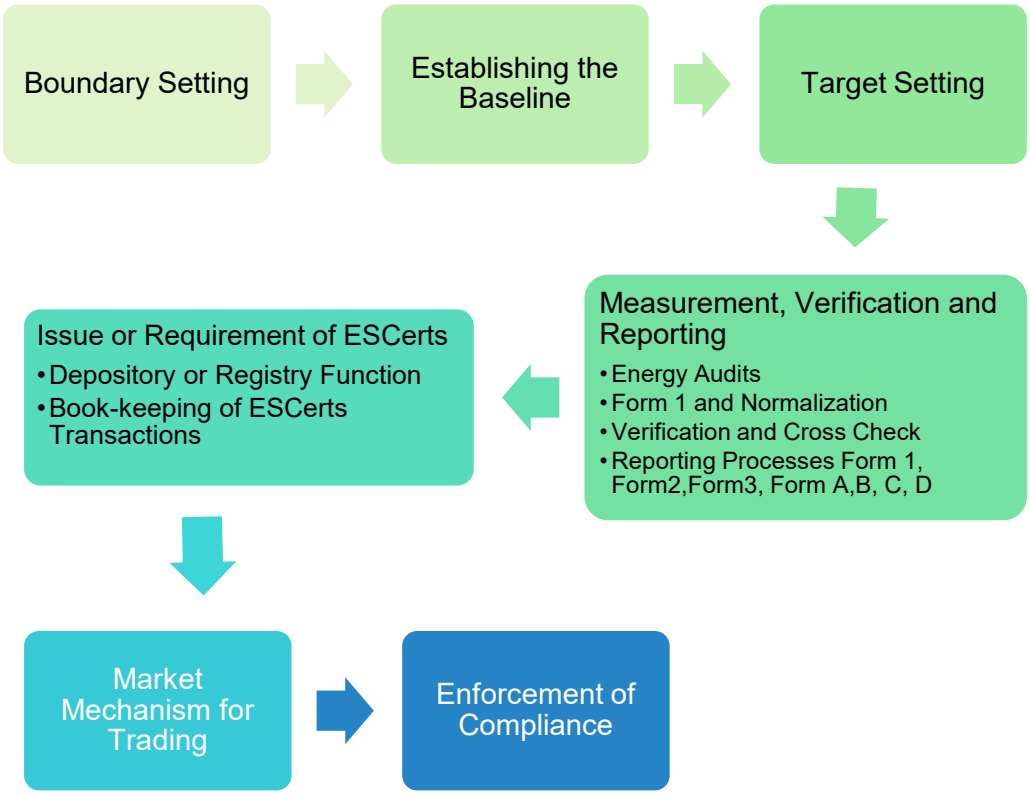


Table 6: PAT Stakeholders and responsibilities

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

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 I, PAT Cycle II was launched in 2016 with addition of three sectors, namely, Petroleum Refineries, DISCOMs and Railways. With this widening of the sectors and deepening among existing sectors, 173 DCs were added during PAT Cycle II, taking the total number of DCs to 621 across 11 target sectors, as seen in Table 7.

Table 7: PAT Sector Overview:

Sector	Minimum annual energy consumption for the DC (toe)	No. of DCs	
		Cycle I	Cycle II
Thermal Power Plant	30,000	144	154
Iron and Steel	30,000	67	71
Cement	30,000	85	111
Fertilizer	30,000	29	37
Aluminium	7,500	10	12
Pulp and Paper	30,000	31	29
Textile	3,000	90	99
Chlor-Alkali	12,000	22	24
Petroleum Refineries	90,000	-	18
Railways	Zonal Railways - 70,000	-	16
	Production Unit (by Name)	-	6
DISCOMs	86000	-	44
	Total	**478**	**621**

Since 2017 and onwards every year, PAT Cycles are notified on rolling basis. PAT Cycle III is launched in 2017 for 116 newly identified DCs within the existing 11 target sectors. PAT Cycle IV is launched in 2018 with expansion to two more sectors – Petrochemicals and Commercial Buildings, and 109 DCs across 13 sectors. The newly added sectors Petrochemicals and Buildings contribute 8 DCs and 37 DCs respectively.

PAT framework has come a long way in its sixth cycle, covering 13 Sectors and 1073 DCs with estimated energy saving of around 28 Mtoe till PAT Cycle–VI. These industries would be among the top 1100 energy consumers, and they (including the power sector) account for significant share in the total energy consumption in India. Details are presented in Table 8.

Table 8: PAT details till Cycle VI

Sector / No. of DCs	Till PAT Cycle II	PAT Cycle-III	PAT Cycle-IV	PAT Cycle- V	PAT Cycle- VI	Total DCs
Thermal Power Plant	154	37	17	17		225
Iron & Steel	71	29	35	23	5	163
Cement	111	14	1	12	37	175
Aluminium	12	1	-	1		14
Fertilizer	37	-	-	-		37
Paper & Pulp	29	1	2	8	2	42
Textile	99	34	7	16	7	163
Chlor- Alkali	24	-	2	2		28
Refinery	18	-	-	-	2	20
Railways	22	-	-	-		22
DISCOMs	44	-	-	-		44
Petrochemical	-	-	8	-		8
Buildings	-	-	37	31	64	132
Total	**621**	**116**	**109**	**110**	**117**	**1073**

2.1.2. PAT Cycle I

PAT Cycle I which completed in March 2015, 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 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.

As such, the complete turn-around implementation of PAT Cycle I has generated outcomes in two folds, namely,

1. Generation of huge quantity of first-hand, measured and verified, industrial energy consumption data

2. Specific experiences among a multitude of stakeholders with respect to implementation of the PAT framework, including policy makers and implementers, DCs, institutional framework (SDAs, SERCs, etc.), industrial bodies (industry associations, think tanks, etc.), international development agencies, key market elements of EE technologies, etc.

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 Table 9.

Table 9: 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**

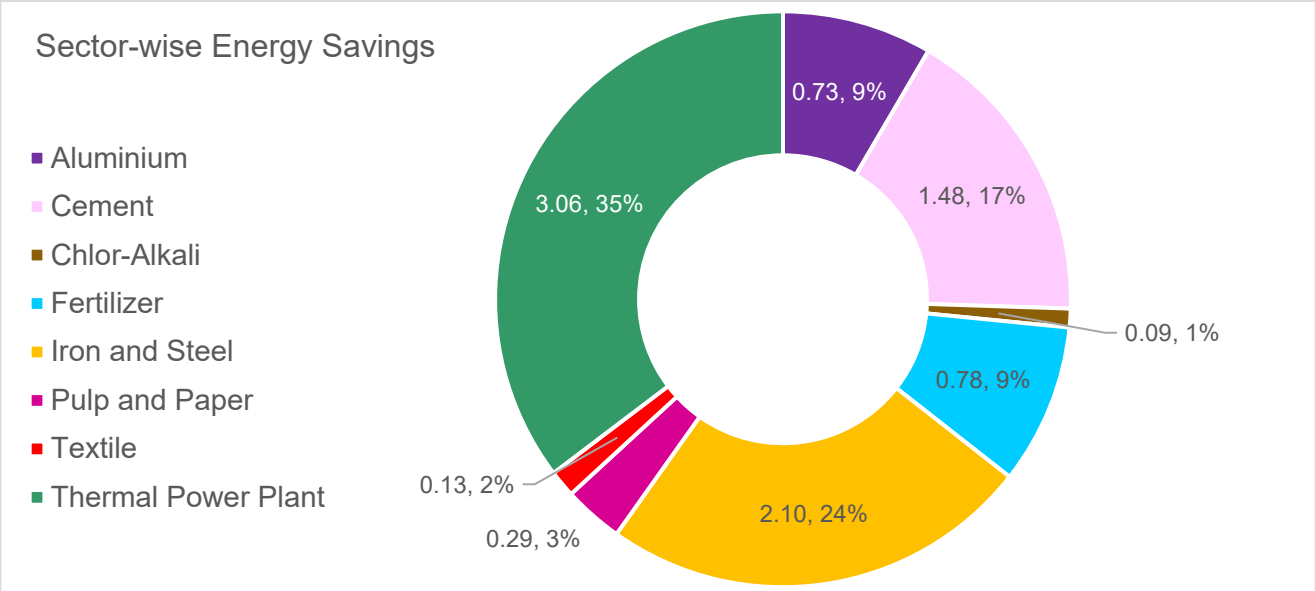


Figure 12: PAT Cycle I – Sector-wise Energy Savings

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.

Deepening study resulted into identification of 89 DCs from the existing sectors of PAT. Widening study resulted into notification of three new sectors namely Refineries, Railways and DISCOMs under PAT scheme. PAT in its second cycle (2016-17 to 2018-19) seeks to achieve an overall energy consumption reduction of 13.633 Mtoe for which energy reduction targets have been assigned and notified to DCs in these 11 sectors (eight existing sectors and three new sectors). PAT Cycle II commenced from 1st April, 2016 covering 621 DCs from 11 sectors which include eight existing sectors and three new sectors viz. Railways, Refineries and DISCOMs. Summary of target savings and DCs are presented in Table 10.

Table 10: 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**

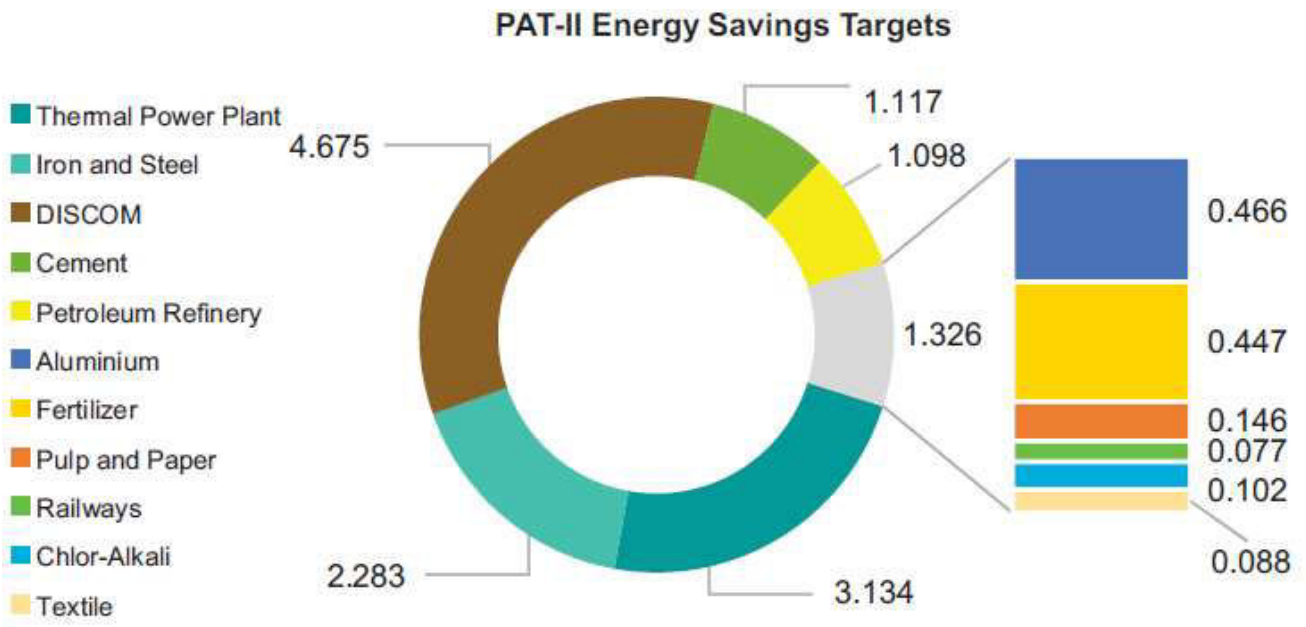
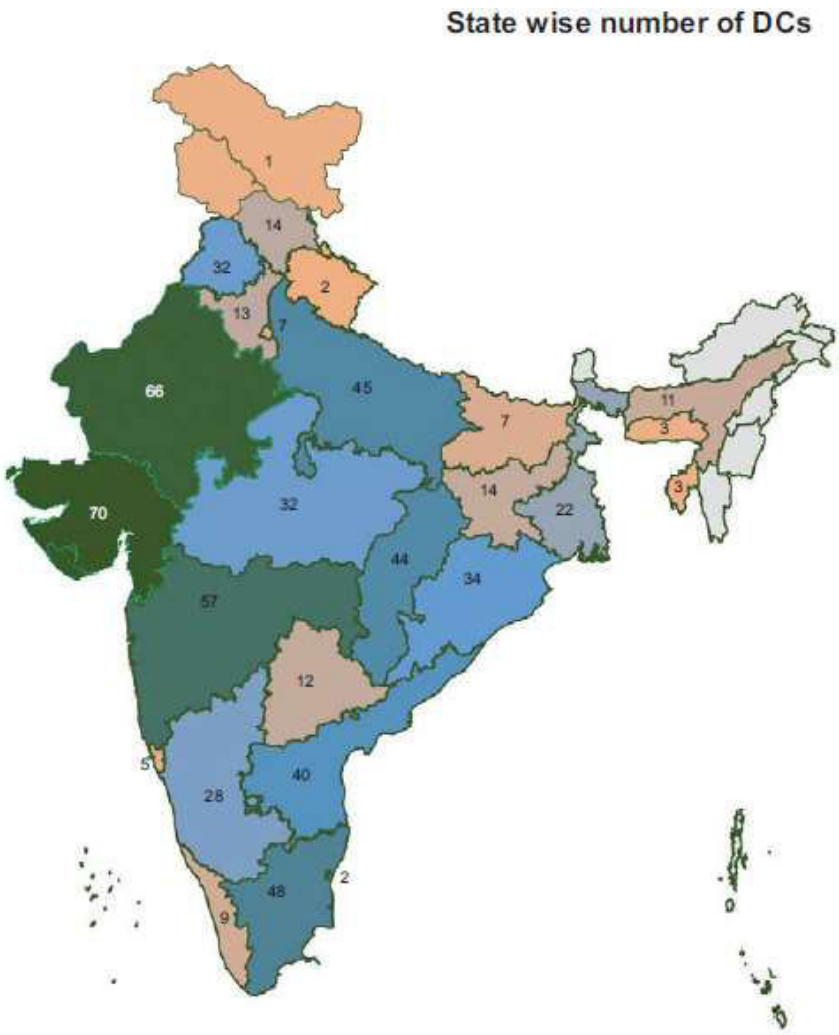


Figure 13: PAT Cycle II Energy Savings Targets



States/UTs	Number of DCs
Andhra Pradesh	40
Assam	11
Bihar	7
Chhattisgarh	44
Delhi	7
Goa	5
Gujarat	70
Haryana	13
HimachalPradesh	14
Jammu & Kashmir	1
Jharkhand	14
Karnataka	28
Kerala	9
Madhya Pradesh	32
Maharashtra	57
Meghalaya	3
Odisha	34
Puducherry	2
Punjab	32
Rajasthan	66
Tamil Nadu	48
Telangana	12
Tripura	3
Uttar Pradesh	45
Uttarakhand	2
West Bengal	22

Figure 14: PAT Cycle II State-wise No. of DCs

2.1.3.1. Methodology adopted to calculate the savings

The PAT Cycle-II concluded with Monitoring and Verification (M&V) of energy savings reported by the DCs through various reporting and assessment forms (Forms 1, 2, 3, and Form A, B and C, etc.), submitted to BEE by DCs at regular reporting intervals.

The verification of the M&V reports was carried out by the State Designated Agencies (SDAs) and at BEE. M&V completion status of the PAT cycle II is presented in Table 11.

Table 11: PAT Cycle II- Number of PAT DCs Analyzed for Monitoring and Verification

Sector	Total DC	Total Finalized DCs after M&V	Closed	Below Threshold	M&V Not Done
Aluminium	12	11	1		0
Cement	111	99	9	3	
Chlor-Alkali	24	24			
Fertilizer	37	36		1	
Iron and Steel	71	67	1	1	2
Pulp and Paper	29	24	2		2
Textile	99	85		6	8
Thermal Power Plant	154	118	18	18	

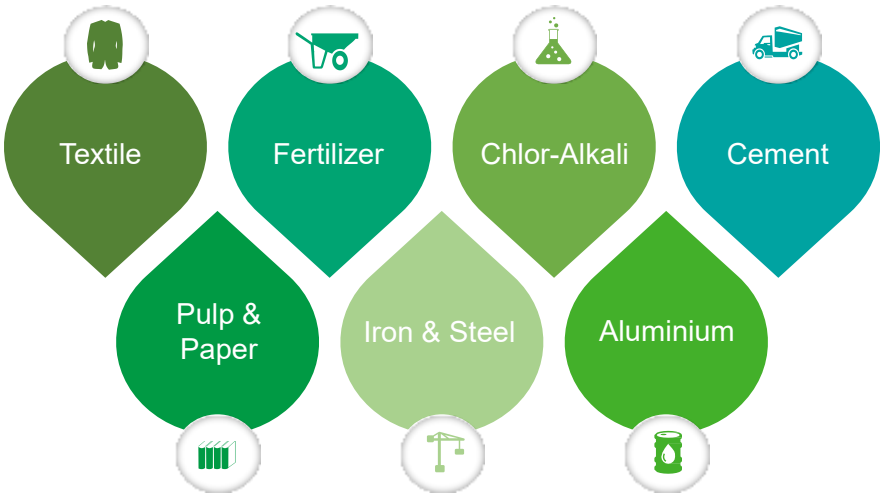
Sector	Total DC	Total Finalized DCs after M&V	Closed	Below Threshold	M&V Not Done
Petroleum Refinery	18	17			1
Railways	22	22			
DISCOM	44	41		1	5
Grand Total	**621**	**544**	**31**	**30**	**18**

In order to calculate the savings under the PAT scheme, the 544 DCs of PAT Cycle-II and their M&V data (Assessment year 2018-19) have been considered.

2.1.3.2. Estimation of Energy Savings:

Following set of equations are used in order to calculate the energy savings, using the data for above mentioned DCs. The production data of the baseline year of PAT Cycle II, i.e. 2014-15 has been taken into consideration, in line with PAT rules, and the M&V exercise conducted by BEE.

As increase in annual production may or may not directly lead to overall energy savings. Therefore, we have adopted the conservative estimate of energy savings based on the baseline year production for measuring the impact of PAT scheme in FY 2018-19. The following calculations were adopted for each of the below mentioned sectors:



i. Step I: Obtain the Specific Energy Consumption (SEC) for the base year 2014-15 = $SEC_{2014-15}$

ii. Step II: Obtain the SEC for the M&V year 2018-19= $SEC_{2018-19}$

iii. Step III: $SEC_{2014-15}$ - $SEC_{2018-19}$ (Improvement in Energy Efficiency)

iv. Step IV: In order to calculate the Energy (thermal) Savings (ES) in Mtoe, the results of Step 3 to be multiplied by the total production of respective DCs for the year 2014-15.

Formula = $ES_{Plant\ 1}$= ($SEC_{2014-15}$ - $SEC_{2018-19}$) x $Production_{2014-15}$

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

Railways:

Similarly, for the Railways, following steps were considered. The Indian railway has 16 zones and 6 production units across India that are a part of the PAT Cycle II. The 16 zones consume diesel and electricity for its operation (passenger and goods) purposes.

i. Step I: In this sector, in order to calculate the energy savings, it is important to identify fuel consumption in the base year (2014-15) and M&V year (2018-19) as Fuel Consumption$_{2014-15}$ and Fuel Consumption $_{2018-19}$ respectively. The unit of fuel consumed is Liter/1000 GTKM. The GTKM means KM earned with the gross tonnage hauled including the weight of the locomotive.

ii. Step II: Identify 1000GTKM value for each zone.

iii. Step III: The energy saved for all the zones are calculated as:

$ES_{Zone\ 1}$ = (Fuel Consumption$_{2014-15}$ - Fuel Consumption $_{2018-19}$) x Utilization (1000GTKm)$_{2014-15}$

iv. Step IV: $\Sigma ES = ES_{Zone\ 1} + ES_{Zone\ 2} + ES_{Zone\ 3} + ES_{Zone\ 4}$ +----------+ $ES_{Zone\ N}$

In case of railway production units, following steps were considered:

i. Step I: Obtain the SEC (in kgoe/No of equivalent units) for the base year 2014-15 = $SEC_{2014-15}$

ii. Step II: Obtain the SEC (in kgoe/No of equivalent units) for the M&V year 2018-19= $SEC_{2018-19}$

iii. Step III: $SEC_{2014-15}$ - $SEC_{2018-19}$ (Improvement in Energy Efficiency)

iv. Step IV: In order to calculate the Energy (thermal) Savings (ES) in kgoe, the results of Step 3 to be multiplied by the total production in terms of no. of equivalent units for the year 2014-15.

Therefore formula = ES $_{Production\ Unit\ 1}$= ($SEC_{2014-15}$ - $SEC_{2018-19}$) x Production$_{2014-15}$

v. Step V: $\Sigma ES = ES_{Production\ Unit\ 1} + ES_{Production\ Unit\ 2} + ES_{Production\ Unit\ 3}$ + ----------+ ES $_{Production\ Unit\ N}$

Thermal Power Plants:

In case of Thermal Power Plants, following steps were considered:

i. Step I: Obtain the Net Heat Rate (kcal/kWh) for base year 2014-15= $NHR_{2014-15}$ kcal/kWh

ii. Step II: Obtain the Net Heat Rate (kcal/kWh) for the M&V year 2018-19= $NHR_{2018-19}$ kcal/kWh

Step III: Identify kWh generated by the notified plant for the M&V year 2018-19= Production$_{2014-15}$

iii. Step IV: Adopt the following formula to calculate the Energy Savings (ES)

Formula = $ES_{Plant\ 1}$= ($NHR_{2014-15}$ - $NHR_{2018-19}$) x Production$_{2014-15}$

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

Refinery

Similarly for the Refinery sector, following steps were considered:

i. Step I: Identify Million British Thermal Unit per Thousand barrels per Energy Factor (MBN) of the notified plant for base year 2014-15 = $MBN_{2014-15}$

ii. Step II: Identify Million British Thermal Unit per Thousand barrels per Energy Factor (MBN) of the notified plant for M&V year 2018-19 = $MBN_{2018-19}$

iii. Step III: Identify the crude throughput by the notified plant for the M&V year 2014-15, Production$_{2014-15}$ in Million Barrels (MBLs)

iv. Step IV: Identify the complexity of the refinery plant, which is expressed as NRGF. It is the composite NRGF of the plant and is calculated considering the individual energy factor and throughput of each sub-process= $NRGF_{plant\ 1}$
v. Step V: Adopt the following formula to calculate the Energy Savings (ES)
vi. Formula = $ES_{Plant\ 1} = (MBN_{2014\text{-}15} - MBN_{2018\text{-}19}) \times Production_{2014\text{-}15} \times NRGF_{plant\ 1} \times 0.252$
vii. Step VI: $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +\text{----------}+ ES_{Plant\ N}$

2.1.3.3. Impact of PAT Cycle II:

The impact under the PAT scheme for this report was calculated based on the data of 544 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 12:

Table 12: PAT Cycle II Energy Savings Achieved

PAT Sector (Demand Side)	PAT Sector (Supply Side)	Number of PAT DCs analyzed for M&V	Energy Savings Achieved (Mtoe)	% Share of Savings (Sector-wise)	% Share of Savings (Demand & Supply wise)
Aluminium		11	1.226	8.7%	48.24%
Cement		99	1.559	11.1%	
Chlor-Alkali		24	0.133	0.9%	
Fertilizer		36	0.383	2.7%	
Iron and Steel		67	2.845	20.2%	
Pulp and Paper		24	0.315	2.2%	
Textile		85	0.135	1.0%	
Railways		22	0.196	1.4%	
	Thermal Power Plant	118	3.435	24.4%	51.76%
	Petroleum Refinery	17	1.430	10.2%	
	DISCOM	39	2.423	17.2%	
Grand Total		**544**	**14.08**	**100%**	**100%**

The sectors mentioned in above table 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.

Other sectors, primarily consume energy as one of the inputs or factors of production, and hence energy efficiency measures in these sectors are classified as demand side energy efficiency. The analysed data of demand side sectors demonstrates the total energy savings of 6.793 Mtoe while the total energy savings for the supply side sectors amounts to 7.288 Mtoe for FY 2018-19, saving due to these interventions will be carried forward to FY 2019-20 and 2020-21.

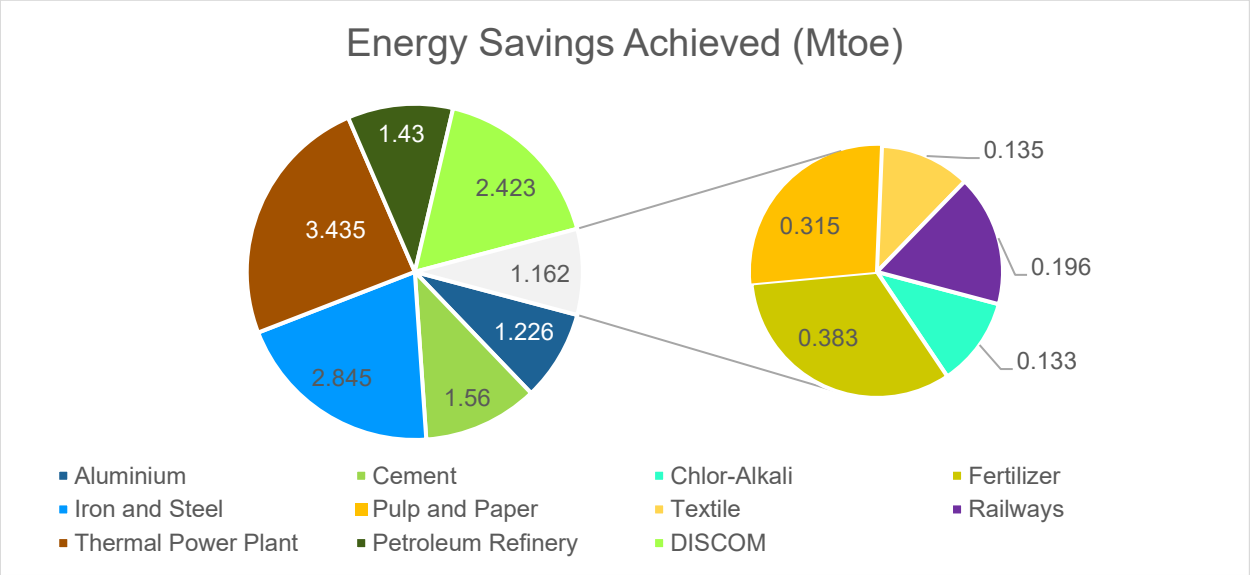


Figure 15: PAT Cycle II Energy Savings Achieved

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 in the Table 13:

Table 13: 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	11	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	17	0.08	0.196	145%
DISCOM	41	3.73	2.423	(35%)
Grand Total	**544**	**12.13**	**14.08**	**16%**

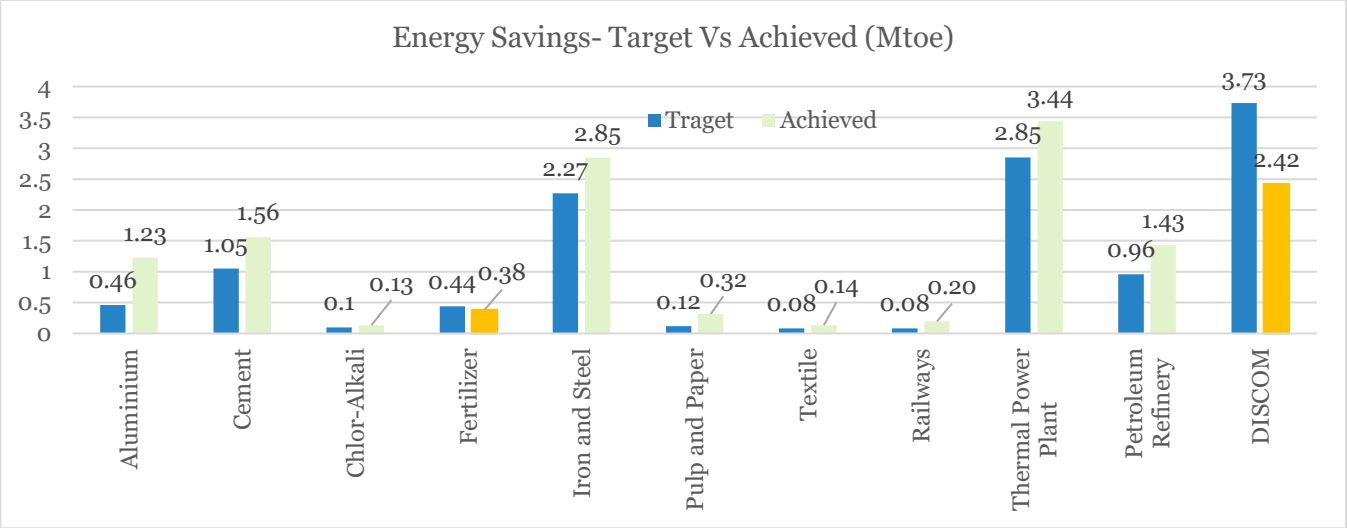


Figure 16: Energy Savings - Target Vs Achieved

2.1.3.3.1. 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 as provided in Table 14.

Table 14: Fuel-Mix for each PAT Sector:

Sector	Fuel Mix %			
	Coal	Oil	Gas	Electricity
Aluminium	94.0%	4.5%	0.5%	1.0%
Cement	97.0%	1.0%	0.0%	2.0%
Chlor-Alkali	75.0%	2.0%	13.0%	10.0%
Fertilizer	8.0%	0.0%	90.0%	2.0%
Iron and Steel	83.5%	2.0%	1.5%	13.0%
Pulp and Paper	80.0%	5.0%	0.0%	15.0%
Textile	71.8%	0.9%	2.6%	24.7%
Thermal Power Plant	99.5%	0.5%	0.0%	0.0%
Petroleum Refinery	15.9%	24.3%	50.2%	9.6%
Railways	0.0%	69.0%	0.0%	31.0%
DISCOM	0.0%	0.0%	0.0%	100.0%

Post that conversion factor of 860 kcal/kWh is considered for calculation of electrical energy savings. Both thermal and electrical energy savings for each PAT sectors provided in Table 15

Table 15 Demand and supply side Energy saving (Thermal and electrical)

PAT Sector (Demand Side)	PAT Sector (Supply Side)	No. of PAT DCs	Thermal Energy Savings (Mtoe)	Electrical Energy Savings (BU)
Aluminium		11	1.214	0.143
Cement		99	1.529	0.363
Chlor-Alkali		24	0.120	0.155
Fertilizer		36	0.375	0.089
Iron and Steel		67	2.475	4.301

Pulp and Paper		24	0.268	0.549
Textile		85	0.102	0.388
Railways		22	0.135	0.707
	Thermal Power Plant	118	3.435	0.000
	Petroleum Refinery	17	1.293	1.598
	DISCOM	41	0.000	28.174
Grand Total		**544**	**10.945**	**36.466**

The analysed data of sector under the consumption side demonstrates the total thermal energy savings of 6.217 Mtoe and electrical energy savings of 6.694 BU. While the sector under the supply side demonstrates the total thermal energy savings of 4.728 Mtoe and electrical energy savings of 29.772 BU.

2.1.3.3.2. 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 as per Table 14. Post those following assumptions were taken for calorific values, density of respective fuels and CO2 conversion factors as presented in Table 16.

Table 16: kcal value and CO2 conversion factors for various fuels

Gross Calorific Values	kcal/kg	kcal/kWh	CO2 Emission Factors	
			kg of CO2 / kg of fuel	kg of CO2 / kWh
Coal	4500		1.52	
Oil	10050		3.13	
Gas	9500		2.69	
LPG[20]	11900		2.89	
Electricity		860		0.79

Overall, the energy savings of 10.945 Mtoe and 36.466 BU under PAT Cycle II has resulted in reduction of 71.47 MtCO2. Emission reduction due to PAT Cycle II is presented in Table 17.

Table 17: Share (Value) of reduction in CO2 emission by each sector

Sector	Total DCs	Evaluated DCs	Total Emission Reduction (Million tCO2)	% Share
Aluminium	12	11	4.20	6.14%
Cement	111	99	5.45	7.96%
Chlor-Alkali	24	24	0.55	0.80%
DISCOM	44	41	25.44	37.18%
Fertilizer	37	36	1.18	1.72%
Iron and Steel	71	67	11.85	17.32%
Petroleum Refinery	18	17	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%

[20] https://www.hindustanpetroleum.com/AboutLPG#:~:text=Properties%20of%20LPG,-LPG%20is%20twice&text=LPG%20can%20be%20compressed%20at,in%20high%20efficiency%20heat%20output.

Sector	Total DCs	Evaluated DCs	Total Emission Reduction (Million tCO2)	% Share
Thermal Power Plant	154	118	11.57	16.91%
Grand Total	**621**	**544**	**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 18:

Table 18: PAT Cycle II emission and energy saving summary

Parameters	Values
No. M&V Analyzed PAT DCs	544
Total Energy Savings achieved under PAT II	14.08 Mtoe
Overall reduction in CO2 emission	68.43 MtCO2
Energy (thermal) saved at consumption side	6.22 Mtoe
Energy (thermal) saved at supply side	4.73 Mtoe
Energy (electrical) saved at consumption side	6.69 BU
Energy (electrical) saved at supply side	29.77 BU

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 19.

Table 19: PAT Cycle III- Energy savings targets:

S No	Sector	PAT-III (as per base year 2015-16)		
		Number of DCs	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. Following set of equations prepared in order to find the energy savings:

viii. Step I: Obtain the Specific Energy Consumption (SEC) for the base year 2015-16 = $SEC_{2015-16}$

ix. Step II: Obtain the Estimated SEC target for the year 2019-20= SEC_{target}

x. Step III: $SEC_{2015-16}$ - SEC_{target} (Improvement in Energy Efficiency)

xi. 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 2015-16.

Therefore formula = $ES_{Plant\ 1}$= ($SEC_{2015-16}$ - SEC_{target}) x $Production_{2015-16}$

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

2.1.4.2. Impact of PAT Cycle III

M&V Data for 100 DCs under PAT cycle III was analyzed and as per preliminary assessment it has been estimated that this will result into energy savings of 1.746 Mtoe (based on baseline year production data of FY 2015-16). The share of energy saved by each sector is presented in Table 20.

Table 20: PAT Cycle III 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)
Aluminium		1	1	0.09	2.5%	31.55%
Cement		14	12	0.15	4.7%	
Iron and Steel		29	20	0.57	21.0%	
Pulp and Paper		1	1	0.01	0.3%	
Textile		34	31	0.05	3.1%	
	Thermal Power Plant	37	35	0.88	68.5%	68.45%
Grand Total		**116**	**100**	**1.75**	**100%**	**100%**

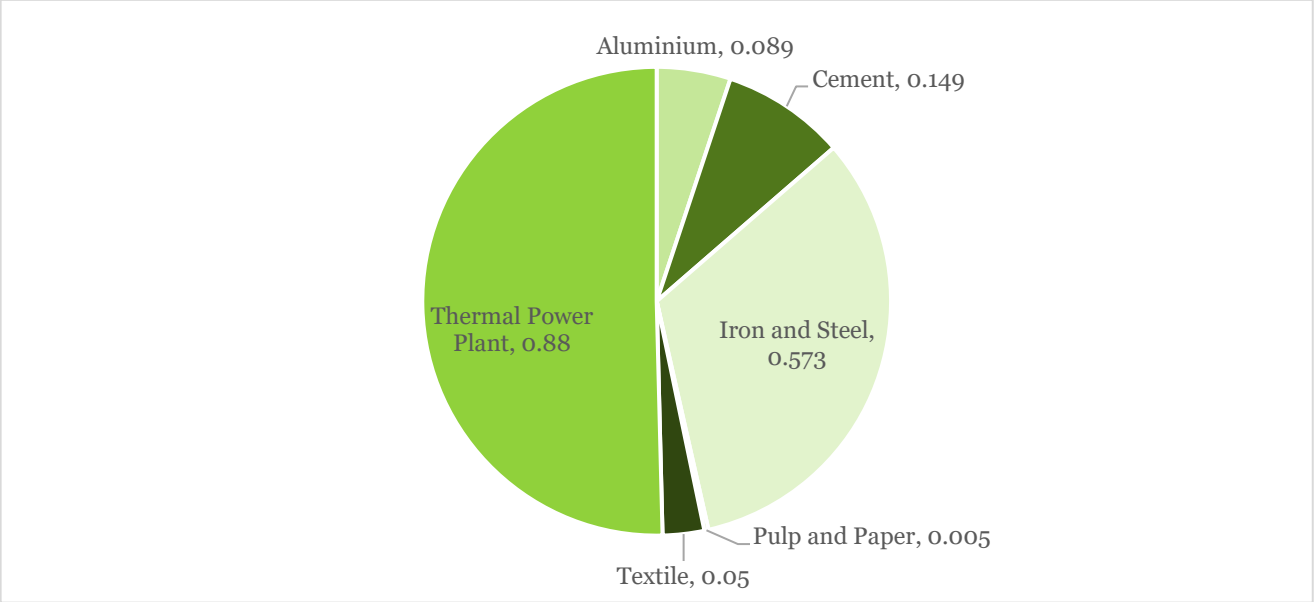


Figure 17: PAT Cycle III Energy Savings Achieved

The sectors mentioned in above table 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 0.866 Mtoe while the total energy savings for the supply side sectors amounts to 0.88 Mtoe for FY 2019-20.

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 are identified as provided in Table 14 is used for estimation of thermal and electrical saving, details are presented in Table 21.

Table 21 Demand and supply side Energy saving (Thermal and electrical)

PAT Sector (Demand Side)	PAT Sector (Supply Side)	No. of PAT DCs	Thermal Energy Savings (Mtoe)	Electrical Energy Savings (BU)
Aluminium		1	0.088	0.002
Cement		12	0.130	0.227
Iron and Steel		20	0.556	0.203
Pulp and Paper		1	0.005	0.000
Textile		31	0.034	0.182
	Thermal Power Plant	35	0.880	0.000
Grand Total		**100**	**1.693**	**0.614**

The analysed data of sector under the consumption side demonstrates the total thermal energy savings of 0.813 Mtoe and electrical energy savings of 0.614 BU. While the sector under the supply side demonstrates the total thermal energy savings of 0.880 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 as per Table 14. Post those following assumptions were taken for calorific values, density of respective fuels and CO2 conversion factors as presented in previous section in

Table 16 are used for evaluation of the emission reduction. Overall, energy savings of 1.693 Mtoe and 0.614 BU under PAT Cycle III has resulted in reduction of 6.426 MtCO2. CO_2 emission reductions due to PAT Cycle III is presented in Table 22.

Table 22: Share (Value) of reduction in CO2 emission by each sector

Sector	No. of DCs	Emission Reduction ($MtCO_2$)	% Share in Total reduction
Aluminium	1	0.375	5.84%
Cement	12	0.369	5.74%
Iron and Steel	20	1.887	29.37%
Pulp and Paper	1	0.016	0.24%
Textile	31	0.269	4.19%
Thermal Power Plant	35	3.51	54.62%
Total	**100**	**6.426**	**100.00%**

Summary:

Under the PAT scheme III, overall summary of energy (thermal & electrical) savings, and corresponding reduction in CO2 emissions is presented in Table 23.

Table 23: PAT Cycle III emission and energy saving summary

Parameters	Values
No. of M&V Analyzed PAT DCs	100
Total Energy Savings achieved under PAT III	1.746 Mtoe
Overall reduction in CO2 emission	6.43 MtCO2
Energy (thermal) saved at consumption side	0.866 Mtoe
Energy (thermal) saved at supply side	0.880 Mtoe
Energy (electrical) saved at consumption side	0.614 BU
Energy (electrical) saved at supply side	0 BU

2.1.5. Summary of PAT Cycle II & III

Interventions in large industries, Thermal Plants, DISCOMs, Railways, & Buildings under PAT Scheme has led to total saving of 15.826 Mtoe (Thermal energy saving of 12.638 Mtoe and 37.08 BU of the electrical energy saving) under PAT cycle II, III. Sector wise energy saving is presented in Table 24.

Table 24: Total Energy saving Achieved from PAT cycle II, III

PAT Cycle	Total Energy Savings Achieved		
	Thermal (Mtoe)	Electrical (BU)	Total (Mtoe)
PAT II	10.945	36.466	14.080
PAT III[21]	1.693	0.614	1.746
Total	**12.638**	**37.08**	**15.826**

[21] Evaluation is done on basis of M&V data reported by 100 DCs to BEE

Note: *M&V of PAT Cycle IV was postponed in the FY 20220-21 due to COVID pandemic. Hence, the savings achieved from PAT Cycle IV is not considered in the energy and corresponding emission savings for the year 2020-21.*

Chapter 3:
MSME Sector

3. *MSME Sector*

The Micro, Small and Medium Enterprises (MSME) sector has emerged as a highly vibrant and dynamic sector of the Indian economy over the last five decades. It contributes significantly to the economic and social development of the country by fostering entrepreneurship and generating large employment opportunities at comparatively lower capital cost, next only to agriculture. MSMEs are complementary to large industries as ancillary units and this sector contributes significantly to the inclusive industrial development of the country. The MSMEs are widening their domain across sectors of the economy, producing a diverse range of products and services to meet the demands of domestic as well as global markets.

MSMEs account for about 40% of India's total exports and around 30% contribution to the GDP as a whole[22]. Accounting for 90% of industrial units, in FY 20-21 MSME contributed 45%[23] of total industrial value addition and almost half of the exports.

The growing economy results in an increase in energy demand. Among various sectors of the economy, the industry and MSME sector in the country is the largest consumers of energy[24]. The share of the MSME sector in India’s total industrial energy consumption is also very high.

The Industrial segment has been contributing to the bulk of the energy consumption (56%) in India (at 318 Mtoe)[25]. Among this large share, the MSME sector contributes about 20-25%[26] of overall industrial energy consumption, estimated at 70 Mtoe. This immense quantum of energy consumed by the MSME sector signifies the immense potential for energy conservation across the sector.

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

The strategic importance of Micro, Small and Medium Enterprises (MSMEs) is today acknowledged across the world. MSMEs are the prime movers of employment and economic growth in both high- and low-income countries. They are also an integral part of the

[22] Source: Financial Express
[23] Source: Financial Express
[24] Source: Energy Statistics 2021, MoSPI
[25] https://beeindia.gov.in/content/small-medium-scale-enterprises-sme
[26] https://beeindia.gov.in/sites/default/files/UNNATEE_report_11.04.19.pdf

manufacturing value chain and underpin the ability of large manufacturing enterprises to become competitive and successful. In India too, MSMEs form a critical part of the economy. According to the annual report (2020-21) of the Ministry of MSME, there are about 63.88 million MSMEs in India employing over 100 million people. The sector is the biggest employer in India outside the agriculture sector.

In accordance with the provision of the Micro, Small & Medium Enterprises Development (MSMED) Act, 2006 the Micro, Small and Medium Enterprises (MSME) are classified as below:

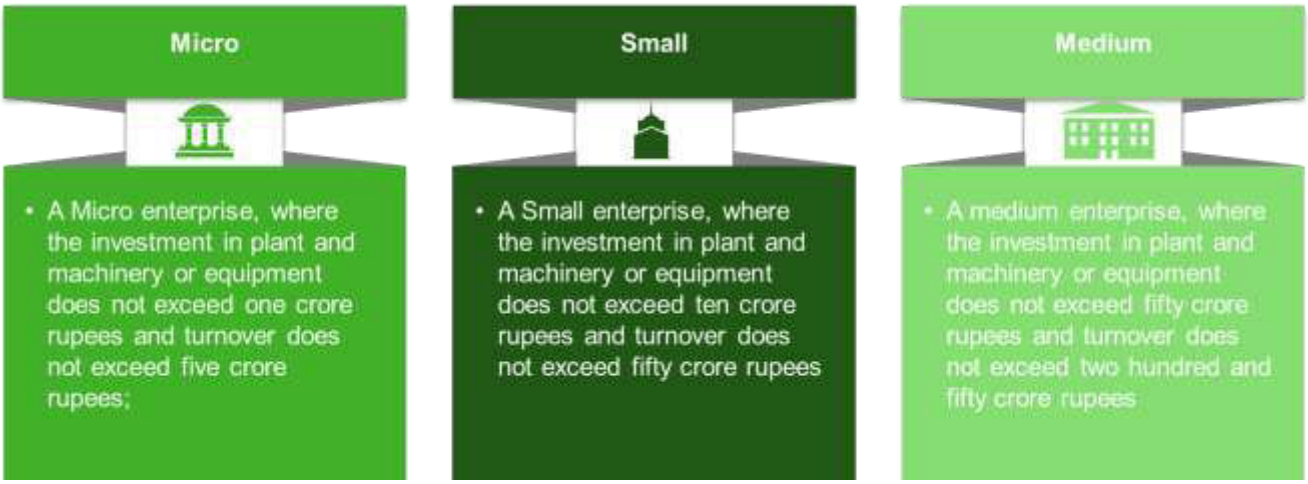


Figure 18: Definition of Micro, Small and Medium enterprises

The micro sector with 630.52 lakh estimated enterprises accounts for more than 99% of the total estimated number of MSMEs. The Small sector with 3.31 lakh and the Medium sector with 0.05 lakh estimated MSMEs accounted for 0.52% and 0.01% of total estimated MSMEs, respectively. As per the Ministry of MSME Annual Report 2020-21, out of 633.88 estimated number of MSMEs, 324.88 lakh MSMEs (51.25%) are in rural areas and 309 lakh MSMEs (48.75%) are in the urban areas.[27]

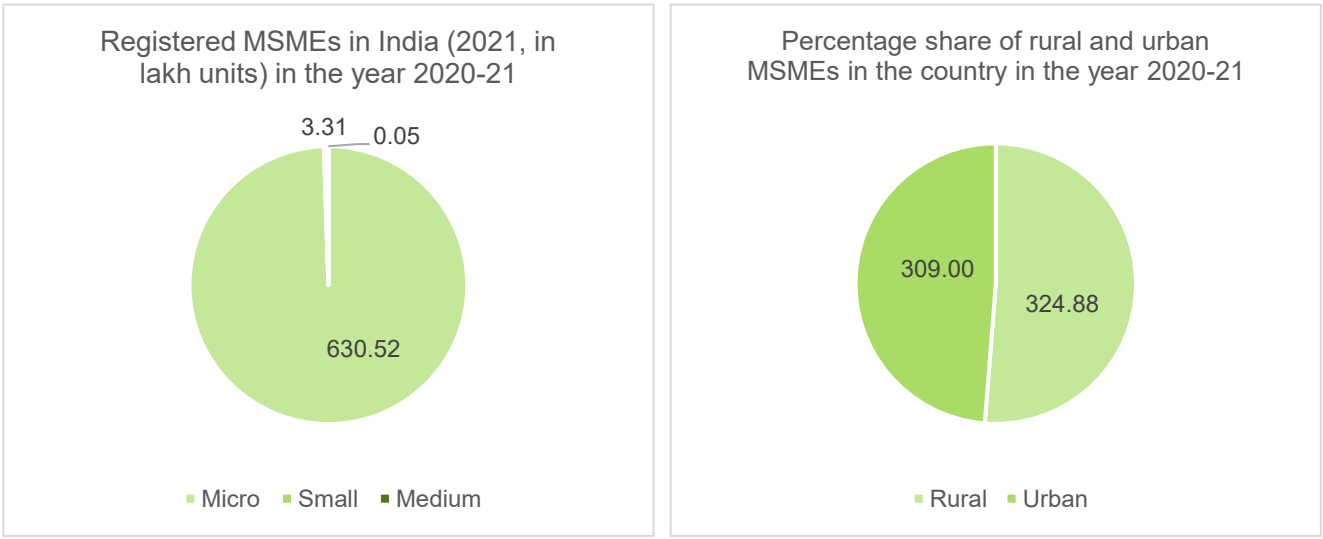


Figure 19: Number of MSMEs and distribution of enterprises in rural and urban Areas

[27] Source: Ministry of MSME Annual Report 2020-21

Today, the sector produces a wide range of products, from simple consumer goods to high-precision, sophisticated finished products. It has emerged as a major supplier of mass consumption goods as well as a producer of auto components, plastic goods, electrical equipment and pharmaceuticals. An impetus to the sector is likely to have a multiplier impact on economic growth.

Many MSMEs sectors are energy-intensive, i.e. cost of energy is a significant % of manufacturing cost.

The micro, small and medium enterprise (MSME) is an important sector of the Indian economy comprising several energy intensive industries, such as foundry, forging, textile, ceramics, refractory, glass, dairy, etc. Indian MSME sector is characterized by the presence of many geographical clusters with similar product offerings. There is a great deal of variation in technology and management practices within the MSME sector. While at one end of the MSME spectrum, there are highly innovative and growth-oriented enterprises, on the other end there are unregistered units, and enterprises deploying obsolete technologies and practices. Due to wide variation in technology and operating practices, there is a wide variation in their energy performance and GHG emissions as well. There are many energy-intensive sectors where energy costs account for a major share of the operating costs.

These MSME clusters exhibit several commonalities, such as technology use, production capacities, operating practices, etc. With the use of conventional technologies and poor operating practices, it offers significant potential for energy saving through technology upgradation and adoption of best operating practices (BOPs) in the production processes.

3.1.2. Programmatic interventions in the energy efficiency domain

To tap the above-mentioned energy efficiency potential, the Indian government has undertaken several policies, strategies and programs targeted at promoting energy efficiency in the MSME sector at the national level. In its endeavor to accelerate the uptake of energy efficiency in the MSME sector, BEE initiated an SME programme in the year 2009 with the objective to improve the energy performance of the MSME sector.

Energy Efficiency in the MSME sector has also remained on the programme agenda of several institutes and development agencies, including World Bank, UNIDO, UNDP, JICA and GIZ etc. for a significant time now. Some of the commercial banks have also been providing concessional energy efficiency loans to MSMEs under different Government schemes and bilateral lines of credit, as shown in Table 25.

Table 25: BEE Programmatic Interventions

Programmatic Interventions	Achievements
BEE – SME Program **National Program for EE in SMEs**	• Technology gap assessment study in 35 energy intensive clusters • Preparation of 375 Technology specific bankable DPRs • Energy efficient technologies demo projects in 21 units of 4 selected clusters

Programmatic Interventions	Achievements
	• More than 100 Capacity building cum Knowledge dissemination programme was organized • Identification of more than 70 local service providers for supplies of EE technologies in 5 clusters • Created Knowledge Management Portal "SIDHIEE" which hosts fifty videos of multimedia tutorials for MSMEs for the adoption of EE technologies • Energy mapping of MSME clusters on pan India basis covering 8 sectors and 40 MSME clusters
GEF-World Bank BEE SIDBI Project Financing Energy Efficiency at MSMEs	• Program footprint to 25 MSME clusters till the third phase. • Reached out to 5000 MSME units through Capacity Building Workshops, and B2B Exhibitions • EE Implementations in more than 1250 MSME units • Resulted in emission reductions of 1.9 MTCo2 • Support to more than 45 MSMEs for implementation of Energy Management System (EnMS) ISO 50001 • Key Performance Indicators (KPI) and EE Benchmarks for MSMEs in various sectors • Around 200 participants from 20 MSME clusters have participated in ISO 50001 training workshops • Estimated EE saving potential of INR 900 lakh was identified from the implementation of ISO50001 and EnMS
GEF UNIDO BEE Program- Promoting EE and Renewable Energy in Selected MSME Clusters	• Focused to 23 clusters in 5 sectors • 1198 Small scale projects implemented in SMEs • 301 Case studies • 300 Detail Project Reports • 21 Pilot Projects implemented • 7 International study tours organized • 230 SME stakeholders trained with National Productivity Council • 95 Capacity Building workshops were conducted • 603 EE and RE measures implemented • Benchmarking tool for 6 sectors developed • 12 Energy Management Centres established • 500 Local Service Providers were trained • Attracted investment of 23139 Lakh INR • Annual Energy savings of 20200 toe
BEE, SDC Sameeeksha Project 'Scaling up Energy Efficiency in Small Enterprises'	• Cluster profile reports for 108 energy intensive MSME clusters • MSME Energy Map providing insights of energy intensive clusters

Although programmatic interventions have demonstrated the effectiveness of energy efficient technologies, the large-scale deployment of energy-efficient technologies in MSMEs has been limited.

Across these MSMEs, there are various proven as well as emerging innovations in Energy Efficient technologies including Waste heat recovery solutions, servo motors, induction furnaces, CNC machines, VFD installed plastics moulding machines, and efficient Permanent Magnet Motors for air compressors.

Apart from these, the use of emerging technologies such as automated data acquisition and analysis, Artificial Intelligence, Internet of Things (IoT) and Industry 4.0 is slowly gaining visibility as a means of improving efficiency, productivity and cost effectiveness.

Energy savings through the adoption of innovative technologies, increasing the scope of energy related policies with the inclusion of financing schemes and sensitizing the MSMEs towards the importance of energy efficiency in their day-to-day operations would go a long way in making the MSME sector self-reliant energy efficient.

3.2. BEE – SME Programme

The MSME sector holds immense potential in fostering energy efficiency and the upgradation of the technologies in routine processes. Nevertheless, there is still plenty of room for improvement in terms of concrete measures, most of the SME entrepreneurs claim not to have been able to identify any potential savings in their businesses. Considering the urgent need to develop, demonstrate and disseminate energy efficient technologies at the cluster level, "National Programme on Energy Efficiency and Technology Upgradation in SMEs" was evolved by the Bureau of Energy Efficiency to address the various challenges faced by MSMEs in India.

Major challenges faced by the SME sector are the lack of know-how of modern technologies, availability of finance for energy efficient equipment and technologies, lack of proven case studies, etc. To overcome these barriers, BEE initiated the BEE-SME programme in 2009.

Objective of BEE-SME Programme

To improve energy efficiency of SME sector in India through accelerating adoption of energy efficient technologies, knowledge sharing, capacity building and development of financial of innovative financial mechanisms

Following activities were undertaken to encourage efficient energy consumption in the MSMEs in India:

Over 375 Bankable DPR's for energy efficiency projects were prepared in 35 clusters across India. Under the programme, several initiatives were taken for capacity building of Local Service Providers/Technology Providers. Also, BEE facilitated the implementation of Energy Efficiency Measures through the development of DPRs in 29 out of the 35 clusters for which baseline studies were undertaken.

BEE – SME Programme during the year 2017 - 2021

With the collective efforts of the Bureau towards improving the energy performance, the current state of awareness, perception and responsiveness towards energy efficiency programmes of the MSME segment in India, Energy Efficiency interventions in the SME sector are yet to become the mainstream across the country.

Although the energy saving potential is immense in this sector which BEE intends to unlock, there is quite a challenge faced by Indian MSME entrepreneurs which are risk averseness, cumbersome documentation and lack of awareness/motivation. Following are the key activities under implementation:

1. Technical Assistance and Capacity Building of energy intensive SME sectors
2. Promoting Energy Efficiency and Technology Upgradation in SMEs through the ESCO route
3. Energy mapping of SME clusters on pan India basis.

A large number of Small and Medium Enterprises (SMEs) like foundries, brass, textiles, refractories, brick, ceramics, glass, utensils, rice mills, and khandsari manufacturing units, etc., are said to have large potential for energy savings. Many of these units are in clusters located in various states of the countries.

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

United Nations Industrial Development Organization in collaboration with the Bureau of Energy Efficiency, is executing a Global Environment Facility funded national project "Promoting energy efficiency and renewable energy in selected MSME clusters in India". The main project partners for this project are GEF, UNIDO, BEE, MoMSME and MNRE. This programme follows a holistic approach which includes conducting energy audits at MSMEs to assess the present level of operational efficiency and formulation of the energy baseline. Other components include technology identification, and providing handholding support to SMEs for implementing energy efficiency. The programme also aims to build capacity on EE interventions across the cluster and to strengthen the vendor and local service provider network to ease the availability of the technologies for SMEs. One of the important components of the program is demand aggregation to reduce the cost of the EE interventions that helps the SMEs in getting the new technology at a reduced cost due to economies of scale and also helps the technology provider with a business opportunity pipeline.

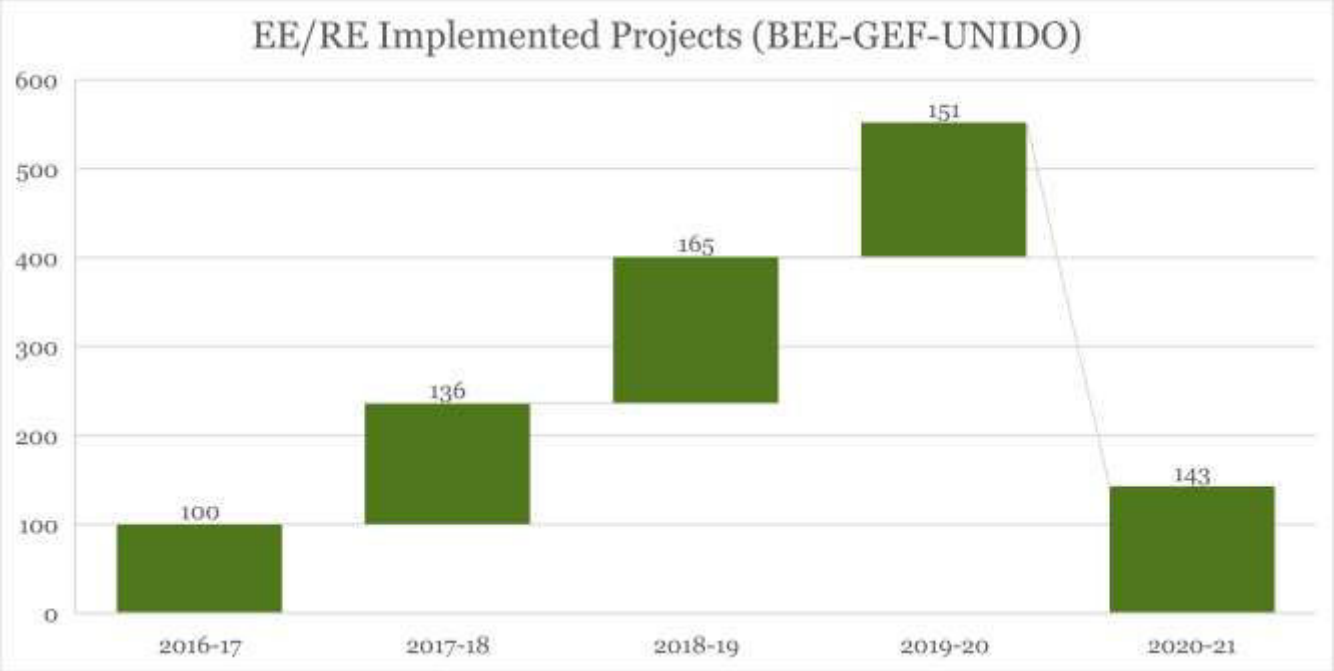


Figure 20: Numbers of EE/RE projects implemented under the project

The programme "Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India" has major four components as seen in Figure 21.

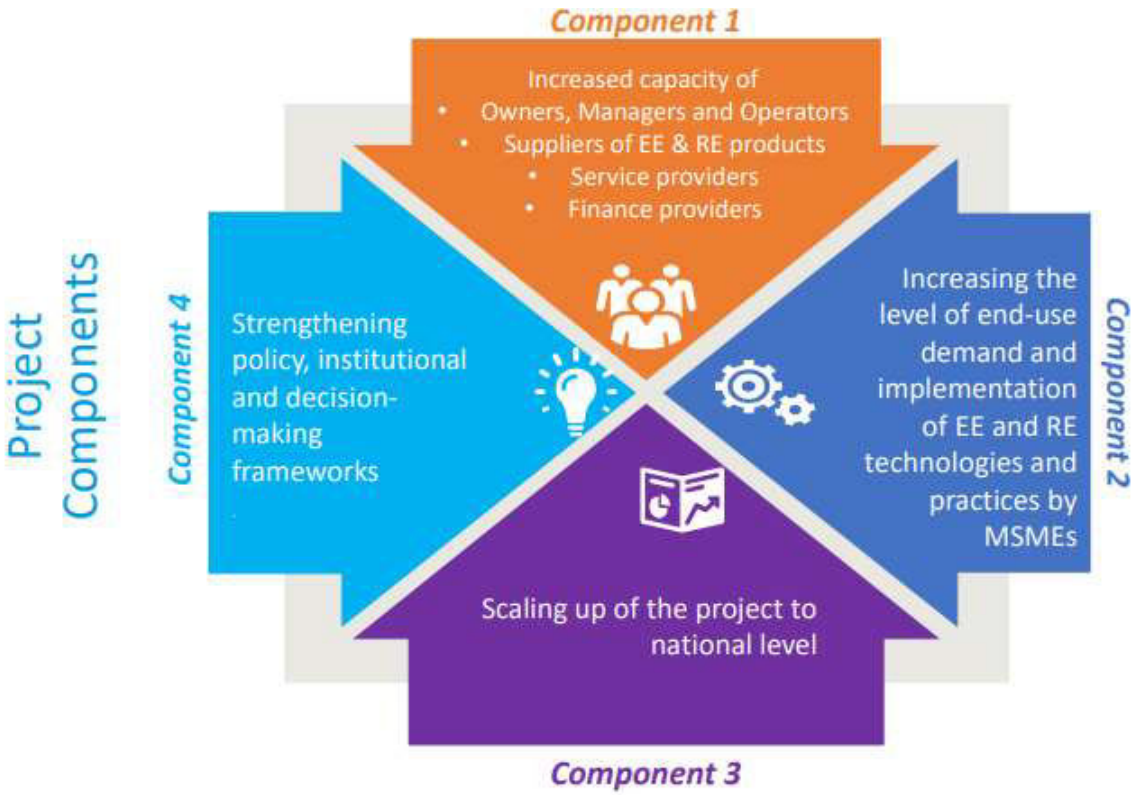


Figure 21: Project Components of BEE-GEF-UNIDO Project

Programme is operational in 23 MSME clusters in India from five sectors, respectively: *Brass* (Jamnagar); *Ceramics* (Khurja, Thangadh and Morbi, Himmatnagar, Virudhachlam); *Dairy* (Gujarat, Sikkim and Kerala, Tamil Nadu, Odisha, Madhya Pradesh, Andhra Pradesh & Telangana, Haryana, Maharashtra, Punjab); *Foundry* (Howrah, Ahmedabad, Belgaum,

Coimbatore and Indore); and hand tools (Jalandhar and Nagaur). Mixed Clusters in Indore (10 foundries, 20 Auto components, 30 Ready-made garments, 15 pharma, 25 food processing units), Sikkim (15 Pharma, 5 Beverage, 5 food processing units).

Methodology for estimation of the saving

$$Energy\ Saving = (Specific\ Energy\ consumption_{Baseline} - Specific\ Energy\ Consumption_{Post\ EE\ Interventions}) * Annual\ Production$$ [28]

Various energy efficiency interventions have been carried out in above-mentiooned MSME clusters. Energy saving obtained from BEE-GEF-UNIDO and BEE-SME Programme being implemented in Selected MSME Clusters in FY 20-21 is showcased in the Table 26.

Table 26: Energy saving from BEE-GEF-UNIDO Programme and BEE-SME Programme in Selected MSME Clusters in FY 20-21

Cluster	Sector	No. of Units	Total Investment (INR) Crores	Energy Saved (TOE)	Reduction in CO2 emission (tCO2)
Thangadh	Ceramic	136	41.39	1794	15483
Morbi					
Ahmedabad					
Khurja					
Jalandhar	Hand Tool	120	10.42	626	3223
Nagaur					
Gujarat	Dairy	74	66.92	3845	26016
Kerala					
Telangana					
Andhra Pradesh					
Maharashtra					
Tamil Nadu					
Sikkim					
Punjab					
Haryana					
Odisha					
Madhya Pradesh					
Coimbatore	Foundry	285	26.72	2600	17117
Belgaum					
Ahmedabad					
Indore					
Eastern Zone					
Jamnagar	Brass	80	11.66	830	3113
Total		**695**	**157.11**	**9695**	**64952**

The energy savings and corresponding GHG Emission reduction from the BEE-GEF-UNIDO are showcased in the Figure 22.

[28] Baseline audits defines the present energy consumption and operational hours, Proposed energy consumption based on guaranteed energy saving by technology provider.

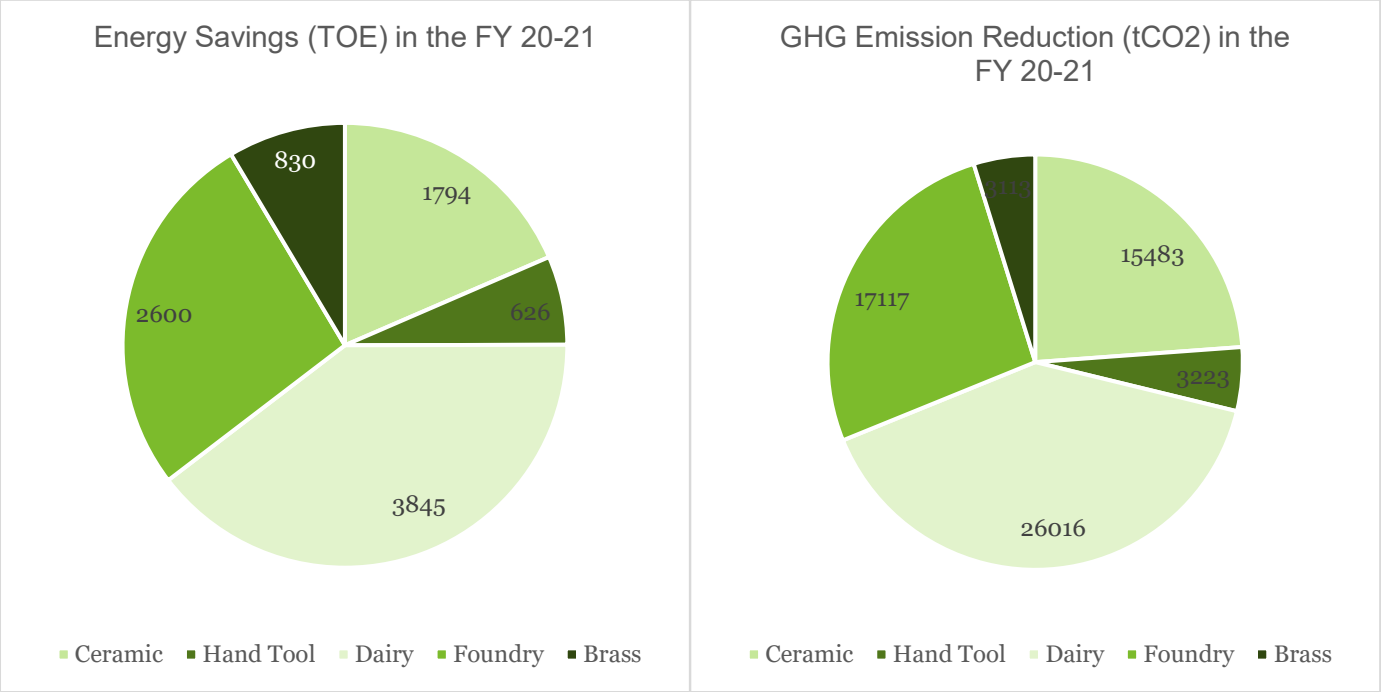


Figure 22: Energy Savings and GHG Emission Reduction from BEE-GEF-UNIDO Programme and BEE-SME Programme in FY 2020-21

Resource Mapping of MSME 45 CLUSTERS:

BEE, in an ongoing initiative titled '**Energy and resource mapping of MSME clusters'**, has intervened in nine energy-intensive MSME sub-sectors and has adopted an approach of deep-diving in these sub-sectors. The initiative aims at overcoming the lack of comprehensive and updated knowledge on various MSME clusters across the country —many of them in energy intensive sub-sectors— in regard to aspects such as production processes, technologies and fuels in use, energy saving potential, energy efficiency options, and so on.

The broad objective of this initiative is to develop sectoral benchmarks and prepare a roadmap for sustainable growth and make the intervening sub-sectors globally competitive.

Under the program, BEE has identified nine energy intensive MSME sub-sectors—brick, chemicals, dairy, forging, foundry, glass & refractory, paper, pharmaceuticals, and steel rerolling mills—for conducting a comprehensive energy and resource mapping exercise.

Studies were undertaken on each sub-sector, assisted by structured questionnaires and interactions with important stakeholders such as entrepreneurs and industry associations, R&D institutions, government agencies, and so on.

The studies and stakeholder interactions had assisted in developing a clear profile of each sub-sector including the important clusters, the diverse technologies and operating practices that are being used by MSMEs in different clusters, and market-related information for their products as well as for raw materials and services. The exercise helped in identifying the various entities that have linkages with the MSMEs at cluster/sector levels and outline the nature of support they provide to the MSMEs (materials, machinery/equipment, services, etc.).

These entities included local service providers (LSPs); equipment/machinery suppliers; technical/academic institutes; banks and NBFCs; technical consultancy organizations; government departments such as MSME Development Institute (MSME-DI), District Industries Centre (DIC), state pollution control board, and so on.

Five clusters per sub-sector were identified for detailed analysis. Detailed energy audits (DEAs) were conducted in ten units in each of these five clusters. Information and insights were gathered on the following key aspects:

- Current energy consumption scenario at the subsector and cluster levels, covering the various kinds of fuels used and the quantities consumed.
- Various raw materials used and consumption levels.
- The existing manufacturing processes, including the machinery and equipment used, and the potential for energy efficiency improvements.
- Possible EE technological options and best operating practices (BOPs)
- Readiness of the MSMEs and other cluster-level stakeholders to adopt the identified EE options.
- Market-related information on both supply and demand sides, including prospects.
- Relevant policy-level aspects.

Benchmarking

Based on the knowledge from the sub-sector/cluster level studies, key performance indicators (KPIs) will be determined for each energy intensive process and/or technology: for example, specific energy consumption (SEC) standards will be determined for each energy consuming technology/stage of the production process such as batch preparation, preheating, melting, reheating, drying, and so on.

By comparing these KPIs with the best KPI levels achieved by other industries within and outside India, benchmark standards will be set for energy efficiency for each process/technology. This exercise will also help assess and quantify the potential for bringing about energy efficiency improvements in each technology/process stage.

Roadmap

Based on the findings of the studies and the benchmarking exercise, a detailed road map will be prepared for an energy efficiency intervention in each sub-sector, in close consultation with the concerned industry stakeholders. The road map will set out an implementation plan covering technological, financing and capacity building aspects, and include policy recommendations (i.e., specific policy-level measures that could create an enabling policy and institutional level environment for the uptake of EE technologies). The road map will include information on the following key elements.

- Production
- Energy consumption pattern
- Existing technologies
- Energy saving potential.
- EE technologies that can be adopted
- Financial and other resources that might be required by MSMEs to adopt the EE technologies.
- Awareness and capacity building measures that might be required at unit/cluster levels.
- Existing institutional environment for supporting energy efficiency improvements
- Policy recommendations.

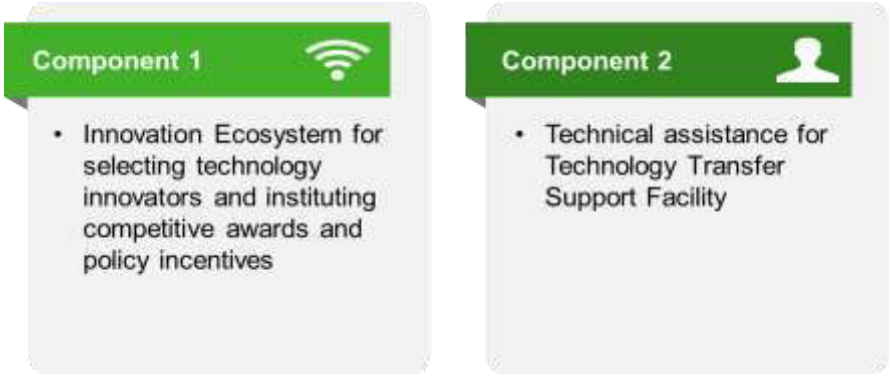
The findings of this study will further help BEE to formulate policies and prepare an implementation plan for pacing up the energy efficiency initiatives in the MSME clusters across India.

3.4. "Facility for Low Carbon Technology Deployment"

The Facility for Low Carbon Technology Deployment (FLCTD), which was launched in the year 2016 and is an 8-year project, being implemented by the United Nations Industrial Development Organization (UNIDO) in collaboration with the Bureau of Energy Efficiency and is funded by the Global Environment Facility (GEF). The project aims to promote innovation of low-carbon technologies and their deployment in industrial and other related sectors of the Indian economy.

The main objective of the project is to facilitate the validation of innovative low carbon technology thereby assist in scale up, deployment and scaling up of low-carbon technologies in India to promote the use of innovative clean and low-carbon technologies in selected sectors and thereby address technology gaps to mitigate climate change

The project objective is being accomplished through two main components, described below:



Component 1 – Innovation Ecosystem for selecting technology innovators and instituting competitive awards and policy incentives

Under this component, the project has developed and evolved a mechanism to identify early-stage innovations that address the technology gap and have the potential for energy savings as well as replication. This is being achieved through a series of annual "Innovation Challenges" an open award competition calling for innovative solutions in 6 technology verticals:

Figure 23: Open award competition for innovative solutions in 6 technology verticals

Each technology vertical, showcased in the figure above, has an expert panel that defines the requirements of the Innovation Challenge and selects promising innovations that address the technology gaps and have the potential to reduce energy consumption. The project provides financial assistance up to USD 50,000 to the winners to validate the innovation and demonstrate its efficacy in the field conditions – a necessary pre-condition for commercialization.

In addition to identifying low carbon technology innovations and nurturing their development deployment and validation for commercialization through technology challenges, the project is also tasked to guide the strengthening of the innovation ecosystem, comprising of knowledge-based institutions, government, industry and other stakeholders in the innovation arena.

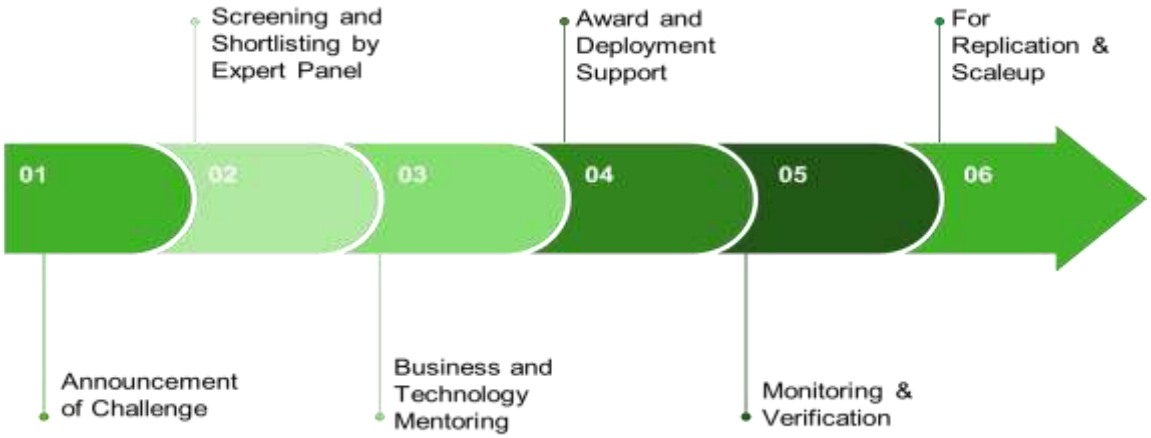


Figure 24:Innovation Challenge Cycle

Interventions carried out under the project have led to total energy savings of 804.24 tonnes of oil equivalent during FY 2020-21. A summary of the energy savings and corresponding emission savings obtained by implementing the technologies through the FLCTD project in the FY 2020-21 is showcased in the table below:

S.No.	Technology	Savings from single pilot demonstration			Savings from all pilot demonstrations	
		Annual Energy Savings (coal / diesel / electricity)	Net annual CO_2 emissions avoided (tCO2/annum)	No. of pilot demonstrations	Annual Energy Savings (coal / diesel / electricity)	Net annual CO_2 emissions avoided (tCO2/annum)
Waste Heat Recovery						
1	Waste Heat Recovery System for the Textile Dyeing unit Hot Effluent	453 tons of coal per WHR system	618	1	453 tons of coal per WHR system	618
2	Development of regenerative burners	2.79kg of LPG per hour in a 50,000-kcal test furnace	0.008 tons per hour	1	2.79kg of LPG per hour in a 50,000-kcal test furnace	0.008[29]
Pumps, Pumping systems, and motors						

[29] Note: As this is pilot site only, Annual savings are not calculated.

3	Performance improvement of mixed flow centrifugal multistage pump	12.5 MWh per pump	9.8	10	125	98
4	Micro Smart Pump	1.3 MWh per pump	1	17	22.1	17
Space Conditioning						
5	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
6	Refrigeration systems powered by farm waste using climate-friendly refrigerant provide on-farm cooling	5.4 MWh per GreenChill	0.039	1	5.4	0.039
7	Milk-can cooling solution for chilling milk in the village with a thermal storage system	367 litres of diesel per milk chiller	0.8	11	4037	8.8
	Total	**977 litres of diesel** **453 tons of coal** **19.2 MWh electricity** **2.79 kg/hr of LPG**	**635 tons of CO_2/annum avoided**	53	**11357 litres of diesel** **453 tons of coal** **152.5 MWh electricity** **2.79 kg/hr of LPG**	**804.239**

Component 2 – Technical assistance for the Technology Transfer Support Facility

The objective of component 2 is to establish a deployment support ecosystem for clean, low carbon and energy efficient technologies. This component is expected to support the creation of an innovation ecosystem for low-carbon and sustainable energy solution providers in India.

Under this component, capacity building activities through consultations/workshops with international/national experts, with documentation and dissemination of the Facility are being carried out. A focused effort to gather and disseminate good practices is being undertaken by the project team in this regard.

In 2019, FLCTD Accelerator Program was started to provide training and mentoring support to start-ups that are in the early stage of developing clean technology solutions. FLCTD has collaborated with 'Start up India' for the 4-month Accelerator programme, in which industry personnel and potential innovators are provided hands-on guidance to improve their business prospects.

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.

Current Status of the FLCTD Program as of 31st March 2021

1. In the FY 2020-21 FLCTD launched the third annual innovation challenge on 6th April 2020 in WHR, Space Conditioning and Pumps vertical. Outreach and publicity were carried out

via emails, social media platforms, through CII-GBC and the social media team. Four outreach webinars were held in April which attracted the participation of 766 participants across industries, startups, academia, and policy agencies and research organizations, among others. Also, the project successfully leveraged the GoI platforms like AGNIi and Startup India for wider publicity of the innovation challenge

2. On 22nd May, FLCTD held a half-day online workshop on "Mainstreaming innovation for the adoption of low-carbon technologies", with a panel of industry leaders and experts. The discussions were represented by key personnel from UNIDO, Bureau of Energy Efficiency, Grundfos Pumps India, Danfoss and members of the expert panels. The workshop was attended by 495 participants.
3. The FLCTD Accelerator call-for-application for the 2nd accelerator cohort was launched on Startup- India website on 5th June. After receiving 155 applications on 24th August, the 2nd batch of FLCTD Accelerator was launched with 25 startups shortlisted for the programme and the 20 mentors. The launch event included a panel discussion on "Fostering Low Carbon Innovation to decarbonize Industrial and Commercial sectors". The event was attended by 71 stakeholders including officials from, Atal Innovation Mission, AGNIi, IIT-Delhi, along with UNIDO Representative.

4. The 3rd annual innovation challenge was closed on 31st May and received 177 expressions of interest i.e., 69 entries in the Waste Heat Recovery vertical, 64 in Space Conditioning and 44 in Pumps & Motors technology vertical. After screening and shortlisting of the applications by the experts, 13 companies were announced as winners which are to be supported under the project.

5. The announcement of call-for-applications for the 2nd batch Accelerator was made in the 1st week of June jointly with "Startup India". The call-for-applications to accelerator on the Startup India web portal was closed on 31st July 2020 and received 155 applications out of which 28 were selected.

6. The FLCTD Accelerator programme concluded in January with the completion of the 2nd batch's training in December 2020. The Accelerator programme started in November 2019 and was implemented by Sangam Capital Advisor in 2 batches.

7. In January, the competition was organized among the 40 participants including the participants from the 1st cohort who attended the accelerator programme. 19 judges evaluated the presentation of the start-ups on the criteria of value proposition, business model, impact measurement, positioning etc. Based on the score 8 were shortlisted for the final day event which took place on 22nd January 2020. The event was attended by 60 participants including an official from the Bureau of Energy Efficiency and UNIDO.

3.5. "Promoting Market Transformation for Energy Efficiency in Micro, Small & Medium Enterprises" EESL-UNIDO – GEF-5 programme

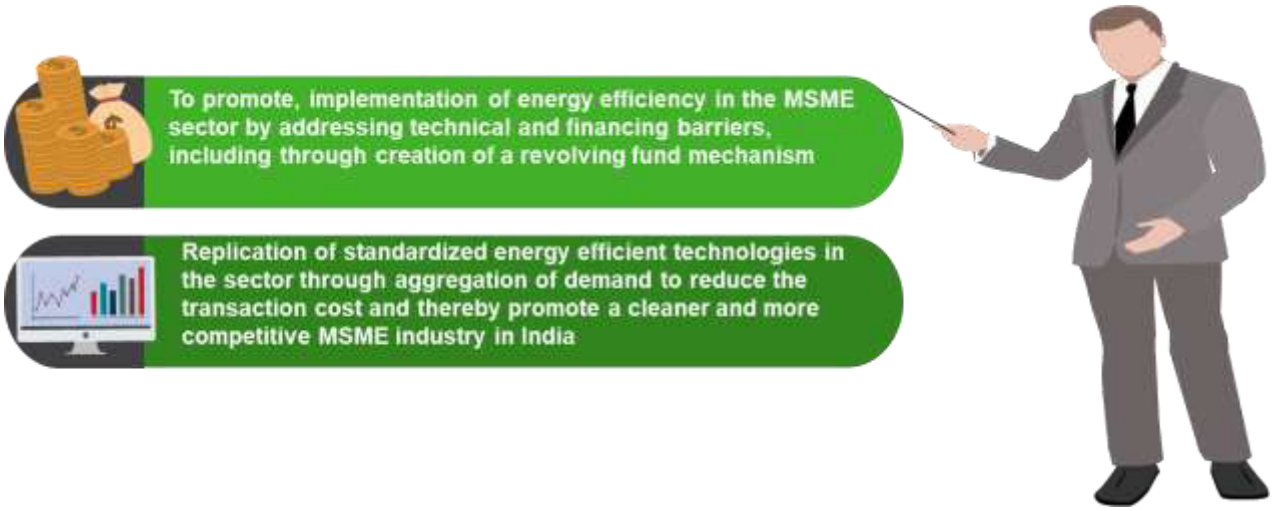
In order to overcome the existing barriers to the implementation of energy efficiency in the Indian MSMEs, the project, "Promoting market transformation for energy e-ciency in Micro, Small & Medium Enterprises," a joint initiative conceptualized by the United Nations Industrial Development Organization (UNIDO) and office of the DC MSME, targets to create and sustain

a revolving fund mechanism as a mode to ensure replication of energy efficiency measures in selected 10 industrial clusters.

The key Executing Partner for the project is Energy Efficiency Services Ltd (EESL). Small Industrial Development Bank of India (SIDBI) and Bureau of Energy Efficiency (BEE) are the guiding agencies for the project.

Programme Objective

The project aims to:



The project targets to accelerate the adoption of energy efficient technologies in the sector by removing its key barriers. The project aims to deploy 33-35 technologies in selective MSME clusters in the country which have the maximum possibility of replication and the potential to improve the energy baseline of fellow MSMEs units. Aiming at market transformation wherein the project will adopt various innovative business models of ESCO (Energy Servicing Company) based financing wherein the MSME units are expected to repay from their monetized energy saving in a stipulated period of time.

EESL is implementing this project in 10 MSME clusters (Surat, Ankleshwar, Jorhat, Vellore, Jalandhar & Batala, Varanashi, Sundargarh, Howrah, East Godavari, Muzafarnagar) in India. A GEF grant to the tune of $3 million has been allocated to EESL to execute various activities which are at different stages of execution. The following are the highlights of the project in 2020-21[30]:

- 740 surveys, 78 detailed Energy Audits and more than 70 technology specific baseline studies have been completed.
- EESL has identified more than 30 energy efficient technologies for demonstration and has signed an agreement with more than 35 MSME units.

[30] https://eeslindia.org/wp-content/uploads/2021/06/Annual%20Report2020-21.pdf

- Procurement for 19 technologies (with bulk procurement for 2 technologies) and demonstration of 14 technologies have successfully been completed.
- EESL has conducted more than 100 awareness / consultation / training workshops in 10 clusters for faster adoption of the technologies

The details of the above-mentioned clusters and the activities done under this programme in the FY 2020-21 is discussed below:

Surat Textile and Ankleshwar Chemical Cluster – One of the largest textile manufacturing clusters in India is located in Surat (Gujarat). The Surat cluster accounts for over 18% of the total manmade (synthetic) fibre exports and 40% of manmade fibre production in the country. The products primarily comprise synthetic sarees & dress materials and cotton dress materials. There are about 400 textile processing units in the cluster, operating over 600,000 power looms[31].

India's largest chemical industry cluster is located in Ankleshwar, in Bharuch district of Gujarat in Gujarat. This cluster hosts over 700 MSMEs manufacturing various kinds of chemicals: about 67% of the units produce dyes and pigments; 27% produce pharma and pharma intermediates; and the remaining 6% produce pesticides and chlor-alkalis. The production capacity of the units ranges from 100 tonnes to 1000 tonnes per annum.[32]

Under the project in FY 2020-21, several EE interventions were implemented in both the cluster. The implementations were carried out in 14 industries leading to energy savings of 1019 tonnes of oil equivalent and GHG emission savings of 5494 tCO2.

Jorhat Tea Cluster – The state of Assam is world-famous for its teas. A large cluster of tea gardens is located around the town of Jorhat, in upper Assam, spreading across Jorhat and Golaghat districts. Many of these tea gardens have their own in-house factories for processing the tea leaves. Jorhat tea cluster has been chosen under BEE-SME programme as the units there are traditionally very old which have not really progressed in pace with the technological advancements. During the FY 2020-21, EE implementations were implemented in 7 SME units which has led to saving of around 126 tonnes of oil equivalent and corresponding GHG emissions of 485 tCO2.

Howrah Forging Cluster – Howrah District is one of the 19 districts in West Bengal and known as the smallest district in West Bengal. One part of the district is fully engaged with industrial activities while other part is still going through the agricultural efforts. Forging industries are predominant in the cluster. Under the programme, several interventions such as waste heat recovery, electrical quality control, improvements in the furnace and burner design etc. were carried out in five units which has resulted to energy savings of 597 tonnes of oil equivalent.

[31] Source: http://sameeeksha.org/index.php?option=com_content&view=article&id=143&Itemid=499#:~:text=One%20of%20the%20largest%20textile,bre%20production%20in%20the%20country.
[32] Source: http://sameeeksha.org/index.php?option=com_content&view=article&id=131&Itemid=499#:~:text=This%20cluster%20hosts%20over%20700,produce%20pesticides%20and%20chlor%2Dalkalis.

Vellore Rice Mill Cluster: Rice is the staple food of majority of Indians and specifically in Southern Indian. Paddy is one of the major crops cultivated in the Southern states, especially in the state of Tamil Nadu. The Rice comes out of the milling of paddy. Hence rice milling is an important activity in the state. Rice mills are the lifeline for the economic development of rural India. The rice mills are generally located in rural areas and near paddy growing areas. There are about 340 rice mills in the Vellore rice mills cluster covering Arni, Arcot and Vellore areas. Considering the potential in the sector, several interventions for energy efficiency improvements were carried out in units leading to energy savings of 33 tonnes of oil equivalent.

Methodology for estimation of energy saving considering the improvement in the specific energy consumption due to the interventions.

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

A summary of energy savings and emission reductions in FY 2020-21, due to the implementation of EE interventions is showcased in the Table 27:

Table 27: Energy saving from the EESL-UNIDO-GEF 5 programme in FY 20-21

State	Cluster	Sector	No. of Units	Total Investment (INR Lakhs)	Energy Saved (TOE/yr)	Monetary Savings (INR Lakhs)	Reduction in CO2 emission (tCO2/yr)
Gujarat	Surat & Ankleshwar	Textile and Chemical	14	190	1019	188	5494
Assam	Jorhat	Tea	7	76	126	23	485
West Bengal	Howrah	Mixed	5	79	597	110	2604
Punjab	BJL	Forging	1	31	101	19	183
Tamil Nadu	Vellore	Rice	2	56	33	6	158
Total			**29**	**432**	**1876**	**345**	**8924**

The energy savings and corresponding GHG emissions reductions due to the implementation consultation/training another EE interventions in the mentioned clusters under this programme in FY 2020-21 are showcased in the Figure 25:

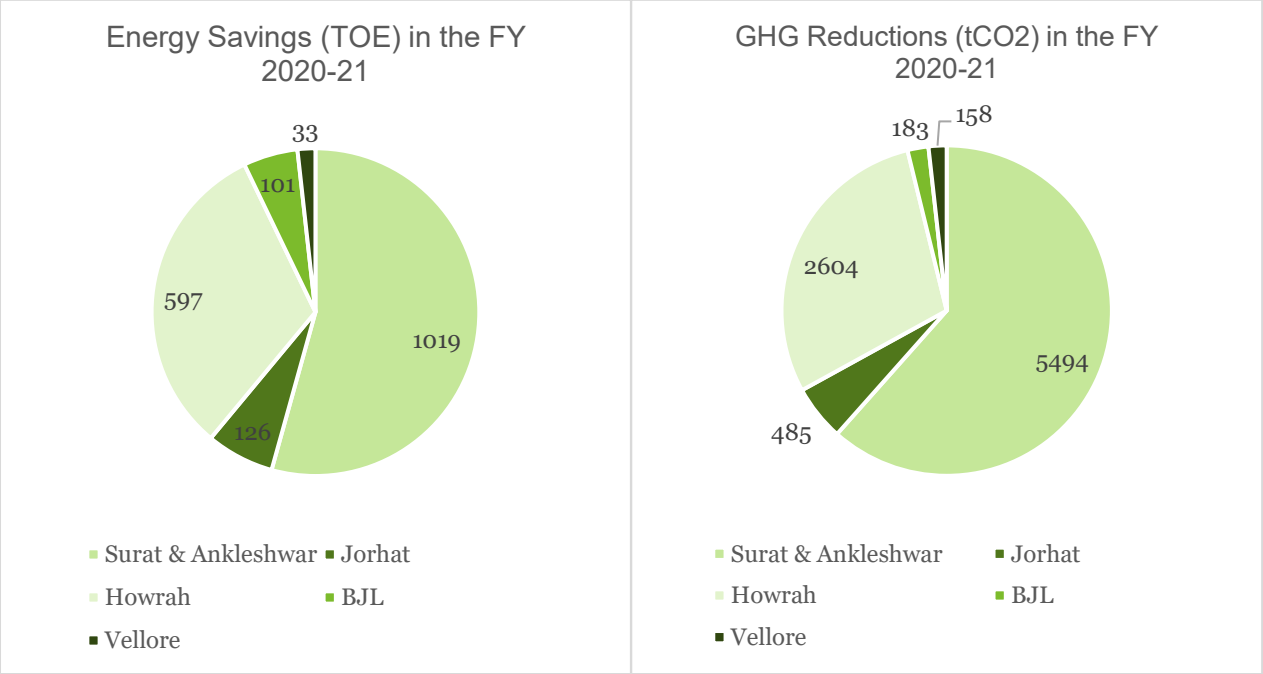


Figure 25: Energy and emission reduction across the five clusters

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

The objective of the Programme is to support the Government of India's efforts to transform the energy efficiency market in India by promoting an increased level of investments in energy efficient projects, particularly through energy service performance contracting delivered through energy service companies ("ESCOs"). The Programme 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.

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).

ESCOs are important vehicles to capture 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 26:

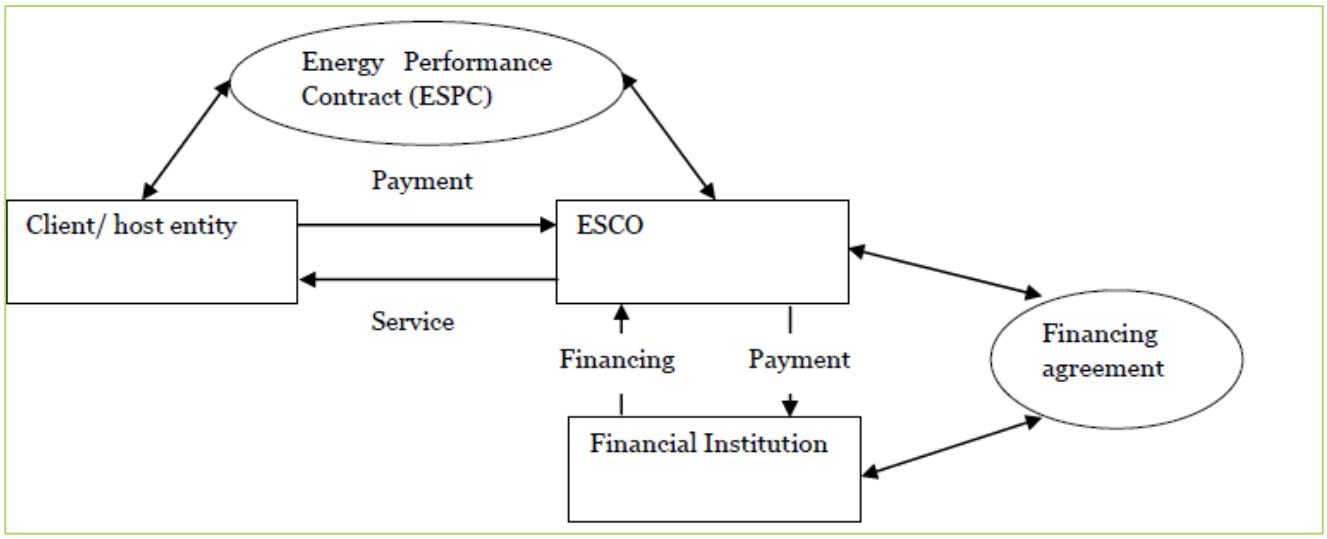


Figure 26: Functioning of PRSF Scheme

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

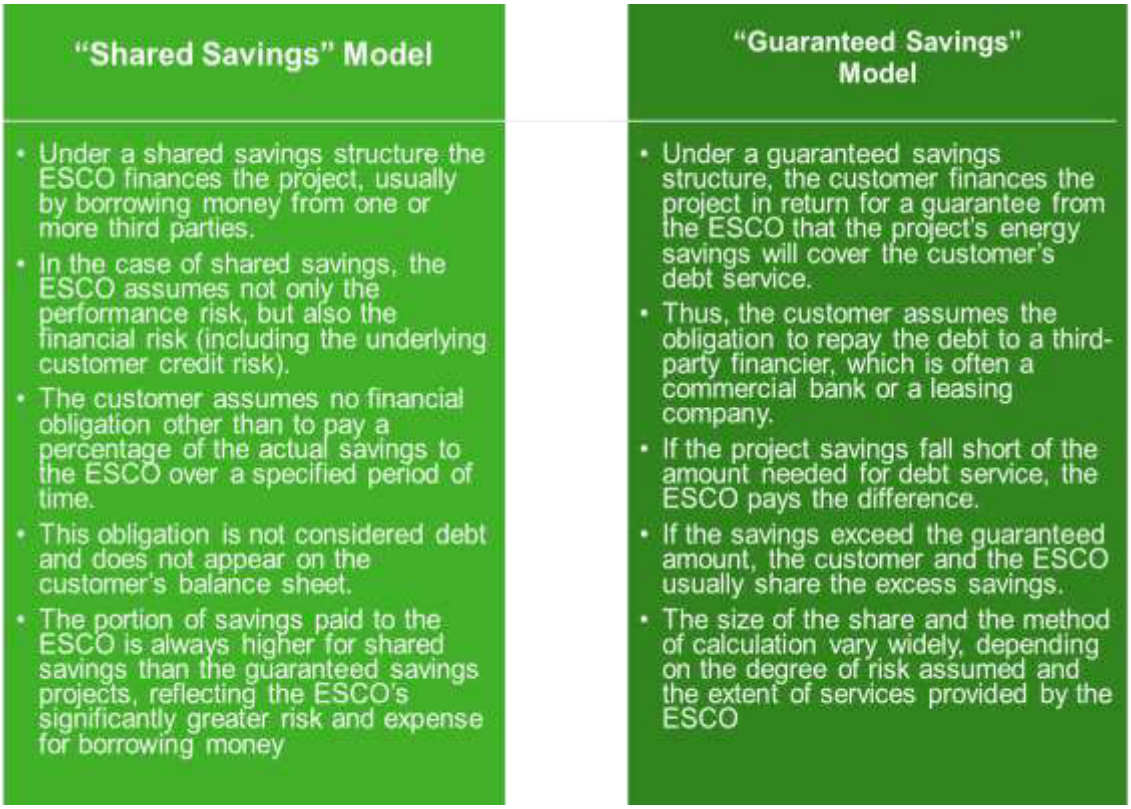


Figure 27: Energy Performance Contracting Models under PRSF Scheme

Project components

The Project has a total outlay of USD 43 million consisting of the "Risk Sharing Facility for Energy Efficiency" component of USD 37 million and a technical assistance component of USD 6 million. The entire "Risk Sharing Facility" component of USD 37 million is managed by SIDBI, under which partial credit guarantees are provided to cover a share of default risk faced by Participating Financial Institutions (PFI) in extending loans to eligible EE projects implemented through ESCOs.

The technical assistance component of USD 6 million is managed by SIDBI and EESL, under which capacity building activities and other developmental/operational support for the project are provided.

Table 28 showcases the energy and emission savings obtained under SIDBI's PRSF scheme for the FY 2020-21:

Table 28: Cluster wise energy savings obtained under SIDBI- PRSF Programme in FY 20-21

Cluster	Sector	No. of Units	Total Investment (INR lakh)	MWh Saved	Total Energy Saved (TOE)	Monetary Savings (INR lakh)	Reduction in CO2 emission (tCO2)
Hoshiyarpur	Foundry	1	545	321	27.61	19	254
Faridabad	Forging & Heat Treatment	1	958	2149	184.81	129	1698
Mandi Gobindgarh	Re-rolling	2	1835	9836	845.90	590	7770
Manipur	DISCOM	1	1417	32287	2776.68	1937	25507
Pune	Chemical	1	354	1277	109.82	77	1009
Ropar	Pharma	1	987	19450	1672.70	1167	15366
Tumkur	Municipality	1	1924	14802	1272.97	888	11694
Chennai	Auto Components	1	772	223	19.18	13	176
Palwal	Electrical Components	1	608	73	6.24	4	57
Total		**10**	**9400**	**80418**	**6915.90**	**4825**	**63530**

Methodology for estimation of energy savings

Energy Saving = (Specific Energy consumption $_{Baseline}$ *– Specific Energy Consumption* $_{Post\ EE\ Interventions}$*)* Annual Production* [33]

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.

Interventions carried out under the project have led to total energy savings of 6915.90 tonnes of oil equivalent[34] during FY 2020-21.

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

[34] Emission reduction due to technology upgradations/changes were calculated by SIDBI implementation agencies based on each intervention and type of fuel saved. Consolidated data of SIDBI study is presented here (2016-19), Phase I of the project is not considered in energy savings

Chapter 4: Buildings

4. *Buildings*

In India, the building sector (residential and commercial) constitutes 34% of total electricity consumption[35]. With the foreseen urbanization electricity demand in residential and commercial buildings sectors is predicted to rise by 5 and 3 folds respectively by the year 2032[36].

In India, commercial buildings consume about 8% of total electricity consumption[37]. As per Energy Conservation Building Code (ECBC), commercial buildings include offices, hospitals, hotels, retail outlets, educational buildings, government offices, etc. The rate of growth in the commercial buildings sector is amongst the highest, and hence, this sector needs to be toned down in its energy consumption. Details of the national electricity consumption including the share of commercial and domestic buildings sectors are presented in Figure 28, which shows that commercial buildings consumed around 8% and domestic (residential) buildings consumed 26% of total energy consumption in India.

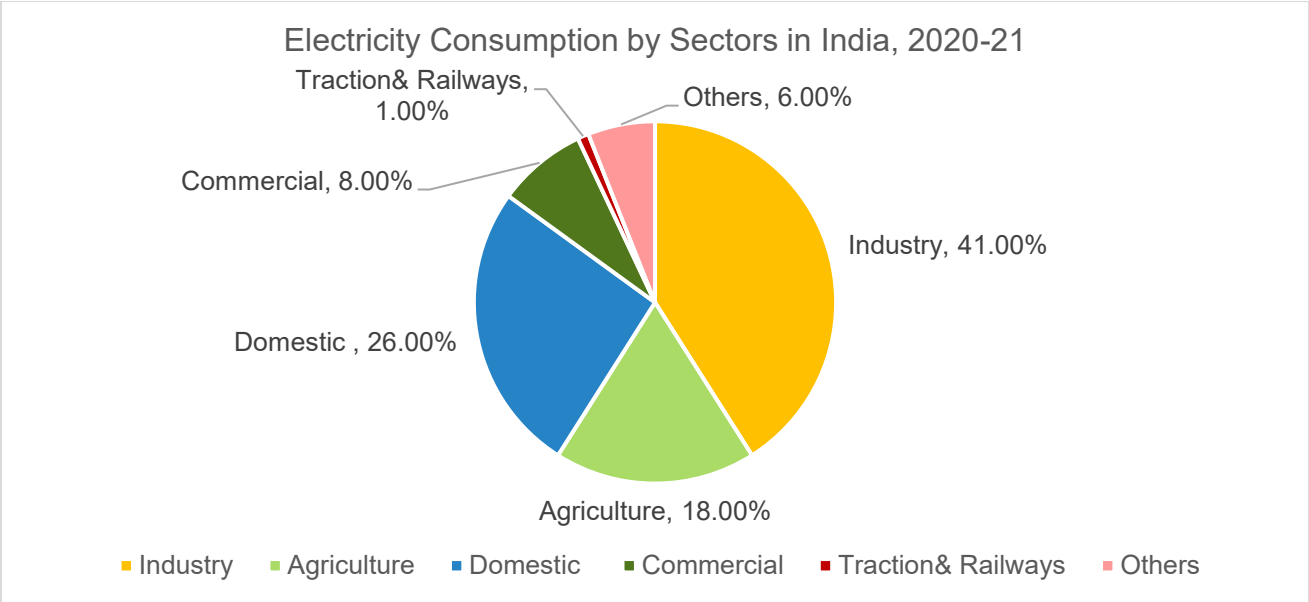


Figure 28: Energy consumption in different sectors in India

The factors affecting energy demand in both domestic and commercial buildings sector have been divided into categories:

Building envelope optimization: The building envelope refers to the structural aspects of a building, which acts as a thermal barrier between the enclosed conditioned space and the outside environment through which the thermal energy is transferred. An energy-efficient building envelope minimizes the heat gain in the building and helps in optimizing the air conditioning system size and lighting system of the building.

Lighting and Electromechanical equipment: Energy consuming equipment in the commercial sector include lighting, heating, ventilation and air conditioning (HVAC), and other

[35] Distribution of electricity consumption across India in financial year 2021, by sector – Statica.com
[36] NRDC
[37] Distribution of electricity consumption across India in financial year 2021, by sector – Statica.com

office auxiliary equipment. HVAC has the greatest share in total electricity consumption at the building level and its demand is primarily from air-conditioning for most of the climatic zones in India.

Multiple energy efficiency programs catering to the buildings sector (both commercial and residential) are therefore initiated to curb the energy consumption in buildings. The various initiatives and programs undertaken by various ministries and institutions in India for the building sector are presented in Figure 29.

Guidelines, Codes and Standards	Energy Efficiency in exisiting buildings	Rating Systems
•Energy conservation building code (ECBC) for commercial buildings •Eco Niwas Samhita- ECBC for Residential Buildings (part 1 and 2) •Residential labeling program focusing on energy efficiency	•PAT scheme for the hotel buildings •Nearly net-zero energy buildings •Shunya labelling program for NZEB and NPEB •EESL Building Energy Efficiency Program •BEE star rating for existing buildings	•GRIHA National rating system for new & existing buildings and large developments •LEED and IGBC rating system for new and existing buildings •GEM rating for buildings •CPWD rating "GHAR"

Figure 29: Programme initiatives in the building sector

4.1. Energy Conservation Building Code (ECBC) 2017

As buildings are one of the major guzzlers of energy and resources, the Energy Conservation Building Code (ECBC) is an essential regulatory tool to curb the energy footprint in commercial buildings in India. The code is developed to achieve energy efficiency by efficient designing of the commercial buildings as they have different consumption patterns as compared to residential buildings. The energy demand by end-use in residential and commercial buildings has a distinct pattern. In residential buildings, fans and lights are major consumers whereas, in commercial buildings, a major part of electricity is consumed for HVAC operation. It is due to this reason that a specific energy conservation code is required for each building type depending on its energy use.

The Bureau of Energy Efficiency (BEE) launched Energy Conservation Building Code (ECBC) in 2007 to establish minimum energy performance standards for buildings in India. Building energy codes are updated regularly to catch up with the curve of technology maturation and to set higher benchmarks for energy efficiency in buildings.

Figure 30: ECBC and ENS development and revision timeline

The first version of the Energy Conservation Building Code (ECBC) was launched by the Government of India in 2007. The BEE also launched the Star rating of commercial buildings scheme in India in 2009. EC Act was amended in 2010 with a further update of Commercial ECBC in 2017.

In June 2017, ECBC 2017 was launched which considers existing as well as futuristic advancements in building technology to further reduce building energy consumption and promote low-carbon growth beyond the codes notified under ECBC 2007[38].

24 ECBC cells were placed in different states which were supporting state designated agencies (SDAs) in the adoption, compliance, and enforcement of the code in their respective states. Along with necessary actions for notification of code in the state, the ECBC cells were responsible for training and capacity building programs and demonstration of ECBC in buildings.

4.1.1. Program Overview

Adoption of ECBC 2017 for new commercial building construction in India is estimated to lead to a 50% reduction in energy use by 2030, translating to energy savings of about 300 billion units and a peak demand reduction of over 15 GW in a year. This will be equivalent to expenditure savings of INR 35,000 crore and 250 million tonnes of CO_2 emission reduction.

The code is applicable to buildings or building complexes that have a connected load of 100 kW or greater or a contract demand of 120 kVA or greater and are intended to be used for commercial purposes. However, as per EC Act 2001, section 15, state governments can modify ECBC as per climatic conditions of the state. So, some of the states have amended ECBC as per their climatic conditions.

There are 6 types of buildings classified under ECBC:

- Hospitality (i.e. star and no-star rated hotels, resorts),

[38] ECBC has been amended in July 2021. Since the report covers FY 2020-21, it is not mentioned in detail.

- Educational (i.e. schools, colleges, universities, training institutions),
- Businesses (i.e. daytime use and 24-hours use- small, medium, and large offices based on area)
- Assembly (i.e. theater, transport service facilities, multiplexes),
- Healthcare (i.e. hospitals, out-patient healthcare),
- Shopping facility (shopping malls, stand-alone retails, open gallery malls, supermarkets)

ECBC 2017 is technology neutral. Energy efficiency requirements have been framed to provide architects and engineers artistic and technical freedom as long as minimum efficiency requirements are fulfilled. Passive design strategies like daylight and shading are promoted in the code. Additional parameters include lighting, electrical and renewable energy offering flexibility to the designers to design buildings efficiently for various components.

Post-launch of ECBC in 2017, the code has been revised in April 2018 and July 2021 (proposed) based on market feedback and technical committee approval. Also, to strengthen and regulate the implementation of ECBC, guidelines for its enforcement and implementation were developed by BEE which was notified and published in the official gazette of India as ECBC Rules, 2018.

As on August 2021, ECBC has been notified in 18 states and two UTs: Arunachal Pradesh, Andhra Pradesh, Assam, Tripura, Himachal Pradesh, Kerala, Punjab, Haryana, Karnataka, Odisha, Rajasthan, Telangana, Uttarakhand, Uttar Pradesh, West Bengal, Madhya Pradesh, Mizoram, Sikkim, and Union Territory of Andaman & Nicobar Island & Puducherry.

The code is ready with its proposed amendments in the states of, Jammu and Kashmir, Ladakh, Gujarat, Maharashtra, Chhattisgarh, Tamil Nadu, and Manipur.

Approval to the cabinet for implementation has been processed for Bihar, Goa, Jharkhand, Meghalaya, and Nagaland. The code shall be notified soon in these states.

Training and capacity building

In 2020-21, 575 training programs were conducted across India (in form of webinars/1 day/2 days) to create awareness and hands-on workshops for capacity building of stakeholders in the area of ECBC for its adoption, compliance, and enforcement. In total, around 25500 stakeholders were trained on different aspects of ECBC. Exclusive training focusing on government departments has been conducted for the officials, who will be responsible for the implementation of the code held in each state. Details of the programmatic interventions are presented in Table 29:

Table 29: Workshops conducted across India

State	Total number of workshops (in form of webinars/1 day/2 days workshops)	Total number of stakeholders (Government/private/students)
Andaman and Nicobar Islands	2	120
Andhra Pradesh	14	736
Arunachal Pradesh	9	267
Assam	9	406
Bihar	23	1077
Chandigarh	0	0
Chhattisgarh	28	1862
Dadra & Nagar Haveli & Daman and Diu	18	804
Delhi	24	1219
Goa	12	566
Gujarat	3	33
Haryana	14	635
Himachal Pradesh	18	670
Jammu and Kashmir	17	766
Jharkhand	6	186
Karnataka	17	510
Kerala	12	433
Ladakh	Clubbed with J&K	
Lakshadweep	0	0
Madhya Pradesh	54	2103
Maharashtra	28	1069
Manipur	11	298
Meghalaya	10	268
Mizoram	5	167
Nagaland	14	640
Odisha	32	1205
Puducherry	3	210
Punjab	29	1992
Rajasthan	0	0
Sikkim	10	722
Tamil Nadu	10	282
Telangana	40	2147
Tripura	6	228
Uttarakhand	18	605
Uttar Pradesh	41	1955
West Bengal	38	1412
Total	**575**	**25593**

4.1.2. Level of compliance of buildings:

ECBC 2017 is one of the first building energy codes to recognize performance, beyond the mandatory code requirements. One of the major updates to the code is the inclusion of incremental, voluntary energy efficiency performance levels. To measure the level of compliance of buildings with the code, a parameter – energy performance index (EPI) has been defined. EPI is defined as the ratio of the annual energy consumption (in kWh) and total built-up area (excluding unconditioned basements). The ECBC compliance is checked on basis of the EPI ratio. The EPI Ratio of a building is the ratio of the EPI of the Proposed Building to the EPI of the Standard Building. To Show ECBC compliance, the EPI ratio should be less than or equal to 1.

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

ECBC compliance	ECBC+ compliance	Super ECBC compliance

• Shall demonstrate compliance **by adopting all the mandatory and prescriptive requirements**,
• **Or** by following the provisions of the **Whole Building Performance (WBP) Method,** including compliance with all mandatory requirements
	• shall demonstrate compliance by adopting all the **mandatory and prescriptive requirements**
	• **Or** by following the provisions of the **Whole Building Performance (WBP) Method,** including compliance with all mandatory requirements.
	  • An ECBC+ building is **30-35%** more efficient
		• shall demonstrate compliance by adopting **all the mandatory and prescriptive requirements**
		• **Or** by following the provisions of the **Whole Building Performance (WBP) Method**, including compliance with all mandatory requirements.
		  • A Super ECBC building is **40-45%** more

ECBC compliance	ECBC+ compliance	Super ECBC compliance
	than a conventional building	efficient than a conventional building.

4.1.2.1. 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.

4.1.3. Methodology adopted to calculate the savings

To measure the level of compliance of buildings with the code, a parameter – energy performance index (EPI) has been defined. EPI is defined as the ratio of the annual energy consumption (in kWh) and total built-up area (excluding unconditioned basements). There are a total of 154 buildings[39] 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 Table 30:

Table 30: Details of buildings covered under ECBC in FY 2020-21

Construction Stage	No. of Buildings	Total Area in Mn. Sqm
Completed	19	0.42
Design stage	135	1.48
Grand Total	**154**	**1.90**

[39] There are 82 building ECBC compliant buildings in the state of Punjab which are not considered in calculations due to unavailability of relevant data to estimate energy savings.
Due to unavailability of relevant data for the state of Andhra Pradesh, the baseline energy consumption is considered equivalent to BEE 1 star rated commercial building with EPI of 200 kWh/sqm, considering air-conditioned area more than 50% for warm and humid climate of the state.

4.1.3.1. Estimation of Energy Savings:

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[40] 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 savings for buildings compliant during FY 20-21, 50% of total energy savings are considered.

To calculate the reduction in the total CO_2 emission, the conversion factor of 0.79 kg CO_2/kWh for electricity is considered. The total energy (electrical) saved under the ECBC program is 0.029 BU and the total reduction in CO_2 emission is 0.0206 MtCO_2 for year 2020-21.

Table 31: Energy Saving for ECBC compliant completed buildings FY16-21

Financial Year	No. of Buildings	Energy Savings in MU	Total Area in Mn. Sqm
2017-20	54	115	1.62
2020-21	154	26.15	1.90
Total	**227**	**141.65**	**3.52**

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 2020-21 is considered as 0.026 BU and the total reduction in CO_2 emission is 0.1114 MtCO_2.

4.2. Energy efficiency in the residential sector in India:

In India, by 2040, the real estate market will grow to Rs. 65,000 crore (US$ 9.30 billion) from Rs. 12,000 crore (US$ 1.72 billion) in 2019. The real estate sector in India is expected to reach US$ 1 trillion in market size by 2030, up from US$ 200 billion in 2021, and contribute 13% to the country's GDP by 2025[41]. Rapid commercialization, economic activities, increase in purchase power and urbanization have collectively fueled a rise in the construction of buildings and increasing energy use over the last decade.

India, the fastest growing economy in the world, has seen tremendous construction activities in the last two decades. However, the impact of COVID has been witnessed in the Indian context, but real estate is expected to rise in post covid scenarios. The steep increase in urban population, coupled with the demand for a better lifestyle, has led to high demand for residential buildings. The sector has been growing at Compounded Annual Growth Rate

[40] Conventional EPI is defined considering baseline of ECBC 2007, % saving is considered as per ECBC impact analysis done by IECC under USAID ECO III project.
[41] Indian real estate industry reports by India brand equity foundation

(CAGR) of 6% and by the year 2030; it is estimated that around 3 billion m^2 of the new area will be added with respect to the year 2018.

The economic importance of the residential sector in India can be judged by the estimate that for every Indian rupee (INR) invested in housing and construction, INR 0.78 is added to the gross domestic product[42] of the country. Thus, it is imperative to constantly provide a firm boost to the Indian housing sector to meet the target of housing for all by the Honorable Prime Minister of India under the Pradhan Mantri Awas Yojna (PMAY) and to keep India on the trajectory of expected growth.

Such urbanization and high GDP growth rate have fueled the electricity consumption in the residential sector as well[2]. Electricity demand in the residential sector has been increasing at a CAGR of 8% per year on average. This robust growth shall lead to an increase in electricity consumption from 2730 BU in 2017[43] to almost 700 BU in 2030.

[42] https://economictimes.indiatimes.com/news/economy/indicators/economic-survey-housing-sectors-share-in-gdp-of-india-to-rise-to-6/articleshow/12276533.cms
[43] Energy statistics, 2019- MoSPI

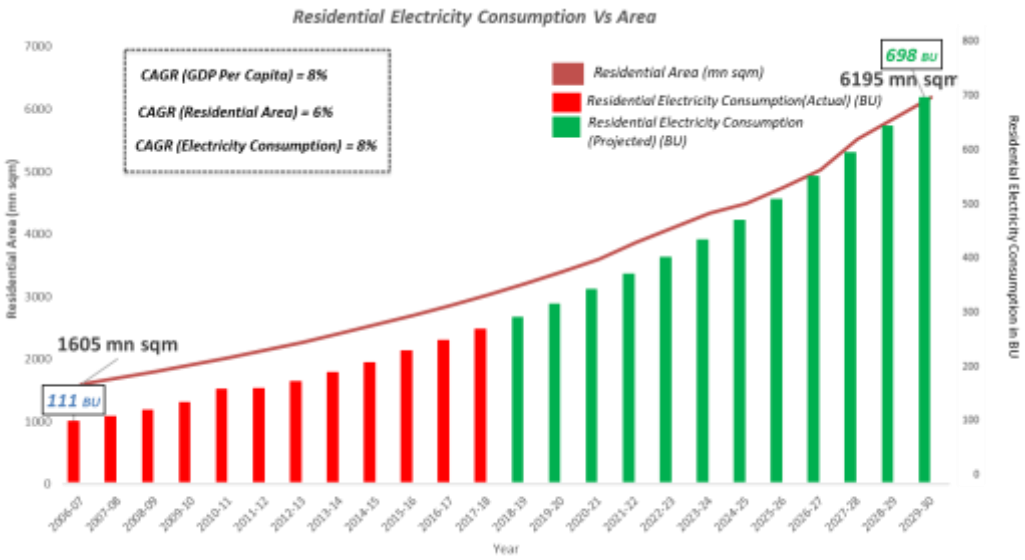


Figure 31: Area of the buildings in residential space and energy consumption forecast

4.2.1. About Eco Niwas Samhita (ENS) – Scope and Requirement

Increment in the residential building stock, coupled with an increase in electricity use for space conditioning, is resulting in a rapid increase in electricity use in residential buildings. As per the projection done by NITI Aayog, electricity consumption for the residential sector is expected to increase 6-13 times by 2047. Another important aspect is thermal comfort, which is of utmost importance in all kinds of housing, but more so in the case of affordable housing, to ensure the health and well-being of the occupants. BEE envisaged a phased approach for the development of the residential building energy conservation code.

The Ministry of Power, Government of India launched the Eco Niwas Samhita 2018 (ENS), The implementation of this Code will provide a boost to energy efficiency in the residential sector. It aims to benefit the occupants and the environment by promoting energy efficiency in the design and construction of single and multi-dwelling units. Eco Niwas Samhita (ENS) will help in making houses energy efficient and is certainly a way of avoiding a long-term futile electricity consumption liability in residential buildings.

The provisions of this code apply to all residential buildings and residential parts of mixed land-use projects, both built on a plot area of ≥500 m^2. However, the actual plot area is subjective to the respective states and municipal bodies on the prevalence in their area of jurisdiction.

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.

4.2.1.1. Building components covered under ENS

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 the compliance.

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

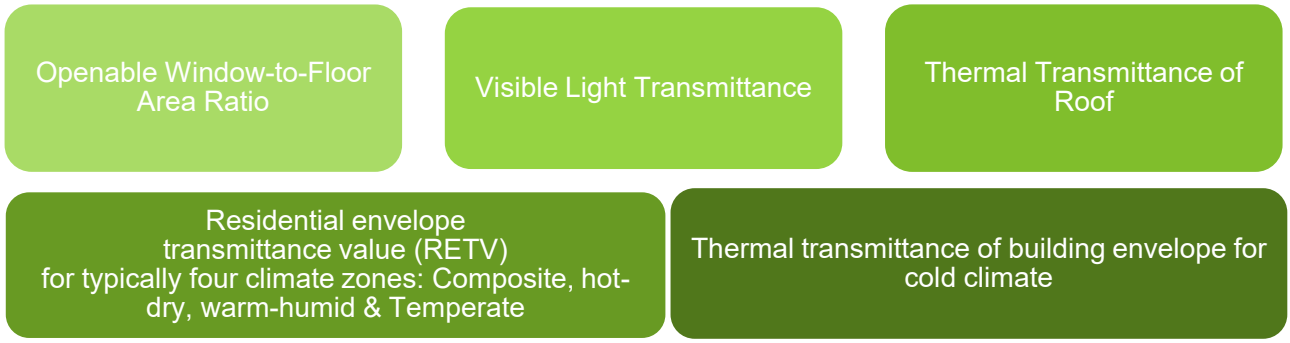


Figure 32: Key components of ENS part-1 building envelope

Eco Niwas Samhita (ENS), Part -2

ENS Part 2 (Electro-Mechanical and Renewable Energy Systems) 2 is developed for code compliance and to provide the minimum requirement(s) for building services, and electro-mechanical and renewable energy systems for new residential buildings. It sets minimum requirements for electro-mechanical systems used in building services (i.e. common area and exterior lighting, elevators, pumps, basement ventilation, transformers, power distribution losses, power factor correction, electrical vehicle supply equipment, etc.), indoor electrical end-use (i.e. indoor lighting, comfort systems, service hot water, etc.) and for renewable energy systems (Solar hot water requirements and Solar Photovoltaic) integration.

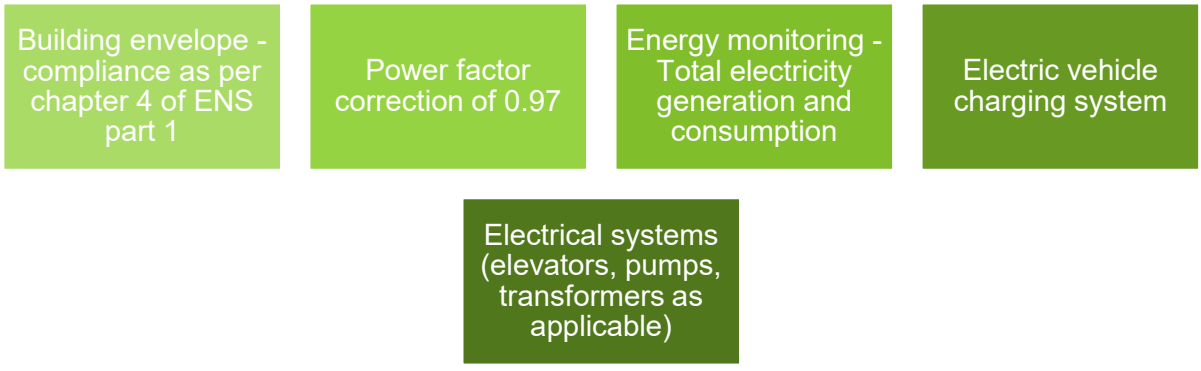


Figure 33: Key components of ENS part 2

Eco-Niwas Samhita Compliance (ENS) Tool:

Under the initiative, BEE has developed online tools for quick evaluation of design for homeowners, contractors, and builders on energy efficiency parameters. The BEE has developed three tools basic, advanced, and optimization tools.

The Basic tool has various categories of options from building envelope (wall, roof & window), Air-conditioning and Ventilation techniques to check the project performance. **An advanced tool** is for the professionals (Architects, Engineers, MEP consultants, project developers, and Industry professionals) who wish to perform a detailed analysis of the project design features in terms of energy efficiency and economic feasibility. The tool has the provision of various inputs of building design parameter options ranging from Building Geometry, Envelope, Lighting, Equipment, HVAC, and Economics to check the project performance. **The optimization tool** is a quick evaluation module to compute the most optimized set of envelope parameters (best wall, best roof, and best window) for the selected location based on the life cycle cost of the envelope options. Just input the cost of the most common envelope assemblies available at the project site and the tool will indicate which envelope will be the best for a site.

Other initiatives taken by BEE under the ENS are –

ENS Cell: In FY 2020-21, ENS cells were established as pilot cells in a few states Punjab, Delhi, UP, Maharashtra, Karnataka, Haryana, Gujarat, Rajasthan, and Andhra Pradesh. There have been 148 training programs organized by ENS cells in the selected states as seen in Table 32.

Table 32: Capacity building training activities conducted by ENS Cells

Workshops conducted across India in 2020-21 (Pilot ENS Cells)		
State	**Total No. of Workshops**	**Total No. of Stakeholders (Govt/Private/Students) trained**
Punjab	25	2112
New Delhi	17	1245
UP	26	2424
Maharashtra	35	2138
Karnataka	35	1376
Haryana	5	281
Gujarat	3	185
Rajasthan	1	50
Andhra Pradesh	1	400
Total	**148**	**10211**

4.2.1.2. Level of compliance of buildings

To demonstrate compliance with the code, the 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 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 in Table 33.

Table 33: 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 buildings	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.

4.2.1.3. Methodology adopted to calculate the savings

ENS part 1 was launched in December 2018. ENS cells were established in 2019 in Delhi, Uttar Pradesh, Punjab, Karnataka, and Maharashtra to implement the residential code for one year.

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[44] of 15 W/m^2.

The demonstration projects in the states (where ENS cell was established) have complied with the minimum RETV requirements (as stated in ENS part 1). The energy savings 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.

[44] BEE plans to improve the RETV norm to 12 W/m2 in the near future and the building industry and regulating agencies are encouraged to aim for it.

Estimation of Energy Savings

As on date, there are 54 residential projects which have shown compliance for ENS part 1. Since the ENS cells were working in selected states (till April 2021), the penetration of ENS is limited.

To calculate the energy (electrical) savings, the difference between the conventional RETV (baseline) and proposed RETV of the respective residential buildings is considered.

Table 34: Energy savings by the adoption of ENS in selected states

Year	Number of buildings	Total built-up area (million sqm)	Energy savings (MU)
2020-21	54	1.55	2.42

To calculate the reduction in the total CO_2 emission, the conversion factor of 0.82 kg CO_2/kWh for electricity is considered. The total energy (electrical) saved under the ENS program is 0.0024 BU and the total reduction in CO_2 emission is 0.00021 $MtCO_2$. This is expected to grow exponentially in the coming years with much aggressive adoption of ENS in all states of India.

4.2.2. Residential Labeling Program

The challenge in terms of soaring energy consumption in the housing segment is needed to be tackled with a multi-faceted approach. Making houses energy efficient is certainly a way of avoiding a long-term futile electricity consumption liability in residential buildings. This program helps the country in the same direction by designing an energy-efficient residential labeling system.

Ministry of Power has already launched EcoNiwas Samhita 2018 on 14th December 2018, which prescribed the minimum energy performance through an energy-efficient envelope design. The proposed labeling program takes forward EcoNiwas Samhita 2018 and motivates consumers to move forward to design more efficient construction. Energy labels help consumers to make efficient decisions through the provision of direct, reliable, and costless information.

4.2.2.1. Objective of the labeling program

The key objective of the program is to make a transparent instrument for the energy performance of a home which will gradually lead to an effective model taken into consideration when deciding on the home prices in the future. 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*

4.2.2.2. Scope of the program

The proposed Labeling program will cover all types of residential buildings in India. All the envisaged objectives can be achieved through the proposed labeling mechanism by making it mandatory in any real estate transaction/ leasing.

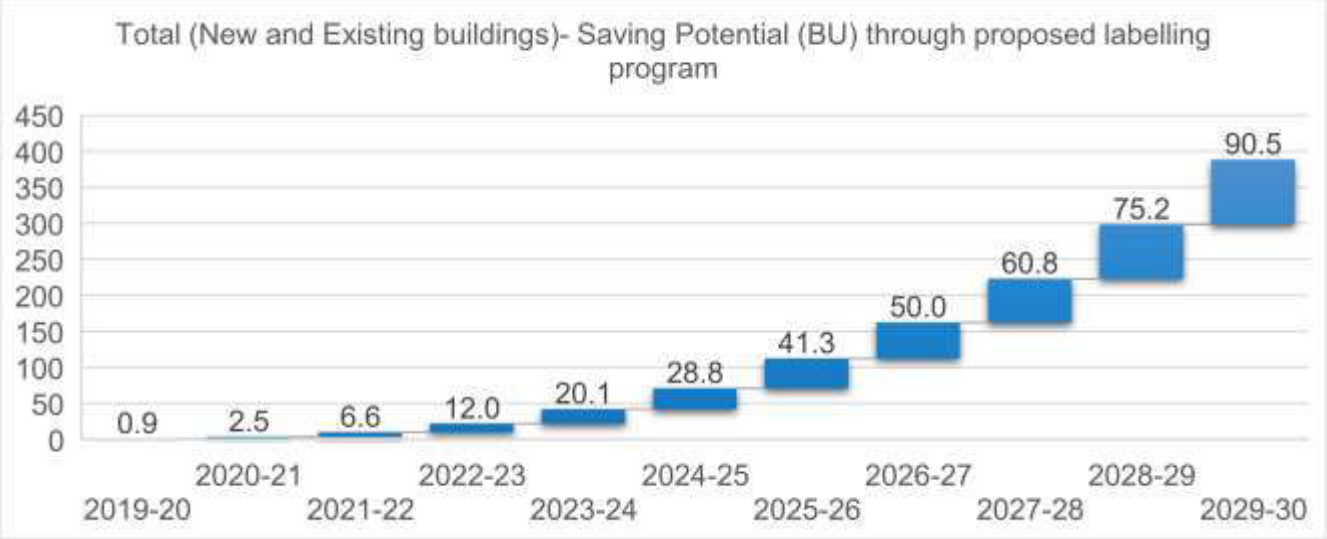


Figure 34: Energy saving potential in buildings through labeling program

4.2.2.3. Benefits of the program

The proposed labeling program is expected to save a large amount of energy by imparting energy efficiency to houses nationwide. 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 proposed labeling program shall act as an embryo to **stimulate the larger energy-efficient materials and technologies market**. To seek the energy efficiency label, customers shall demand energy-efficient building materials which in turn, would give enough impetus to suppliers to produce the same.
2. Post implementation of the labeling mechanism, the housing value chain shall need an additional set of professionals to expedite the complete process of residential label granting. In this way, the labeling regime shall also be a stimulant to the Indian job market.
3. The proposed labeling program will also motivate material manufacturers to invest in energy-efficient material manufacturing in India thus supporting the Make in India program.
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.

4.3. BEE star rating for existing buildings:

BEE launched the Star rating of commercial buildings scheme in 2009. The star rating program is based on the actual performance of a building in terms of its specific energy usage in kWh/sqm/year. This program rates office buildings on a 1-5 Star scale, with 5 Star labeled buildings being the most efficient. The scheme is propagated voluntarily, and the label provided under it is applicable for 5 years from the date of issue.

Under this program, there are 5 categories of buildings that have been identified viz. office buildings (day use), business process outsourcing (BPOs), shopping malls, and hospitals in the 5 climatic zones of the country. This national energy performance rating is a type of external benchmark that helps energy managers to assess how efficiently their buildings use energy, relative to similar buildings nationwide. Additionally, building owners and managers can use the performance ratings to help identify buildings that offer the best opportunity for improvement and recognition.

4.3.1. Program Overview:

Under the present labeling scheme, the buildings are being labeled as per their actual Energy Performance Indices (EPI) on a scale of 1 to 5. The sets of standard EPI bandwidths developed to rate buildings under this scheme for different climatic zones indicate the range of variations in the energy performances of different office building types lying in a particular climatic zone.

To apply for a rating of office buildings, a standardized format is developed for the collection of actual energy consumption: data required includes the building's built-up area, conditioned and non-conditioned area, type of building, hours of operation of the building in a day, climatic zone in which building is located, and other related information of the facility.

Based on the data provided by BEE, there are a total of 264 buildings have been star rated under different categories of buildings as on date (since the start of the program in 2009) as seen in Figure 35. BEE had launched the Star rating program for Offices (February 2009), BPOs (December 2009), shopping malls (January 2011), and Hospitals (July 2014). A Memorandum of Understanding (MoU) is also signed between BEE and CPWD on 10th January 2019 for "Energy Efficiency in CPWD managed Buildings".

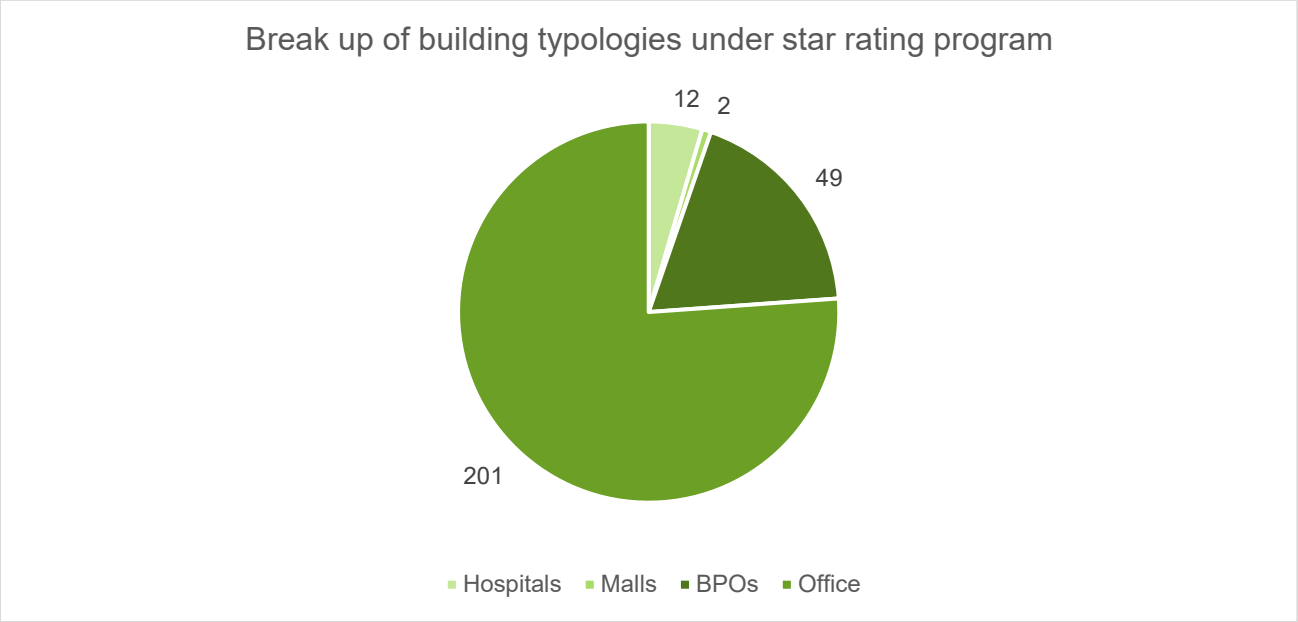


Figure 35: Break up of building typologies since the inception of the program

4.3.2. Star Rating System:

Energy Performance Index (EPI) in kWh / sqm/ year is considered for rating the building. The table indicating the EPI with the corresponding Star Label under the various climatic zones is provided in the below sections for reference- For buildings having an air-conditioned area greater than 50% of their built-up area & for buildings having an airconditioned area less than 50% of their built-up area. Details are presented in Figure 36.

Star Rating for building with >50% of air-conditioned built up area			
Star Label	EPI for composite climate zone	EPI for warm & humid climate zone	EPI for hot & dry climate zone
1	190-165	200-175	180-155
2	165-140	175-150	155-130
3	140-115	150-125	130-105
4	115-90	125-100	105-80
5	Below 90	Below 100	Below 80

Star Rating for building with <50% of air-conditioned built up area			
Star Label	EPI for composite climate zone	EPI for warm & humid climate zone	EPI for hot & dry climate zone
1	80-70	85-75	75-65
2	70-60	75-65	65-55
3	60-50	65-55	55-45
4	50-40	55-45	45-35
5	Below 40	Below 45	Below 35

Figure 36: Baseline EPI for Star rated buildings in 2020-21[45]

Under this program, the user affixes the building rating label as per the label design and specification (both in terms of size and material), manner of display, and the rating plan as prescribed by the BEE for the particular building type. BEE is continuously reviewing its

[45] The same has been revised in FY 2021-22 which shall be covered in next report

technical approach to the development of the rating system to ensure an accurate, equitable, and statistically robust rating because each building type has unique features that impact energy efficiency. BEE has also taken up the exercise of standardization of energy data collection which assists in the comparative assessment and target setting in existing buildings.

4.3.3. Methodology for Energy Savings:

EPI shall be kWh/sqm/year in terms of purchased & generated electricity 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 rating is normalized to account for the operational characteristics that define the building use, hours of operation, climatic zone, and conditioned space.

The methodology adopted for assessing the energy savings of star-rated buildings is based on the difference between the reported EPI value and max EPI for star 1 rated buildings, multiplied by the total built-up area. The bandwidths considered for building energy star rating programs are provided for office buildings in the above section. Similarly, bandwidths for other typology of buildings (hospital, BOP, shopping malls) is considered for the calculation of energy savings. The number of the buildings labeled during 2016-21 are presented in the Figure 37.

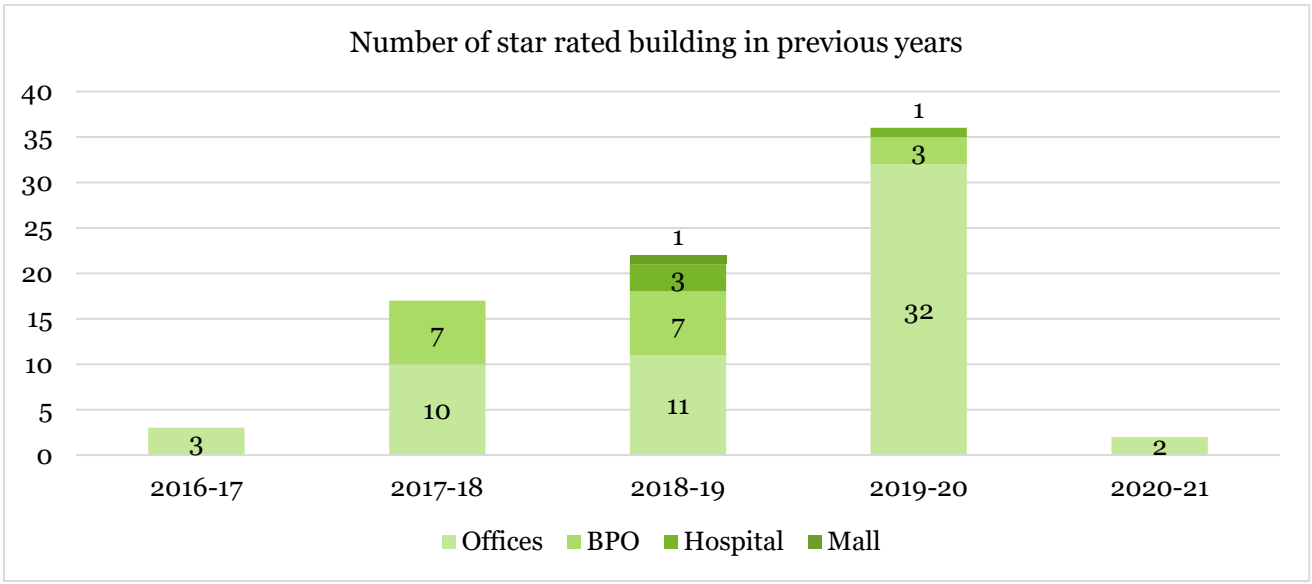


Figure 37: Number of Star rating buildings

$$Total\ Built\ up\ Area * (Conventional\ EPI - Measured\ EPI\ for\ Star\ Rated\ Building)$$

Where Conventional EPI = Max EPI for 1 Star Rated building for a specific category of building in a specific climate zone

4.3.3.1. Type of Buildings and Climate Zones:

The program targets the following 4 climatic zones for air-conditioned and non-air-conditioned buildings:

- Warm & Humid
- Composite

- Hot and Dry
- Temperate

There are a total of four types of commercial establishments that are part of this report, viz. Offices, Hospitals, BPOs, and shopping malls.

1. ***Office Buildings:*** BEE Star Rating Scheme for Office Buildings is notified in the year 2009. The baseline EPIs considered for the star rating program in more than 50 % of air-conditioned built-up areas and less than 50 % of air-conditioned built-up areas are given in Table 35.

Table 35: EPI for star label office buildings

Star Label	Climatic Zone	EPI (kWh/sqm/year)	
		<50% air conditioned	>50% air conditioned
1 Star	Composite	80-70	190-165
1 Star	Warm & Humid	85-75	200-175
1 Star	Hot & Dry	75-65	180-155

2. ***BPO Buildings*:** Star Rating Scheme for BPO buildings was notified in December 2009. Average Annual hourly Energy Performance Index i.e., (AAhEPI) in (Wh / hr/ sqm) has been considered for rating the BPO building. The table indicating the AAhEPI with the corresponding Star Label under the various climatic zones is presented in Table 36.

Table 36: EPI for star label BPO buildings

Star Label	Climatic Zone	Average Annual hourly EPI (AAhEPI) in (Wh / hr/ sqm) >50% Conditioned Area only
1 Star	Composite	52-46
1 Star	Warm & Humid	54-48
1 Star	Hot & Dry	37-31
1 Star	Temperate	47-41

3. ***Shopping Malls:*** BEE Star Rating Scheme for shopping malls is notified in the year 2011. Energy Performance Index (EPI) in kWh / sqm/ year is considered for rating the mall. The table indicating the EPI with the corresponding Star Label under the various climatic zones is presented in Table 37.

Table 37: EPI for star label shopping malls

Star Label	Climatic Zone	EPI (kWh /sqm/year) >50% Conditioned Area only
1 Star	Composite	350-300
1 Star	Hot & Dry	300-250
1 Star	Temperate	275-250
1 Star	Warm & Humid	450-400

4. ***Hospitals:*** BEE launched the Star rating program for Hospitals in July 2014. A benchmarking tool called the ECO bench, available online is used for evaluating the star rating for hospitals. This tool gives the performance distribution curve, EPI, Performance Rank, and relevant Stars to hospital buildings.

4.3.4. Impact of BEE Star Rated Programme:

As the star rating is valid for 5 years and 80 buildings had received a star rating from 2016-17 to 2020-21; 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 2 commercial establishments have received BEE star ratings in FY 2020-21. Due to COVID 19, the star-rated buildings are lesser as compared to previous years.

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 2020-21 is 249.2 MU. This has led to a reduction of 0.196 million Tonnes of CO_2. Details are presented in Table 38:

Table 38: Energy-saving summary of Star rated scheme

Building Type	Energy Savings in MU						CO_2 Emission Reductions (MntCO2)
	2016-17	2017-18	2018-19	2019-20	2020-21	Total	
Offices	0.5	6.2	7.9	51.5	14.3	80.4	0.0635
BPO	0.0	28.6	40.8	86.2	0.0	155.6	0.1229
Hospital	0.0	0.0	3.5	0.9	0.0	4.3	0.0034
Mall	0.0	0.0	8.9	0.0	0.0	8.9	0.0070
Total	**0.5**	**34.8**	**61.0**	**138.6**	**14.3**	**249.2**	**0.1969**

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 & mechanical appliances, therefore, to avoid any duplication, the energy savings of the Star Rating Programme has been already considered under the S&L program. The savings are not counted for the assessment year 2020-21 as the above-mentioned savings have been included in the previous report.

Chapter 5:
Standards & Labelling

5. *Standards and Labeling*

Energy demand in India has increased more than two-fold in the last decades and is expected to overtake European Union as the world's third-largest energy consumer by 2030[46]. Increased greenhouse gas emissions because of India's increased energy consumption and the country's future dependence on fossil fuels to serve its energy security have raised serious environmental concerns. As an emerging economy, India has a huge opportunity to meet its development goals with minimal energy consumption. Energy efficiency will play a pivotal role in determining an optimal energy portfolio for India.

The deployment of clean energy systems is gaining momentum through policy interventions in India and across the globe. Although, one of the most inexpensive achievable options available is adopting an energy efficient lifestyle. Energy efficiency is increasingly becoming a key pillar of energy transformation policies in the world. Implementing robust energy efficiency interventions lead to curbed air pollution, decarbonization, improved energy access, better resource use and enhanced energy security. The transition to clean energy will be faster and cheaper if energy efficiency measures are undertaken.

In this regard, BEE introduced the Standards and Labeling (S&L) program in 2006 to provide the consumer with an informed choice about the energy saving and thereby the cost saving potential of the relevant labeled appliance. The energy efficiency labeling program under BEE is intended to reduce the energy consumption of appliances without diminishing the services it provides to consumers. It provides long-term policy signals and can be applied in various end-use sectors. This program applies not only to a specific appliance but is also used to control the quality of information, particularly at the point-of-sale of energy-intensive appliances. The S&L program has received huge acceptance around the world and is now a common tool for energy efficiency.

There are two components under the Standards and Labeling programme.

Standards: Standards prescribe limits on the energy consumption (or minimum levels of energy efficiency) of manufactured products. Based on the standard, a prescribed energy performance of the manufactured products can be set, sometimes prohibiting the sale of products that are less efficient than a minimum level. Standards may mean well-defined test protocols (or test procedures) to obtain a sufficiently accurate estimate of the energy performance of a product, or at least a

[46] Source: IEA report

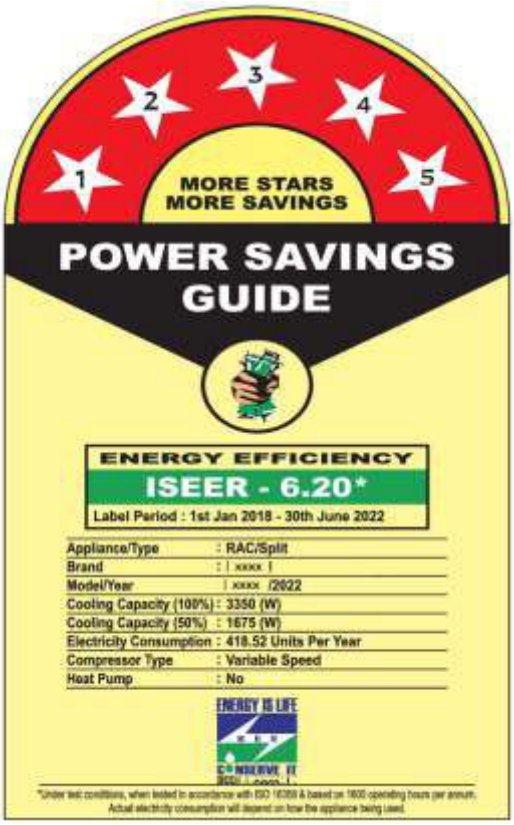
relative ranking of its energy performance compared to that of other models.

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 an 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 Table 39:

Table 39: Energy efficiency labels

Comparative Label



Endorsement Label

The S&L programme was started with voluntary labels for refrigerators and Tubular fluorescent lamps. Since its inception, number of appliances have been added year on year under this programme. During January 2009 affixing label on appliances namely *"Room Air Conditioners, Tubular Fluorescent lamps, Frost Free Refrigerators and Distribution Transformers".* was made mandatory. Till date, twenty-eight appliances are covered under the scheme, out of which, ten are under the mandatory labeling regime and remaining eighteen are under the voluntary regime of labeling.

S&L in India works on a model in which the permittee provides information related to the energy efficiency of the product on the label as prescribed for the respective product by the Bureau from time to time. A star rating, ranging from 1 to 5 in the ascending order of energy efficiency is provided to products registered with the Bureau. The energy performance standards get updated in every two-three year; old inefficient products are replaced with more energy efficient products. For example, 5-star air conditioner of the year 2009 was having an EER of 3.1 which has drastically been improved over years. Presently, in accordance with norms applicable 5-star RAC has an EER of 4.5 or more.

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.

Two new appliances have been added during 2020-21 under the S&L Programme. During the 30th National Energy Conservation Awards (NECA), celebrated on 11th January 2021, the Standards and Labelling Programme for Air Compressors and Ultra High Definition (UHD) TV on a voluntary basis were launched.

The scheme as of 31st March 2021, covers 28 appliances under the S&L programme (10 mandatory and 18 voluntary). Details of the appliances are presented in section 5.1.

5.1. Appliances under S&L

The appliances covered[47] are presented in Table 40.

Table 40: List of appliances covered under the S&L program as of 31st March 2021 [48]

S.No	Appliance Name	Category
1.	Frost Free Refrigerator	Mandatory
2.	Tubular Florescent Lamp	Mandatory
3.	Room Air Conditioners (Fixed Speed)	Mandatory
4.	Direct Cool Refrigerator	Mandatory
5.	Distribution Transformer	Mandatory
6.	Color TV	Mandatory
7.	Electric Geysers	Mandatory
8.	Room Air Conditioners (Cassette, Floor Standing)	Mandatory
9.	Inverter Air Conditioners	Mandatory
10.	LED Lamps	Mandatory
11.	Pump Sets	Voluntary
12.	Ceiling Fans	Voluntary
13.	Induction Motors	Voluntary
14.	Washing Machine	Voluntary
15.	Computer (Notebook/Laptops)	Voluntary
16.	Ballast (Electronic/Magnetic)	Voluntary
17.	Solid State Inverter	Voluntary
18.	Office Equipment's	Voluntary
19.	LPG-Stoves	Voluntary
20.	DG Sets	Voluntary
21.	Diesel Engine Mono-set Pumps	Voluntary
22.	Chillers	Voluntary
23.	Microwave Oven	Voluntary
24.	Solar Water heater	Voluntary
25.	Deep freezer	Voluntary
26.	Light commercial Air Conditioner	Voluntary
27.	Air Compressor	Voluntary
28.	UHD Colour Television	Voluntary

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

5.2. Methodology adopted for saving

The Methodology adopted for the evaluation of the impact of the S&L programme is shown in Figure 38[49]

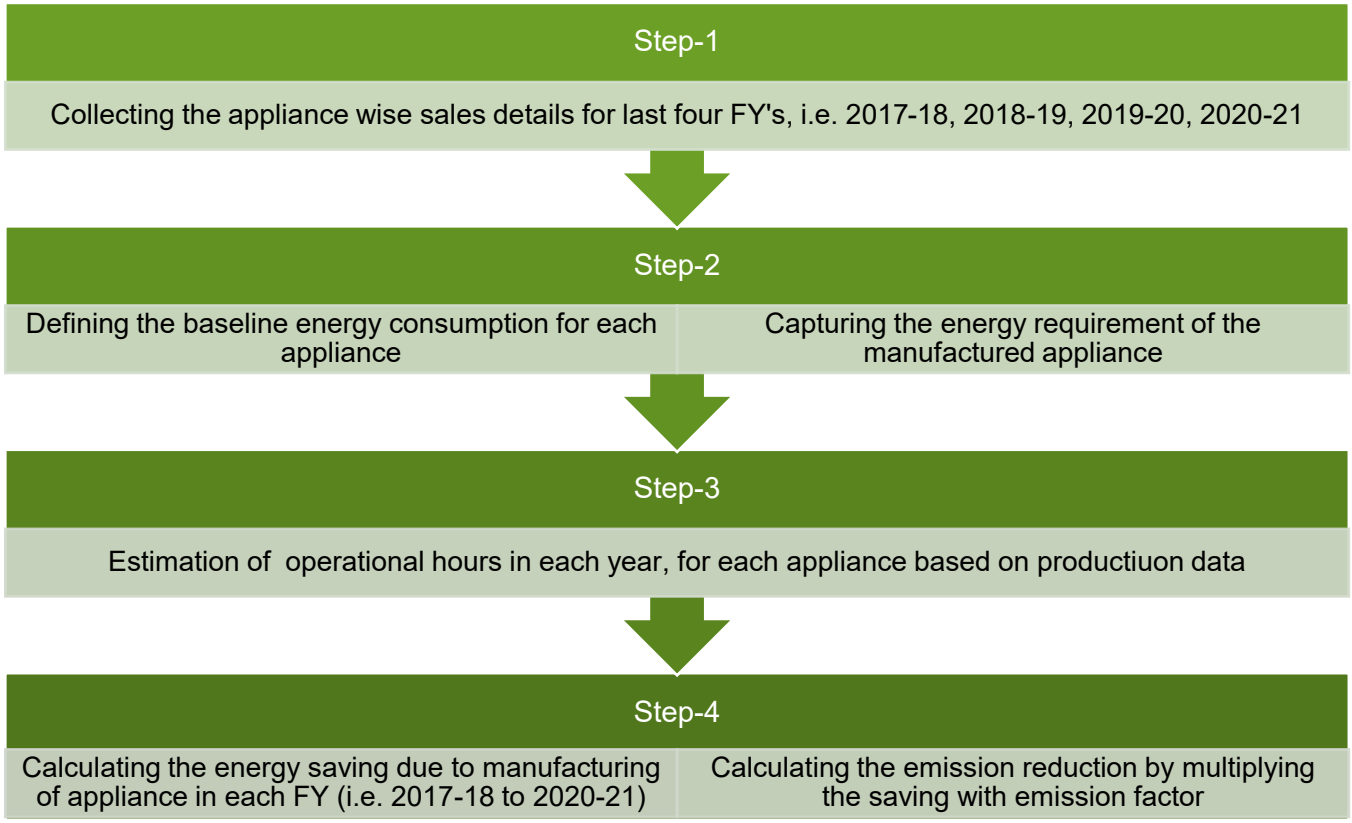


Figure 38: Methodology for impact assessment

[49] Average life of the appliances in considered as four years, hence energy savings due to the sales of Star labeled appliances from FY 2017-18 to FY 2020-21 are considered while evaluating the impact of the scheme for FY 2020-21 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 manufactured data must be captured for the registered appliances under the S&L program. Till 31st March 2021; 28 appliances were registered under the programme, out of which 17 have significant production volume based on data reported under the programme. For the other 11 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 17 appliances being considered for impact assessment is presented in Table 41.

Table 41: List of appliances covered under the S&L programme for impact assessment[50]

S. No.	Appliance
Mandatory Appliances	
1.	Frost Free Refrigerator
2.	Tubular Florescent Lamp
3.	Room Air Conditioners
4.	Direct Cool Refrigerator
5.	Distribution Transformer
6.	Color TV
7.	Electric Geysers
8.	Room Air Conditioners (Cassette, Floor Standing)
9.	Inverter Air Conditioners
10.	LED Lamps
Voluntary Appliances	
11.	Pump Set (Submersible)
12.	Ceiling Fans
13.	Washing Machine
14.	Computer (Notebook/Laptops)
15.	LPG-Stoves
16.	Diesel Engine Mono-set Pumps
17.	Chillers

5.3.1.2. Production Volumes of the appliances for the respective FY (2017-18 to 2020-21)

The star wise production figures of both mandatory and voluntary appliances, which are considered for the study, for the current FY 2020-21 is showcased in the Table 42.

[50] 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

Table 42: Star wise production figures of appliances (FY 2020 – 21)

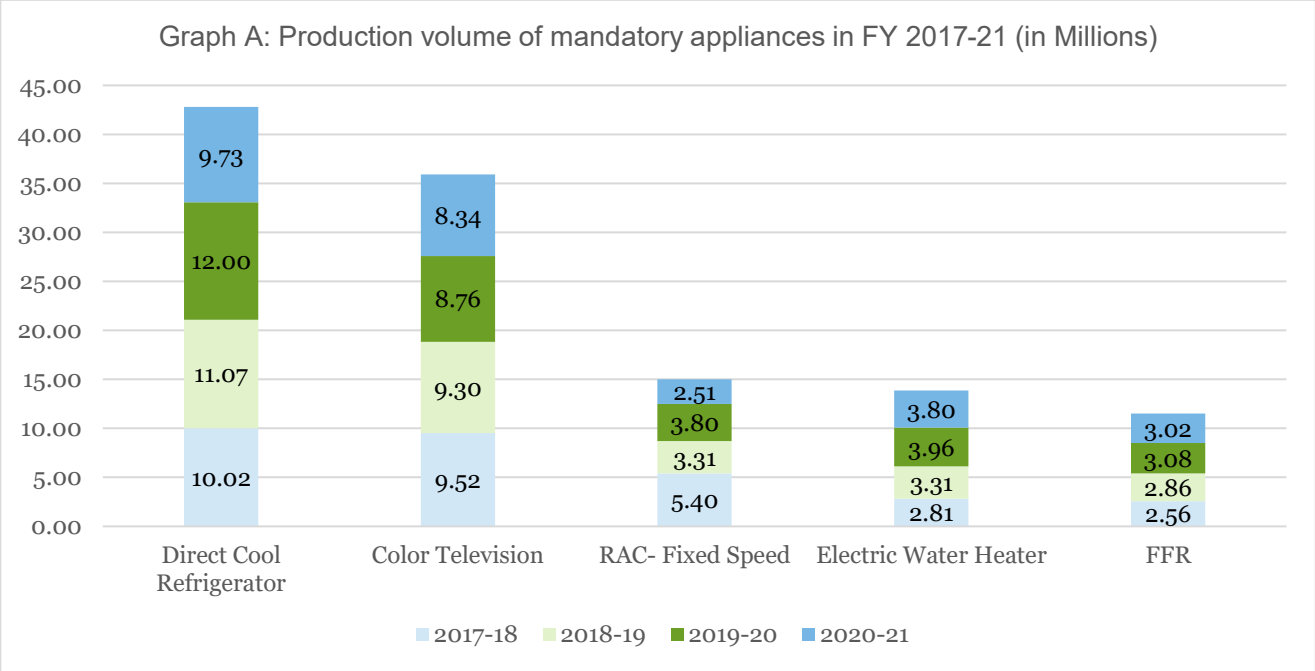
S. No	Appliance	5 Star	4 Star	3 Star	2 Star	1 Star	Total (in Million)
1.	Frost Free Refrigerator	-	649	1,043,629	1,952,009	21,710	3.02
2.	Tubular Fluorescent Lamps	-	-	3,854,515	20,000	44,314,753	48.18
3.	Room Air Conditioners (RAC) Fixed Speed	143,625	8,449	2,218,089	115,684	25,501	2.51
4.	Direct Cool Refrigerator	335,862	1,671,868	3,742,145	3,233,624	748,628	9.73
5.	Distribution Transformer (DT)	13,619	12	1	108,328	216,155	0.34
6.	Color Television	154,524	1,173,949	2,833,504	3,491,189	681,974	8.33
7.	Stationary Storage Type Electric Water Heater (Geyser)	2,400,460	1,298,819	68,193	33,047	-	3.8
8.	Room Air Conditioners (Variable Speed)	1,334,961	438,238	2,340,717	-	42	4.11
9.	LED Lamps	607,632	34,366,771	342,923,716	87,198,304	-	465.09
10.	Pump sets (Submersible and open well pumpsets)	89,370	99,245	123,904	89,961	13,463	0.41
11.	Ceiling Fans	619,546	-	16,453	289,228	2,398,443	3.32
12.	Washing Machine (Semi / Top Load / Front Load)	5,740,248	595,661	346,051	-	-	6.68
13.	Computer					330	0.00033
14.	Domestic Liquefied Petroleum Gas (LPG) Stoves	-	-	-	-	1,213,959	1.21
15.	Monoset Pumps	5,743	518	30,210	11,458	271	0.048
16.	Chillers	-	-	1	4	-	0.000005
Total (in Million)		11.45	39.65	359.54	96.54	49.64	556.78

The consolidated production data of the appliances for the FY 2017-21, is presented in the Table 43.

Table 43: Production figures for appliances (FY 2017 – 21)

S. No	Appliance	FY 2017-18	FY 2018-19	FY 2019-20	FY 2020-21	Total (in Million)
Mandatory Appliance						
1	Frost Free Refrigerator	2,578,277	2,861,285	3,074,275	3,017,997	***11.53***
2	TFL	81,219,925	63,187,569	52,775,743	48,189,268	***245.37***
3	Room Air Conditioner (Fixed Speed)	5,384,058	3,304,280	3,797,043	2,511,348	***14.99***
4	Direct Cool Refrigerator	10,014,626	11,067,110	11,998,899	9,732,127	***42.81***
5	Distribution Transformer	347,515	500,544	464,389	338,115	***1.65***
6	Color Television	9,479,658	9,298,819	8,703,395	8,335,140	***35.81***
7	Stationary Type Water Heater	2,741,279	3,287,462	3,736,438	3,800,519	***13.56***
8	Room Air Conditioner- (Variable Speed)	2,267,364	3,924,884	5,050,951	4,113,958	***15.35***
9	LED LAMPS	27,290,510	243,974,600	505,633,490	465,096,423	***1,241.99***
Total (in Million)		***141.32***	***341.40***	***595.23***	***545.13***	***1,623.09***
Voluntary Appliance						
1	Pump Sets (Open well and submersible)	1,031,896	1,326,818	1,037,081	592,525	***3.98***
2	Ceiling Fan	3,393,289	2,353,916	1,795,718	3,323,670	***10.86***
3	Washing Machines	-	-	1,791,020	6,681,960	***8.47***
4	Computers	-	-	-	330	***0.000330***
5	Domestic LPG Stoves	739,160	821,804	1,326,632	1,213,959	***4.10***
6	Mono set Pump	53,860	72,768	70,835	48,200	***0.24***
7	Chillers			18	5	***0.000023***
Total (in Million)		**5.21**	**4.57**	**6.02**	**11.86**	***27.67***

With reference to the data provided in the above table, the production figures for each mandatory and voluntary appliance for the FY 2017-21 are showcased in Figure 39:



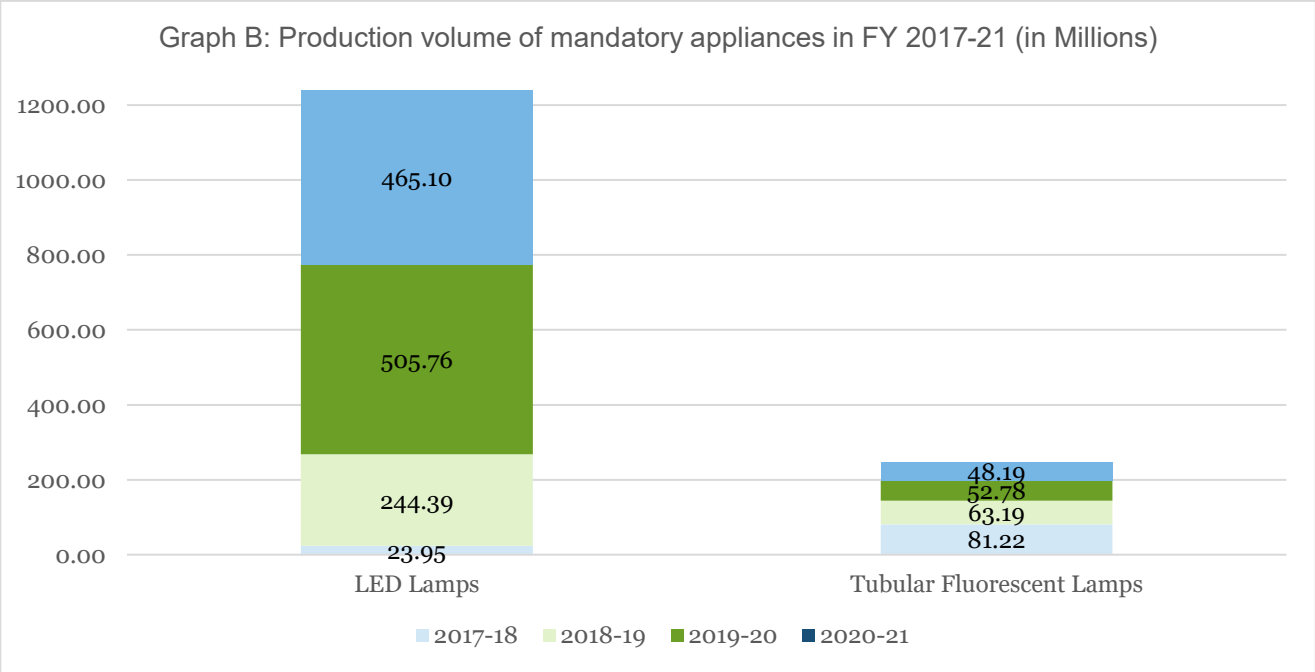
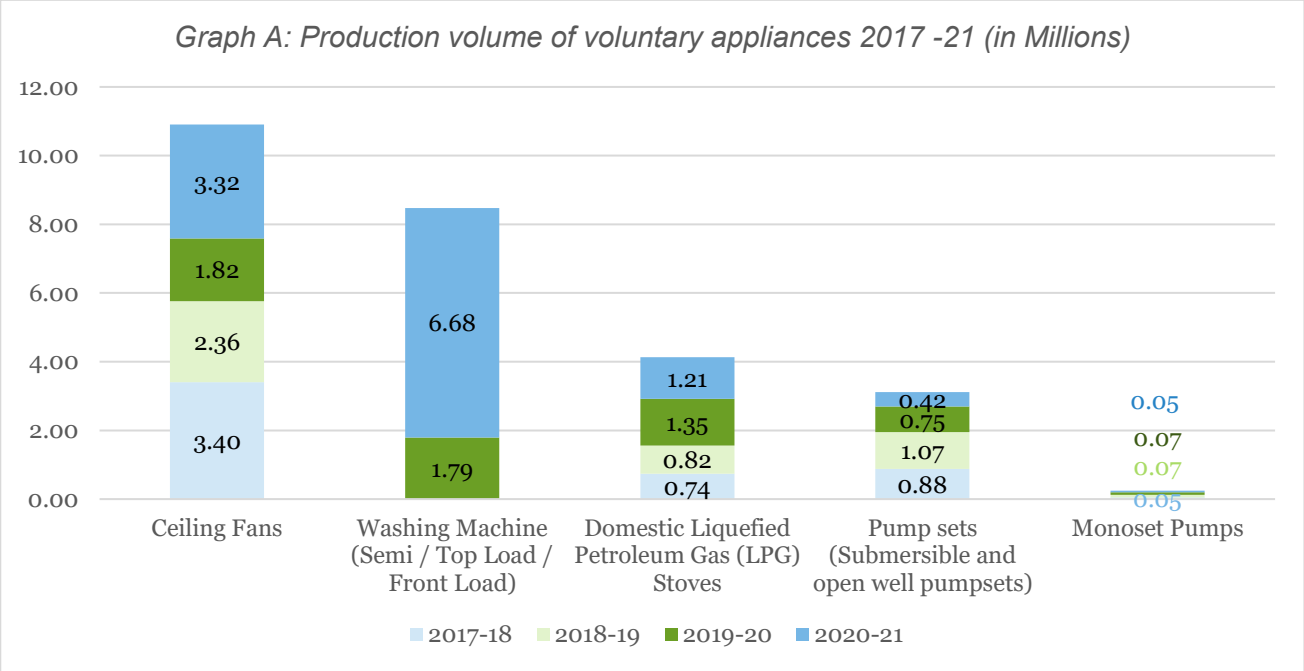


Figure 39: Production volume of mandatory appliances in FY 2017-21



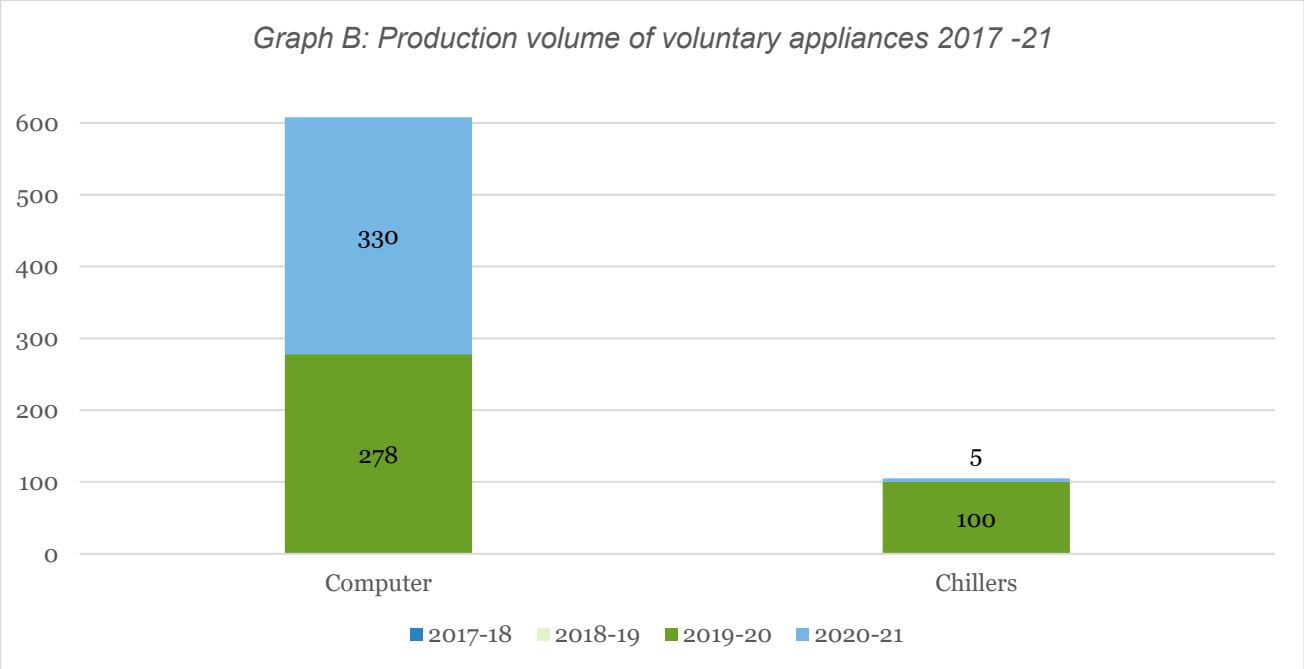
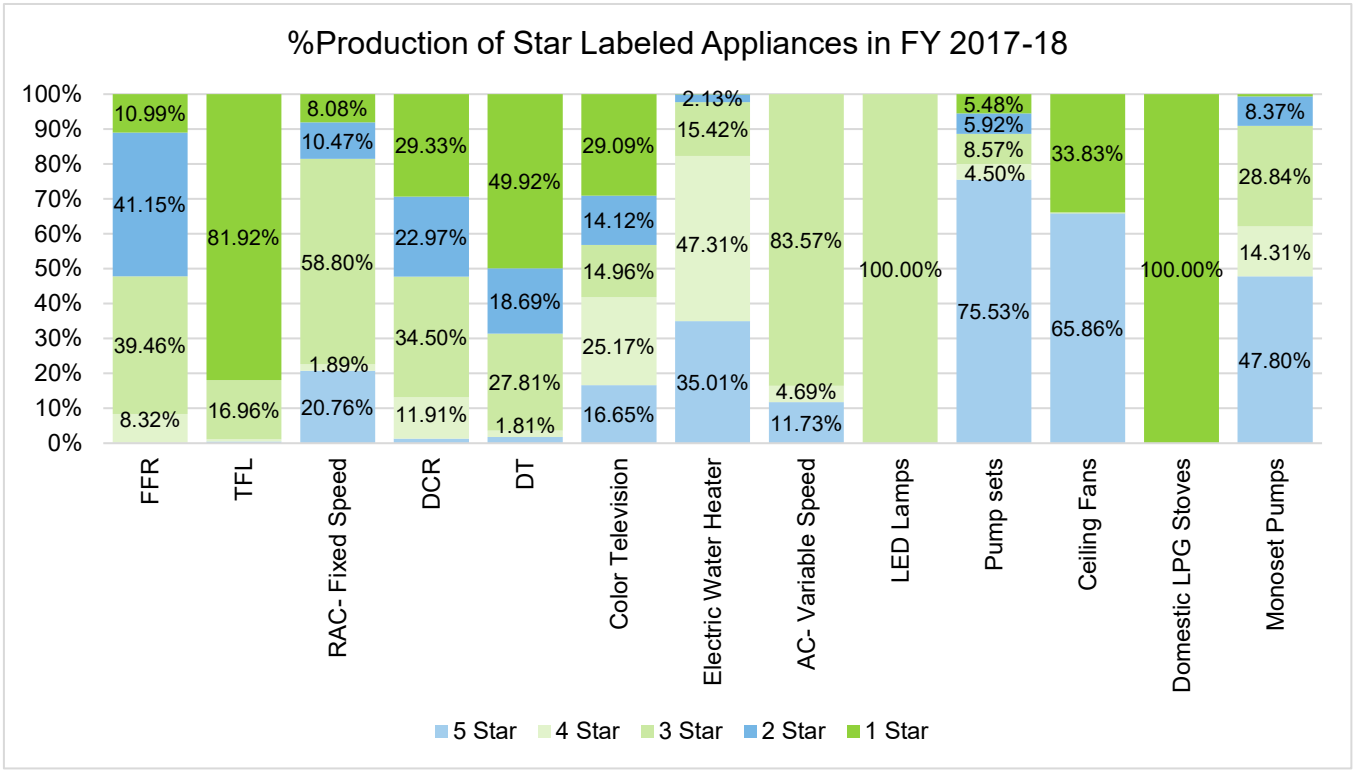


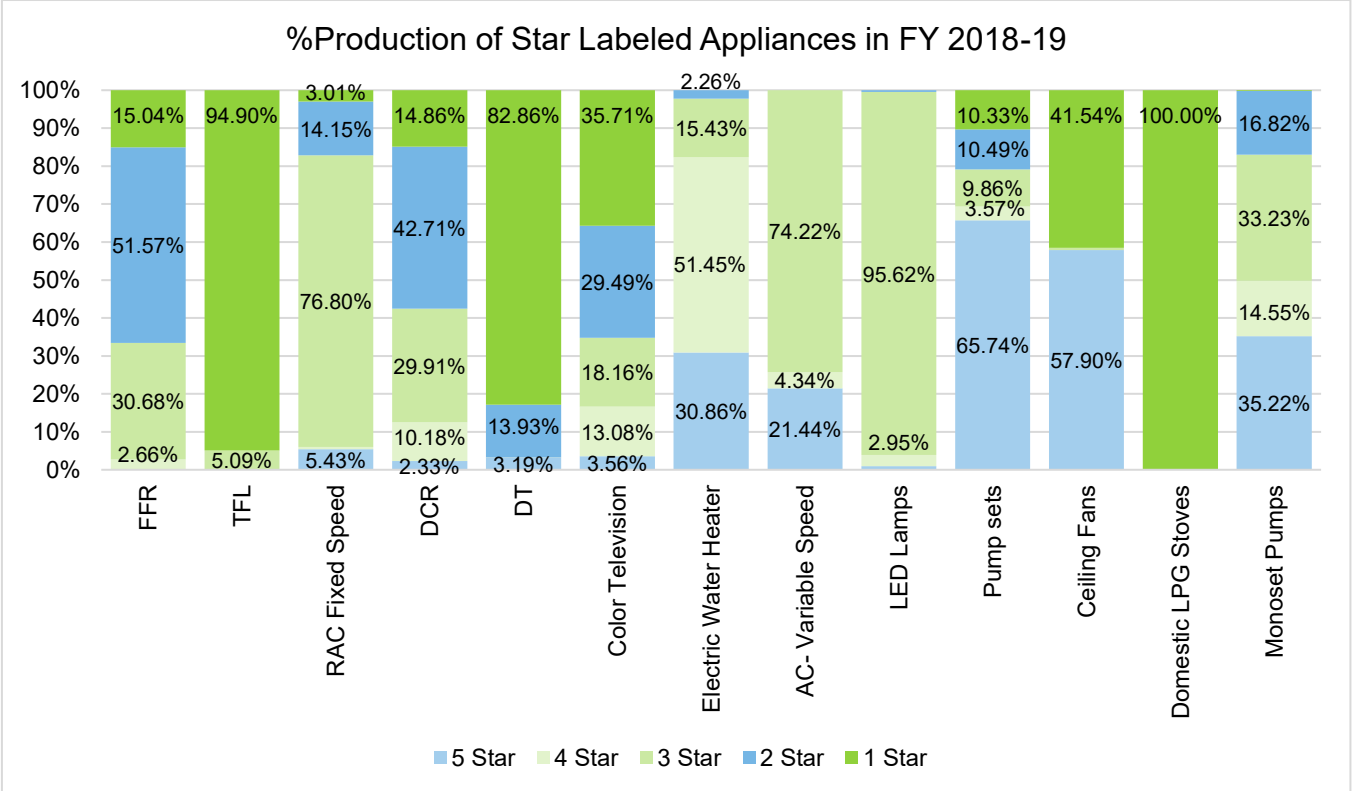
Figure 40: Production volume of voluntary appliances 2017 -21

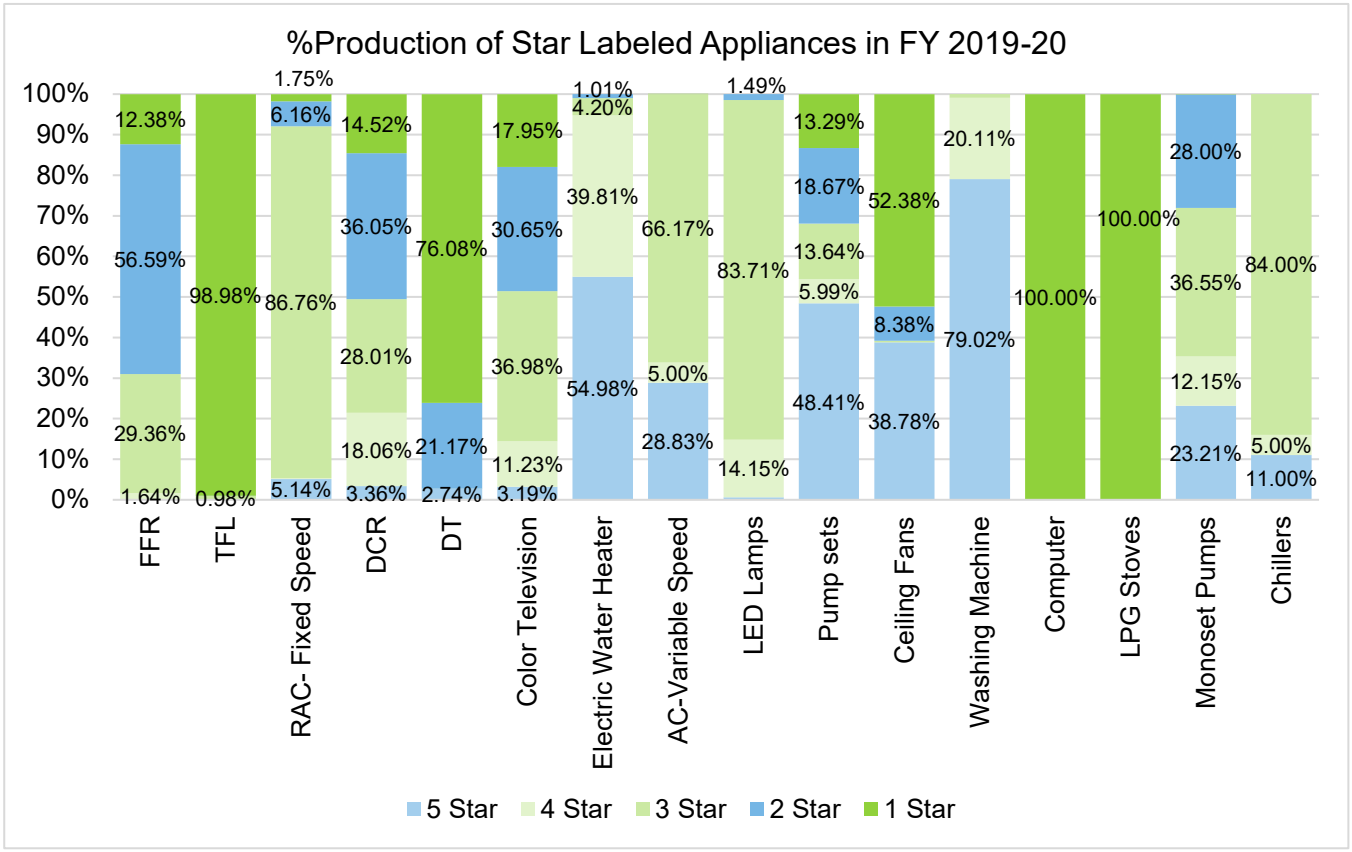
The findings from production volume of appliances showcased in Figure 40 and Figure 41 is listed below:

1. The production of LED lamps and Tubular Fluorescent Lamps were highest for the mandatory appliances
2. While, for voluntary appliances the production was highest for ceiling fans followed by washing machine and domestic LPG stoves for the FY 2017-21.

The consolidated year wise percentage production figures for mandatory and voluntary appliance (considered for the study) for each FY from 2017 to 2021 are showcased in the figures below:







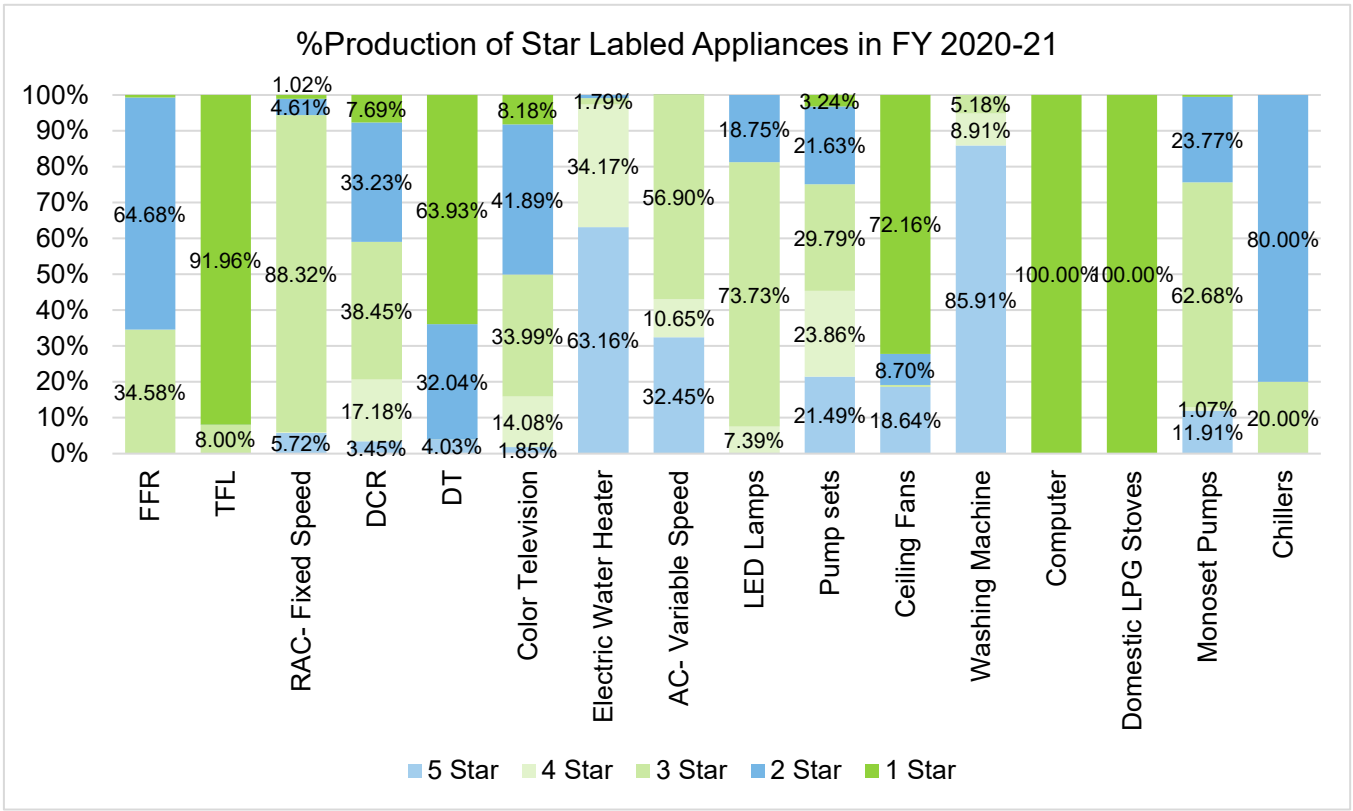


Figure 41: Production as % of total Production for different appliances for the FY 2017-21

It can be inferred from the above analysis that:

1. Maximum percentage of 5 star labeled appliances manufactured during FY 2017-21 are pump sets, followed by water heaters, air conditioners and washing machines.
2. Majority of LED lamps manufactured fall under 3-star label category
3. Majority of TFL lamps manufactured fall under 1 star label category.

5.3.2. Step-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 44.

Table 44: 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 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

S. No	Appliance Name	Label Details	Baseline Energy / Baseline standard
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
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

5.3.3. Step-3: Defining the operating hours

Energy saving for the appliances sold under FY 2017-21[51]

Energy saving (kWh/year) = [Annual Energy consumption by appliance as defined by baseline (kW) – Annual energy consumption of star rated appliance (kW)] * number of respective star labeled appliances produced during the FY 2017-21 * annual operational hours of the appliance as defined under the S&L program

Energy saving for the FY 2020-21 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

[51] 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

occurs in Q4 then appliance can only work for 25% of operation hours during that particular FY i.e. 375 hours.

Accordingly, the contribution of appliances to savings will vary proportionality. Details of the operation hours for the different appliance is defined in Table 45.

Table 45: Annual operation hours for appliance

S.No	Appliance	Annual operation hours [52]
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[53]	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

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 Table 46:

[52] https://beeindia.gov.in/content/standards-labeling

[53] 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

Table 46: Energy Savings in FY 20-21 from appliances manufactured during FY 2017-21 [54]

S.No	List of Appliances	FY: 2017-18 (MU)	FY: 2018-19 (MU)	FY: 2019-20 (MU)	FY 2020-21 (MU)	FY: 2017-21 (MU)
Mandatory Appliances						
1.	**Frost Free Refrigerator**	1967	2178	1558	1279	6982
2.	**TFL**	570	365	176	179	1290
3.	**Room Air Conditioner (Fixed Speed)**	3329	1794	1367	688	7178
4.	**Direct Cool Refrigerator**	4459	5072	3634	2374	15539
5.	**Distribution Transformer**	403	628	244	425	1700
6.	**Color Television**	3806	3749	2412	2023	11990
7.	**Stationary Type Water Heater**	472	563	437	380	1852
8.	**Room Air Conditioner (Variable Speed)**	1461	999	807	1092	4359
9.	**LED Lamps***	65	695	939	810	2509
	Voluntary Appliances					
10.	**Pump set (Submersible and open well)**	2347	3017	1505	480	7349
11.	**Ceiling Fan**	191	156	90	168	605
12.	**Washing Machine**	-	-	17	29	46
13.	**Computer**	-	-	-	0	0
14.	**Mono-set Pump**	46	50	28	18	142
15.	**Chiller**	-	-	1.18	4	6
Total Savings (BU)		**19.1**	**19.3**	**13.22**	**9.95**	**61.57**

The findings of estimated energy savings in FY 2020-21 when compared to previous FY 2019-20 from the above table is as below:

- The production of star-labeled appliances was adversely affected by the impact of COVID-19 pandemic. In lieu of the hardship faced by industrial manufacturing units during nationwide COVID-19 outbreak, the production numbers of star-labeled appliances went down from 601.43 million in FY 2019-20 to 556.81 million in the year 2020-21, with a percentage decrease of 7.42% as compared to last year's production numbers. Due to this, the electrical energy savings from the star labelled appliances went down from 13.22 BU in the year 2019-20 to 9.95 BU in the FY 2020-21. The same is showcased in the Table 47:

[54] Energy savings estimated for LED on account of sales of 197.03 Mn (12.03+185) LED are considered under UJALA programme for FY 2019-21. Saving from 493 Mn LED during 2019-20 and saving from 4.85 Mn LED during 2020-21 is considered under S&L programme. Total discounted saving for LED under S&L programme during 2017-21 is 635.82 MU considered in total. Similar approach is used for emission calculations

Table 47: Impact of COVID-19 on production and energy savings numbers in FY 2020-21

FY	Production figures (Millions)	Energy Savings (MU)	CO2 Emission (MntCO2)
2019-20	601.43	13.22	10.84
2020-21	556.81	9.95	7.86

It is clearly visible from the table above, that due to lower production of star appliances in the FY 20-21, the energy savings has dropped from 13.22 MU in FY 2019-20 to 9.95 MU in FY 2020-21 and corresponding CO2 emission savings has also gone down from 10.84 MntCO2 to 7.86 MntCO2 in the FY 2020-21.

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 48.

Table 48: Thermal Energy saving due to production of Domestic LPG stoves during 2017-21

Year	Q1	Q2	Q3	Q4	Total (toe)
2017-18	490	562	345	238	1635
2018-19	330	450	279	308	1367
2019-20	793	1453	487	145	2879
2020-21	1184	1879	1098	356	4517
Total (2017-21)	**2797**	**4344**	**2209**	**1047**	**10398**

S&L programme has led to saving of 61.57 BU and 10398 toe during 2020-21 due to interventions carried out during the FY 2017-21

The energy savings from each appliance considered in the study (both mandatory and voluntary), is showcased in the form of a pie chart in Figure 42.

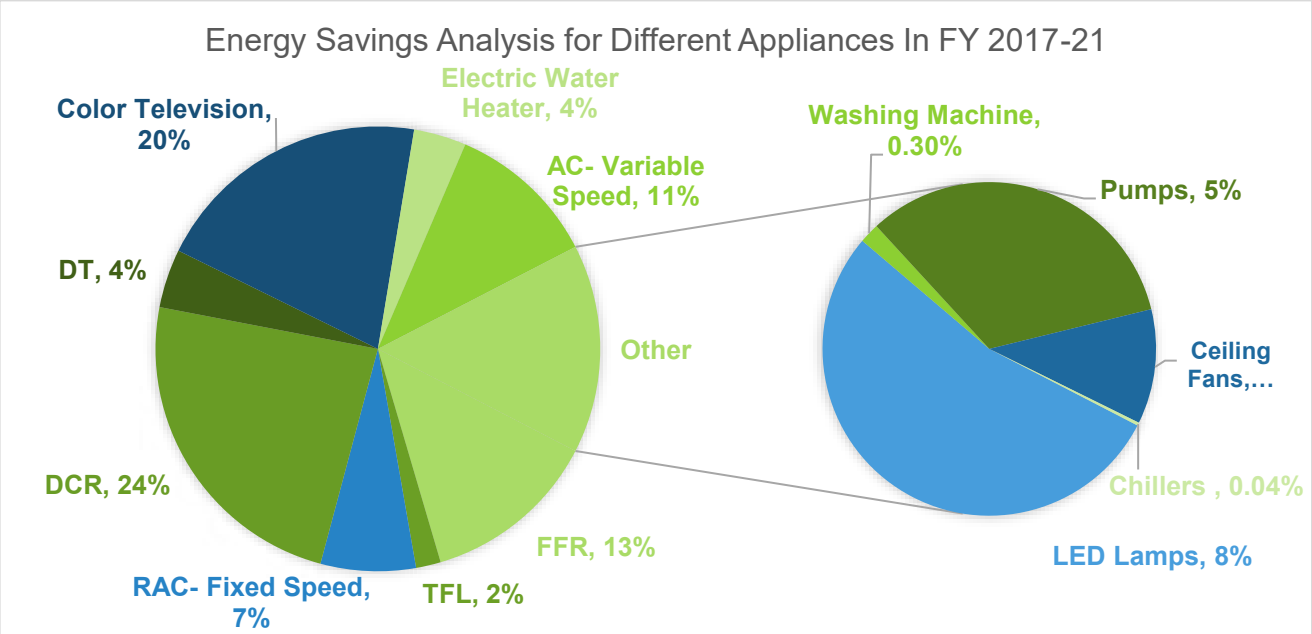


Figure 42: Energy savings analysis for different appliances in FY 2017-21 w.r.t data of Table 46 and Table 48

It can be inferred from the figure above that Direct Cool Refrigerator (25.30%) followed by Color Television (19.5%) and Room AC- fixed speed (11.7%), contributed to 55% of the total energy savings due to star rated appliances under S&L programme.

Summary of the emission reduction is tabulated in Table 49[55]

Table 49 : Annual Emission reduction (Mn tCO2) due to S&L programme

S.No	Appliances	FY: 2017-18 (MntCO2)	FY: 2018-19 (MntCO2)	FY: 2019-20 (MntCO2)	FY 2020-21 (MntCO2)	FY: 2017-21 (MntCO2)
Mandatory Appliances						
1.	Frost Free Refrigerator	1.61	1.79	1.28	1.01	**5.69**
2.	TFL	0.47	0.3	0.14	0.14	**1.05**
3.	Room Air Conditioner (Fixed Speed)	2.73	1.47	1.12	0.54	**5.86**
4.	Direct Cool Refrigerator	3.66	4.16	2.98	1.88	**12.68**
5.	Distribution Transformer	0.33	0.51	0.2	0.34	**1.38**
6.	Color Television	3.12	3.07	1.98	1.60	**9.77**
7.	Stationary Type Water Heater	0.39	0.46	0.36	0.30	**1.51**
8.	Room Air Conditioner (Variable Speed)	1.2	0.82	0.66	0.86	**3.54**
9.	LED Lamps*	0.05	0.57	0.77	0.64	**2.03**
Voluntary Appliances						
10.	Submersible Pump Set	1.93	2.47	1.23	0.38	**6.01**
11.	Ceiling Fan	0.16	0.13	0.07	0.13	**0.49**
12.	Washing Machine	-	-	0.01	0.02	**0.03**
13.	Computer	-	-	-	0.00	**0.00**
14.	Monoset Pump	0.04	0.04	0.02	0.01	**0.11**
15.	Chiller	-	-	0	0.00	**0.00**
Total Savings (MntCO2)		**15.68**	**15.8**	**10.84**	**7.86**	**50.16**

Total CO2 emission savings achieved by S&L program, as showcased in the Table 49, for the FY 2017-21:

S&L programme has led to reduction of 50.16 Mn tonne of carbon dioxide emissions during FY 2020-21 due to interventions carried out during the FY 2017-21

[55] Note: Emission reduction by the initiatives under the programme is evaluated considering the grid emission factor of 0.79 kg of CO2 emission reductions per kWh of the energy saved

Chapter 6: Lighting

6. *Lighting*

According to various research studies the contribution of lighting to the overall residential electricity use was estimated to be ~ 18-27%. In 2011, Indian households had an estimated one billion lighting points, wherein 46% points included CFLs, while 41% consists of tube lights. In addition, ~13% of the total lighting points comprised incandescent bulbs, with only 0.4% accounting for LED bulbs. Assuming a uniform annual use of 1,580 hours for each lighting point, it is estimated that the overall electricity consumption from all these lighting points to be ~27% of the total residential electricity consumption[56].

Although residential LEDs use ~75% less energy and last 25x longer than incandescent lighting, the high cost of LEDs poses a challenge to implement such energy-efficient lighting systems.

To enable this, the government launched the UJALA scheme in 2015, to make energy-efficient household lighting systems affordable for all. Under the scheme, the cost of the LED bulbs—that were distributed through the state-run EESL—was lowered to Rs. 65 in 2016 from Rs. 310 in 2013.

Moreover, to boost adoption of energy-efficient lighting methods/systems in the country, the government initiated numerous programmes such as DSM-based like Street Lighting National Program to replace traditional streetlight with LED streetlights.

Currently, under UJALA programme, EESL is prompting the energy efficiency through the LED bulbs, energy efficient LED tube lights and energy efficient fans. As on 31st March 2021, EESL distributed 3700 Lakh LED bulbs covering all 36 States and Union Territories (UTs.) This resulted into estimated energy savings of 4802.5 Lakh kWh per year with avoided peak demand of 9,615 MW and GHG emission reduction of 394 Lakh t CO2 per year[57].

Also, as on 31st March 2021, EESL distributed **73 lakh LED tube lights** resulting in estimated energy savings of **3200 Lakh kWh per year** with avoided peak demand of 146MW and GHG **emission reduction of 260,000 t CO2 per year**. EESL also distributed **25.92 lakh no.s** of BEE 5 Star rated energy efficient ceiling fans (50 Watt) which resulting into an estimated **energy savings of 2410 Lakh kWh per year** with avoided peak demand of 65 MW and GHG **emission reduction of 198,000 t CO2 per year**. [58]

The UJALA scheme works on a 'demand aggregation-price crash model', which involves lowering costs by using economies of scale.

[56] Source: https://www.pm-yojana.in/en/ujala-scheme
[57] Source: https://eeslindia.org/wp-content/uploads/2021/06/Annual%20Report%20(2020%20-%2021).pdf
[58] Source: https://eeslindia.org/wp-content/uploads/2021/06/Annual%20Report%20(2020%20-%2021).pdf

Under this model, EESL invited manufacturers to submit open bids for a large-scale LED lamp procurement and covered all upfront costs. Through state governments and DISCOMS, EESL established a value chain for the public distribution of these LED lamps under the UJALA programme. Due to this market aggregation, the retail prices of LED dramatically declined to as low as Rs. 65 in 2016.

Under the UJALA scheme, EESL provides two payment options to purchase LED bulbs. In the first alternative, consumers can choose to pay the whole cost upfront, and in the second choice, consumers can opt for the 'pay as you wish/on-bill financing' programme, wherein the program offered customers with the choice to pay initial cost of Rs. 10 per bulb and the remaining balance was recovered through a monthly electricity bill of Rs. 10 per month. The programme allows customers with an opportunity to buy up to eight LED bulbs on a single electricity bill.

6.1. Methodology for estimation of the saving

Methodology adopted for the energy saving for the UJALA programme is illustrated in Figure 43.

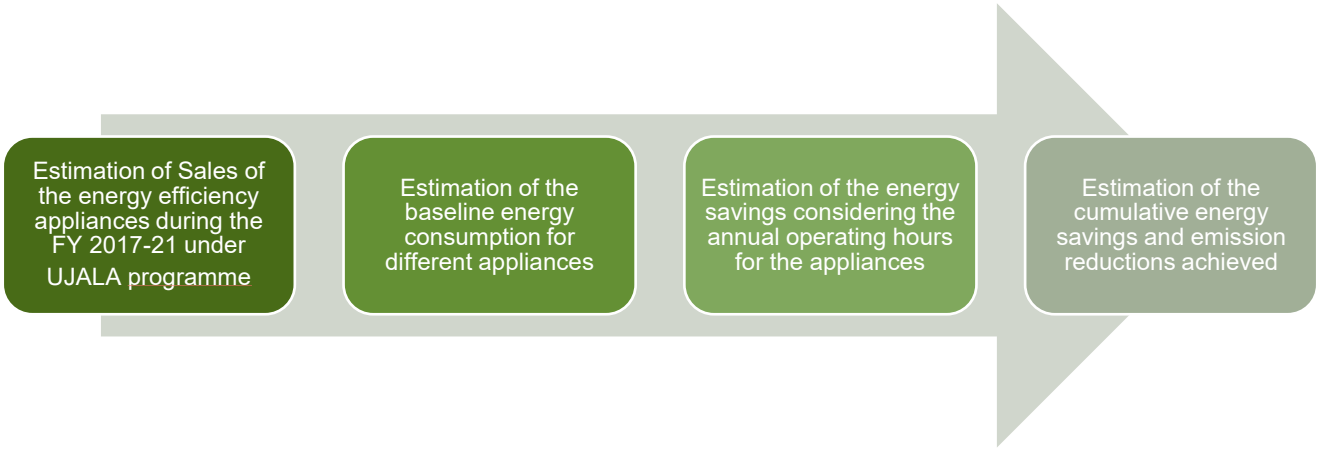


Figure 43: Methodology for estimation of Saving under UJALA scheme

Total number of different appliances retrofitted under UJALA programme is shown in Table 50.

Table 50: Sales of appliances under UJALA programme

Year	Number of units distributed (Million)		
	LED bulbs	LED Tube lights	EE Fans
2017-18	79.8	4.26	1.06
2018-19	58.2	1.52	0.57
2019-20	12.03	0.24	0.11
2020-21	4.98	0.10	0.04
Total	**155.01**	**6.12**	**1.78**

Punjab has the highest distribution of the LED bulbs under the UJALA programme, followed by Telangana.

Figure 44: LED Lamps distribution across different states

Baseline power consumption and power consumption of the energy efficient appliance replaced under the programme is tabulated in Table 51.

Table 51: Power saving estimation per appliance

Appliance	Base line wattage of appliance	Wattage of energy efficient appliance	Reduction in wattage
LED Lamp[59]	59	9	50
LED tube light	40	20	20
EE Fan[60]	75	50	25

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 52. Table 52: Number of LED bulbs distributed across different states

Table 52: Number of LED bulbs distributed across different states[61]

S. No.	States/UTs	No. of LED lamps distributed in Millions				Total No. (Millions) FY: 17-21	Energy saving (MU) FY 17-21
		FY 17-18	FY 18-19	FY 19-20	FY 20-21		
1.	Andaman & Nicobar Islands	0.00	0.01	0.00	-	0.0	1.28
2.	Andhra Pradesh	0.49	0.19	0.01	0.00	0.7	88.3
3.	Arunachal Pradesh	0.25	0.32	0.01	0.00	0.6	74.2
4.	Assam	0.74	4.95	0.10	0.01	5.8	741.5
5.	Bihar	6.16	1.41	0.20	0.05	7.8	999.3
6.	Chandigarh	0.36	0.11	0.01	-	0.5	65.2
7.	Chhattisgarh	3.98	0.98	0.13	0.15	5.2	669.0
8.	Dadra & Nagar Haveli	0.04	0.04	0.03	-	0.1	14.1
9.	Daman & Diu	0.01	0.04	0.02	-	0.1	10.2
10.	Delhi	1.58	0.45	0.25	-	2.3	293.8
11.	Goa	0.00	0.00	0.00	-	0.0	2.6
12.	Gujarat	9.09	1.31	0.37	0.22	11.0	1,404.4
13.	Haryana	4.70	0.84	0.08	0.02	5.6	720.2
14.	Himachal Pradesh	0.47	0.34	0.23	0.14	1.2	150.6
15.	Jammu & Kashmir	1.71	0.26	0.01	-	1.9	247.8
16.	Jharkhand	3.29	1.38	0.14	0.34	5.1	657.5
17.	Karnataka	4.20	2.75	1.21	0.62	8.8	1,121.2
18.	Kerala	5.02	0.33	0.14	0.03	5.5	705.1
19.	Madhya Pradesh	5.79	1.34	0.50	0.07	7.7	984.2
20.	Maharashtra	1.43	0.26	0.02	0.01	1.7	219.9
21.	Manipur	0.13	0.29	0.03	-	0.4	51.1
22.	Meghalaya	0.15	0.22	0.0	-	0.4	51.1

[59] 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
[60] EE fan is 5 star rated 50 W BEE fan
[61] Distribution split of fans and tube lights are not available for different years

S. No.	States/UTs	No. of LED lamps distributed in Millions				Total No. (Millions) FY: 17-21	Energy saving (MU) FY 17-21
		FY 17-18	FY 18-19	FY 19-20	FY 20-21		
23.	Mizoram	0.12	0.09	0.0	0.00	0.2	26.8
24.	Nagaland	0.66	0.25	0.05	-	1.0	127.8
25.	Odisha	6.10	32.33	7.02	-	45.4	5,802.4
26.	Puducherry	0.00	0.03	0.0	-	-	-
27.	Punjab	0.94	0.38	0.12	1.57	3.0	385.0
28.	Rajasthan	1.90	1.46	0.33	0.09	3.8	483.2
29.	Sikkim	0.03	0.04	0.0	0.00	0.1	9.1
30.	Tamil Nadu	1.93	1.84	0.42	0.15	4.3	554.2
31.	Telangana	0.63	0.28	0.01	1.26	2.2	278.7
32.	Tripura	0.23	0.29	0.01	0.02	0.5	69.7
33.	Uttar Pradesh	11.06	1.97	0.31	0.08	13.4	1,714.5
34.	Uttarakhand	0.98	0.63	0.23	0.06	1.9	242.8
35.	West Bengal	5.63	0.80	0.05	0.00	6.5	827.8
36.	**Total**	**79.80**	**58.21**	**12.04**	**4.89**	**154.7**	**19,794.6**

Table 53: Energy saving from UJALA programme[62]

Year	Energy savings (MU): LED lamps	Energy savings (MU): LED Tube lights	Energy savings (MU): EE Fans
FY 17-18	10,195	153	99
FY 18-19	7,436	57	55
FY 19-20	1,533	8.7	10
FY 20-21	630	4.5	4
Total	**19,794**	**223.2**	**168**

LEDs contribute to 98.68% of the total energy savings under the programme, and tube lights contribute 0.7% of the savings and EE fans contribute 0.7% of the savings. CO_2 emission reductions are calculated considering the grid emission factor as 0.79 kg/kWh. [63]

UJALA programme has led to energy savings of 25.42 BU *during 2020-21 on account of the implementations carried out during the FY 2017-21*

[62] Saving of the fans is considered under S&L programme

[63] https://cea.nic.in/wp-content/uploads/tpe___cc/2022/02/User_Guide__ver_17_2021.pdfhttp://www.cea.nic.in/reports/others/planning/pdm/growth_2018.pdf

Chapter 7: Municipality

7. *Municipality*

The growing demand for public utilities due to rising population and improved standards of living has increased the energy demand for the service provided by the urban local bodies. The Municipality sector consume electricity for various utility services like street lighting, water pumping, sewage treatment, and in various public buildings. Currently around 30% of Indian population lives in urban areas and continuous migration from rural areas is putting additional burden on the urban local bodies.

The energy requirement in ULBs is showcased in the Figure 45.

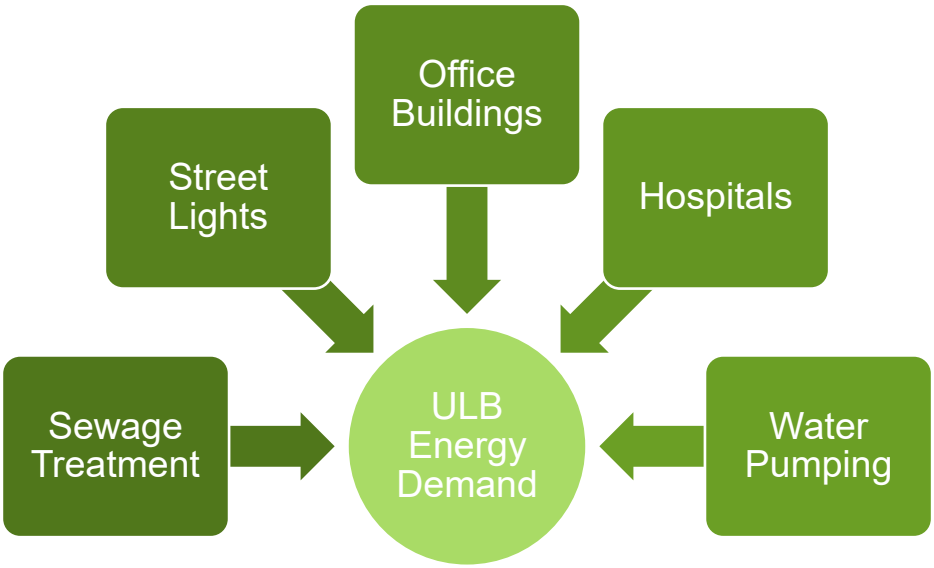


Figure 45: Energy Requirement in ULBs

The energy consumption of the municipality sector is characterized by frequent changes and rising peaks in power load curves in the morning hours due to water pumping and evening hours for street lighting. The inefficient use of electricity due to limited diffusion of energy efficiency technology and demand side management (DSM) initiatives, have considerably increased the energy consumption, thereby resulting in high operating costs of the municipalities.

The Municipal Demand Side Management (MuDSM) programme can improve the overall energy efficiency of the Urban Local Bodies (ULBs) which could lead to substantial savings in the electricity consumption, thereby resulting in cost reduction/savings for the ULBs.

Identifying the immense energy saving potential in municipal sector, BEE initiated Municipal Demand Side Management (MuDSM) during XI plan.

The objective of the programme is to improve energy efficiency in water pumping, sewage pumping, street lighting and public buildings across Urban Local Bodies (ULBs) in the country

Capacity building programmes for the officials of ULBs/UDDs/Municipalities/pump-technicians conducted by BEE:

Under MuDSM programme, capacity building workshops for the officials of Urban Local Bodies (ULBs), Public Water Bodies, Urban Development Directorates (UDDs), Municipal Corporations (MCs) and pump technicians were conducted by Bureau of Energy Efficiency in several states.

The details of such capacity building workshops conducted from the FY 2017-21 is given in Figure 46.

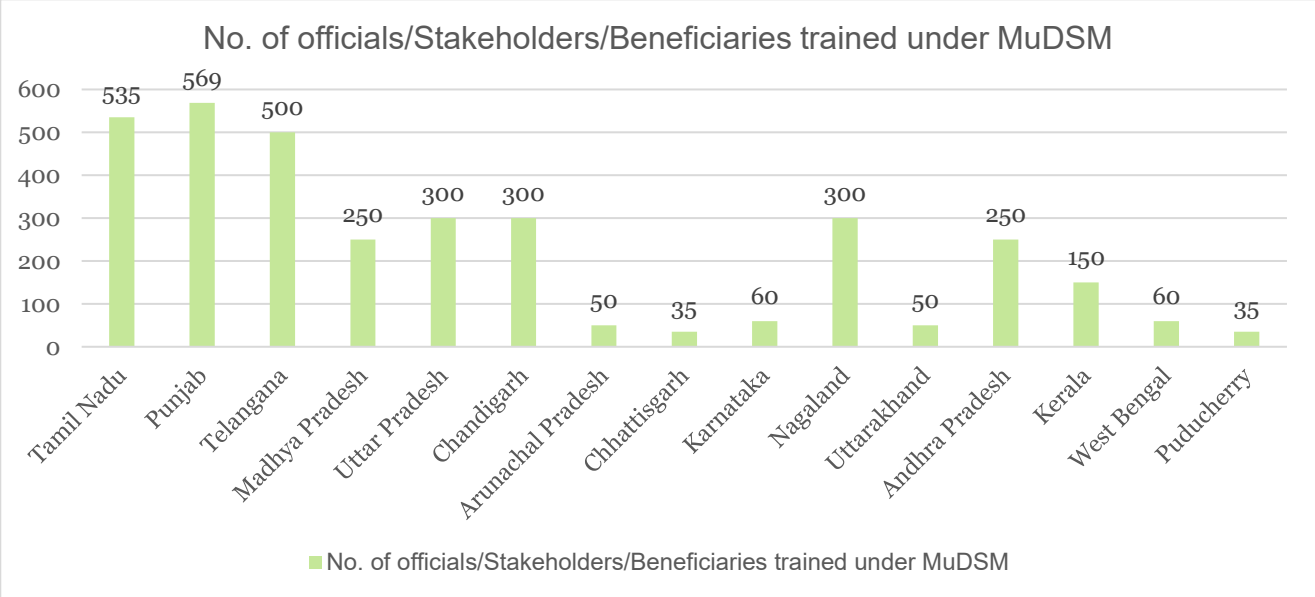


Figure 46: Capacity Building workshop conducted by BEE under MuDSM Programme

Various programmes operational under MuDSM by BEE and EESL to improve the energy efficiency across streetlighting pumping system is discussed in the section below:

7.1. Street Lighting National Programme

Traditionally, city street lighting in India has not been designed, operated, or maintained very efficiently. As a result, the energy consumption for city street lighting in India is very high. Efficient lighting technology was not a viable option in the past because it had to be imported and was expensive, but new energy efficient lighting equipment and good controls are now available in the Indian market.

Public lighting in India consumes 7,753 GWh of electrical energy and is expected to increase by 10% annually in coming years. Due to the inefficient design the energy saving potential in the public lighting is estimated to be 30% (2,326 GWh) of the total energy consumed by the public lighting system.

Keeping this in view, Street Lighting National Programme was launched by Hon'ble Prime

Minister, on 5th January 2015, to replace conventional streetlights with smart and energy efficient LED streetlights across India.

Under SLNP programme, EESL replaces the conventional streetlights with LEDs with no upfront investment from the ULBs, Instead the reduction in energy and maintenance cost of the municipality is used to repay EESL over a period. Usually, the contact duration between EESL and municipalities is of 7 years, where it not only guarantees a minimum energy saving (of-typically 50%) but also provides free replacements and maintenance of lights at no additional cost to the municipality.

Over 96.36 lakh LED street lights have been installed during the FY 2017-21 across India

LED streetlights installed by EESL under the programme are equipped with Central Control and Monitoring System (CCMS), which allows remote monitoring and operation. This ensures that streetlights are automatically switched on after sunset and switched off after dawn. This promotes energy savings by optimal control of lights. The system also sends alerts for each light that needs attention, to reduce failure and the need for sudden repairs.

7.2. Methodology for energy saving estimations

Energy savings due to number of inefficient streetlights that have been replaced by LED streetlights during FY 2017-21, are calculated. To calculate the energy (electrical) savings and emission reduction, following steps are used:

7.2.1. Step-1: Identification of the lights installed during the FY 2016-20

Total number of lights installed during the FY17 -21 are presented in Table 54.

Table 54: State wise installations of LED streetlights[64]

S. No.	States/UTs	No. of LED streetlights installed during FY 2017-21				Total Number of LED lights installed (Lakhs)
		2017-18	2018-19	2019-20	2020-21	2017-21
1	Andaman & Nicobar Islands	13,364	136	1,237	258	**0.15**
2	Andhra Pradesh	436,616	1,505,402	357,639	970	**23.01**
3	Assam	15,691	2,757	17,086	-	**0.36**
4	Bihar	16,450	176,471	250,920	105,866	**5.50**
5	Chandigarh	41,394	548	1,534	1,995	**0.45**
6	Chhattisgarh	254,566	82,136	58,606	-	**3.95**
7	Delhi	41,839	250	26,078	17,400	**0.86**
8	Goa	122,874	0	2,866		**1.26**
9	Gujarat	708,680	35,632	5,081	230	**7.50**
10	Haryana	11,226	52,596	16,340	4,515	**0.85**
11	Himachal Pradesh	32,864	515	3,789	3,318	**0.40**

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

S. No.	States/UTs	No. of LED streetlights installed during FY 2017-21				Total Number of LED lights installed (Lakhs)
		2017-18	2018-19	2019-20	2020-21	2017-21
12	Jammu & Kashmir	11,291	0	74,728	18,896	**1.05**
13	Jharkhand	88,386	1,380	389,493	31,692	**5.11**
14	Karnataka	9,592	290	2,428	-	**0.12**
15	Kerala	1,535	30,032	46,768	161,639	**2.40**
16	Lakshadweep	0	0	1,000	-	**0.01**
17	Madhya Pradesh	49,710	22,518	35,567	33,730	**1.42**
18	Maharashtra	37,428	326,110	420,956	105,613	**8.90**
19	Odisha	49,349	254,397	29,601	4,657	**3.38**
20	Puducherry	100	50	0		**0.00**
21	Punjab	21,380	52,866	29,288	7,056	**1.11**
22	Rajasthan	229,478	79,712	68,827	3,642	**3.82**
23	Sikkim	868	0	0	-	**0.01**
24	Tamil Nadu	6,689	0	1,010	-	**0.08**
25	Telangana	763,772	49,926	161,403	196,942	**11.72**
26	Tripura	30,028	1,559	375	625	**0.33**
27	Uttar Pradesh	474,378	323,644	204,178	113,868	**11.16**
28	Uttarakhand	26,164	8,715	12,304	16,561	**0.64**
29	West Bengal	14,971	5,568	59,690	3,400	**0.84**
Total (Lakhs)		**35.10**	**30.13**	**22.78**	**8.32**	**96.36**

7.2.2. Step-2: Estimation of the energy saving

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 Table 55 and Table 56.

Table 55 Energy savings 2017-21 from Street-Lighting programme:

Sr. No.	FY	Number of Installations	Number of States	Annual energy savings in BU
1.	2017-18	3,510,683	28	2.356
2.	2018-19	3,013,210	24	2.022
3.	2019-20	2,278,792	27	1.529
4.	2020-21	832,873	21	0.559
	Total	**9,635,558**		**6.466**

7.2.3. Step-3: Estimation of the emission reduction [65]

Table 56: Energy saving and emission reduction from SLNP programme (state wise)

S.No.	States/UTs	No. of LED streetlights installed in FY 2017-21	Energy Savings in FY 2017-21 (MU)	Emission reduction (MntCO2)
1	Andaman & Nicobar Islands	14,995	10.071	0.01
2	Andhra Pradesh	2,300,627	1,545.197	1.06
3	Assam	35,534	23.866	0.02
4	Bihar	549,707	369.206	0.25
5	Chandigarh	45,471	30.540	0.02
6	Chhattisgarh	395,308	265.505	0.18
7	Delhi	85,567	57.470	0.04
8	Goa	125,740	84.452	0.06
9	Gujarat	749,623	503.478	0.35
10	Haryana	84,677	56.873	0.04
11	Himachal Pradesh	40,486	27.192	0.02
12	Jammu & Kashmir	104,915	70.465	0.05
13	Jharkhand	510,951	343.176	0.24
14	Karnataka	12,310	8.268	0.01
15	Kerala	239,974	161.177	0.11
16	Lakshadweep	1,000	0.672	0.00
17	Madhya Pradesh	141,525	95.054	0.07
18	Maharashtra	890,107	597.833	0.41
19	Odisha	338,004	227.018	0.16
20	Puducherry	150	0.101	0.00
21	Punjab	110,590	74.277	0.05
22	Rajasthan	381,659	256.338	0.18
23	Sikkim	868	0.583	0.00
24	Tamil Nadu	7,699	5.171	0.00
25	Telangana	1,172,043	787.193	0.54
26	Tripura	32,587	21.887	0.02
27	Uttar Pradesh	1,116,068	749.598	0.52
28	Uttarakhand	63,744	42.813	0.03
29	West Bengal	83,629	56.169	0.04
	Total	**10,195,272**	**6,471.643**	**4.46**

SLNP programme has led to energy savings of 6.47 billion units and reduction of 4.46 Million tonnes of CO_2 emissions during FY 2020-21 on account of the implementations

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

7.3. Municipal Energy Efficiency Programme (MEEP)

MEEP is being implemented in conjunction with Atal Mission for Rejuvenation and Urban Transformation (AMRUT) to unlock India's immense potential for savings in energy, and cost of water supply by retrofitting Energy Efficient pump sets across 500 AMRUT cities. As on 31st March 2020 agreement with 390 ULB in 22 states and 3 union territories have been completed. Investment grade energy audit (IGEA) are being conducted across the different ULB's. EESL will carry out the upgradation of the pumping system including efficient pumps matched with system requirements, essential valves in the pipelines and improved electrical system for operation of the pump sets. EESL will also help the ULBs to build the CCMS based central controlling and monitoring station as per the requirement of the ULB. EESL will carry out the energy efficiency measures at no upfront cost to the municipal bodies and recover investment from savings in energy costs from the ULBs. By aggregating the demand of ULBs and leveraging the economies of scale, EESL will bring down the cost of the energy efficient pumps, making them financially attractive. Along with installation, EESL will also provide 7 years of repair and maintenance as well provide managerial, technical and turnkey project implementation support. EESL maintains the dashboard where the detailed status of the programme is made online for the public: https://meep.eeslindia.org/dashboard/.

Over 250 ULB's have been audited during FY 2017-21 and discussions are being held with ULBs for implementation.

Chapter 8: Transport

8. *Transport*

Transport is a critical infrastructure for the economic development of a country. It impacts the pace, structure and pattern of development. Increased economic activity in past decade has leads to growing income per capita; as standards of living rise and the demand for personal transportation increases, from a non-motorized mobility to a motorized has seen multifold rise in past decade in India. The Road Transport Sector accounts for about 87% of passenger traffic and 60% of freight traffic movement in the country[66]. Easy availability, adaptability to individual needs and the cost savings are some of the factors which go in favour of road transport. Road transport also acts as a feeder service to railway, shipping and air traffic.

With increasing demand for motorized transport, consumption of petroleum products has experienced steady growth over time. From the consumption of 148.13 MTs during 2011-12 to 214.13 MTS during 2019-20 i.e., a growth of 45% over a span of 9 years. However, during FY 2020-21 the same has been decreased by 9.26% and stood at 194.30 MTs mainly because of COVID-19 pandemic.

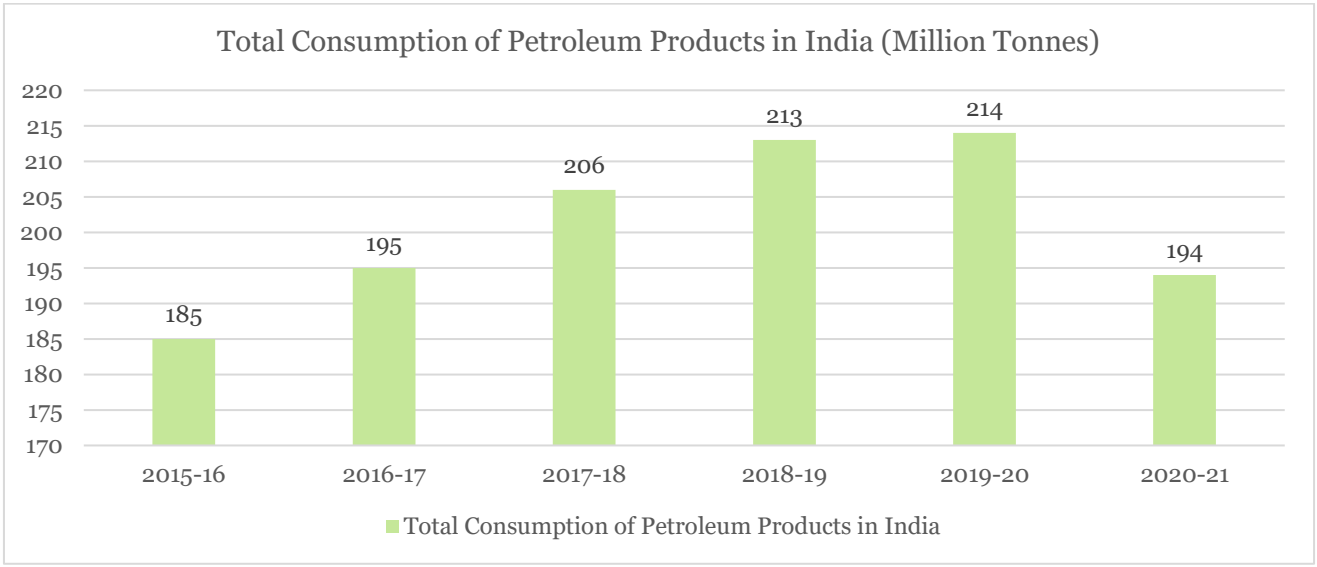


Figure 47: Total Consumption of Petroleum Products in India

Among all the products the High-Speed Diesel Oil (HSDO) accounted for 37.42% of total consumption. This was followed by Petrol (14.40%), LPG (14.18%), Pet Coke (8.03%). The consumption of various types of petroleum products is depicted in Figure 48.

[66] Source: Ministry of Road Transport and Highways

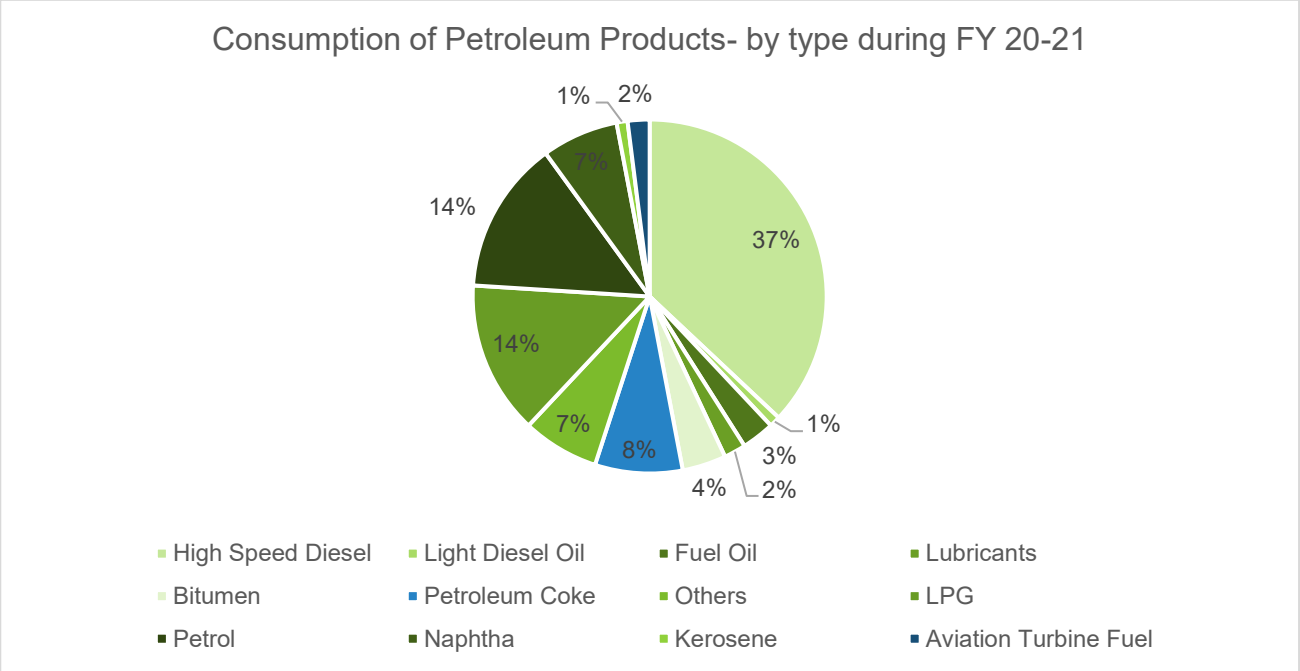


Figure 48: Consumption of Petroleum Products- by type during FY 2020-21

With the view the growing demand of fossil fuel and rapidly growing motor vehicle fleet in India, Government of India set a target to reduce 10% reduction on import by 2022.

The Indian automotive industry produces a wide variety of vehicles: passenger cars, light, medium and heavy commercial vehicles, multi-utility vehicles such as jeeps, two wheelers that include scooters, motorcycles and mopeds, three-wheelers, tractors and other agricultural equipment. The automobile sector of India is showcased in Figure 49.

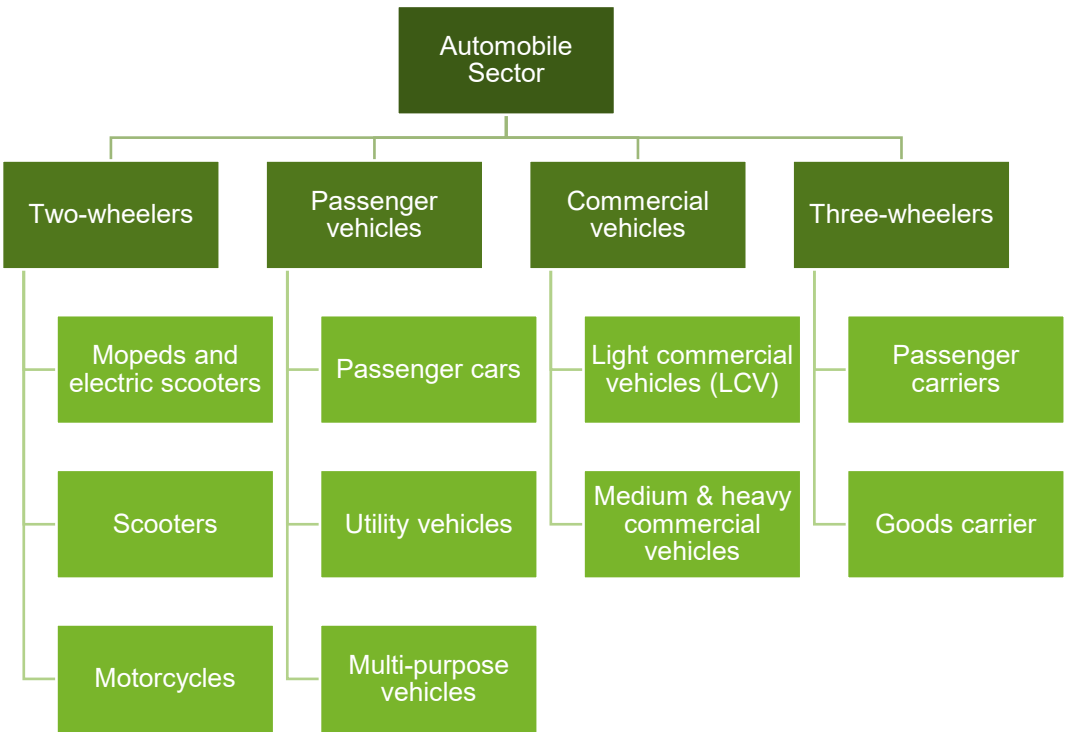


Figure 49:Overview of Indian Automobile Sector

Two wheelers and passenger vehicles dominate the domestic Indian auto market. Passenger car sales are mainly dominated by small and mid-sized cars in India. Sales of Automobiles has decreased to 18.61 Mn during FY 2020-21 from 21.55 Mn in FY 2019-20. The market share by vehicle type and the total vehicle sale in India between FY17-FY 21 is presented in the Figure 50.[67]

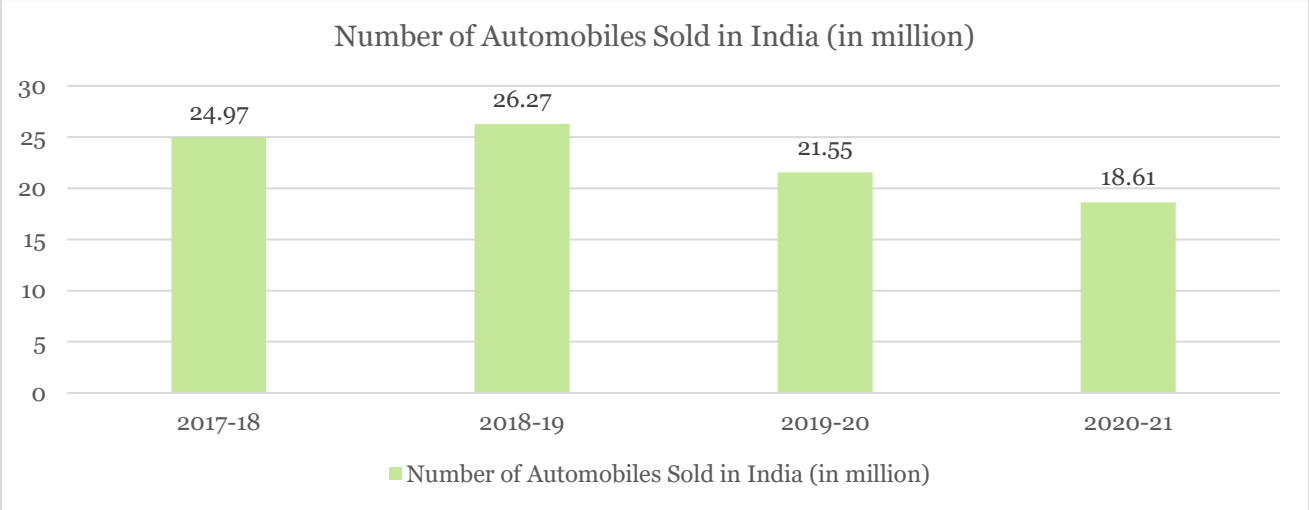


Figure 50 : Sales of Automobiles

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 81.2% and 14 .6% market shares, respectively, accounting for a combined sales of over 17.8 million vehicles in FY 20-21[68].

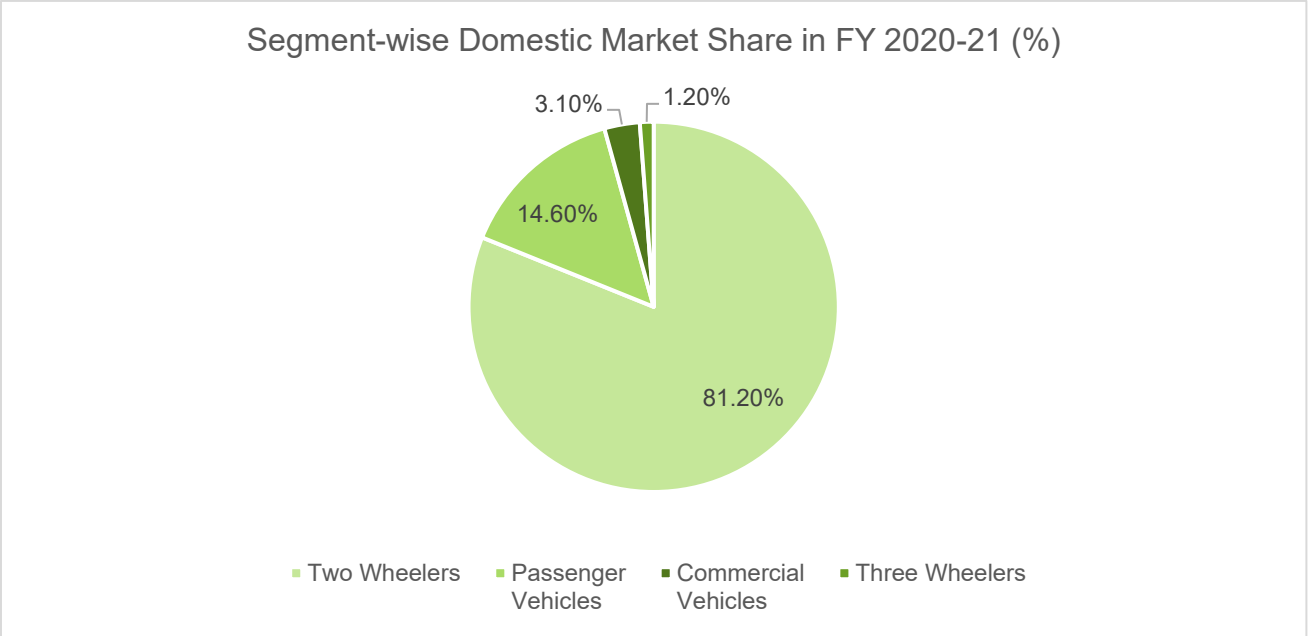


Figure 51 : Segment wise % sales of Automobiles

[67]Source: https://www.ibef.org/download/Automobile-September-2021.pdf
[68] Source: IBEF

The automotive industry is one of the largest industries globally and has deep forward and backward linkages with the rest of the industries. It has a strong multiplier effect and is one of the major drivers of economic growth. With the gradual liberalization of the automotive sector in India since 1991, the number of manufacturing facilities has grown progressively.

The automotive manufacturing industry comprises the production of commercial vehicles, passenger cars, three & two-wheelers. Domestic automobile production increased at 2.36% CAGR[69] between FY17-FY21, however in the FY 2020-21, due to COVID- 19 pandemic, only 22.65 million vehicles were manufactured in the country in FY 2020-21. The Indian auto industry is expected to record strong growth FY 2021-22, post recovering from effects of pandemic. The trend of automobile production in India is shown in the Figure 52[70].

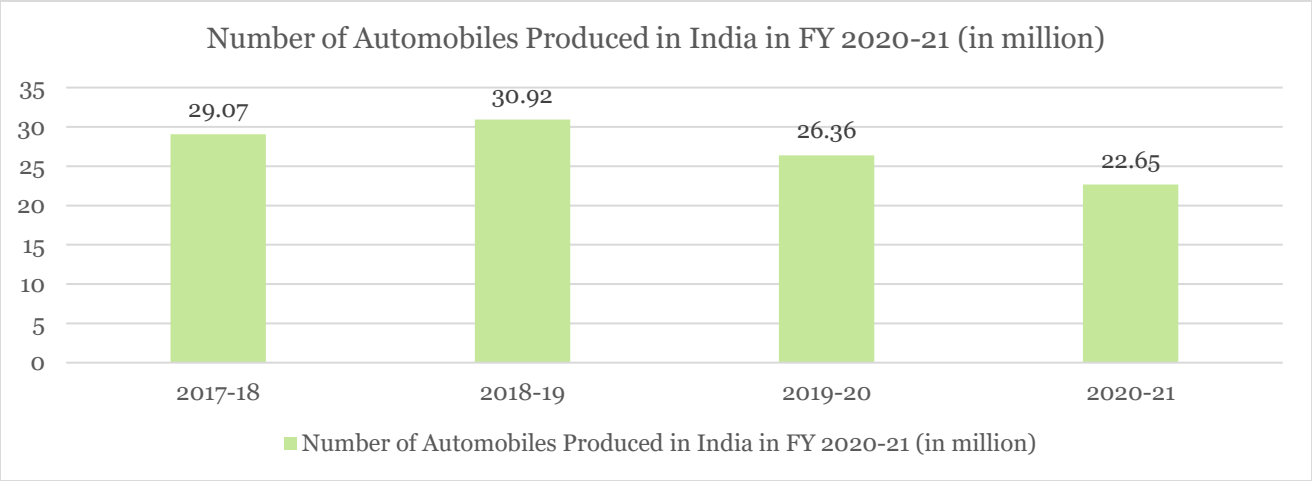


Figure 52: Production details of Automobiles

Overall, automobile export reached 4.13 million vehicles in FY21, while the number was 4.77 million during the last FY19-20. The reduction in exports number was mainly due to impact of COVID-19. Two wheelers made up 73.9% of the vehicles exported, followed by passenger vehicles at 14.2%, three wheelers at 10.5% and commercial vehicles at 1.3%.

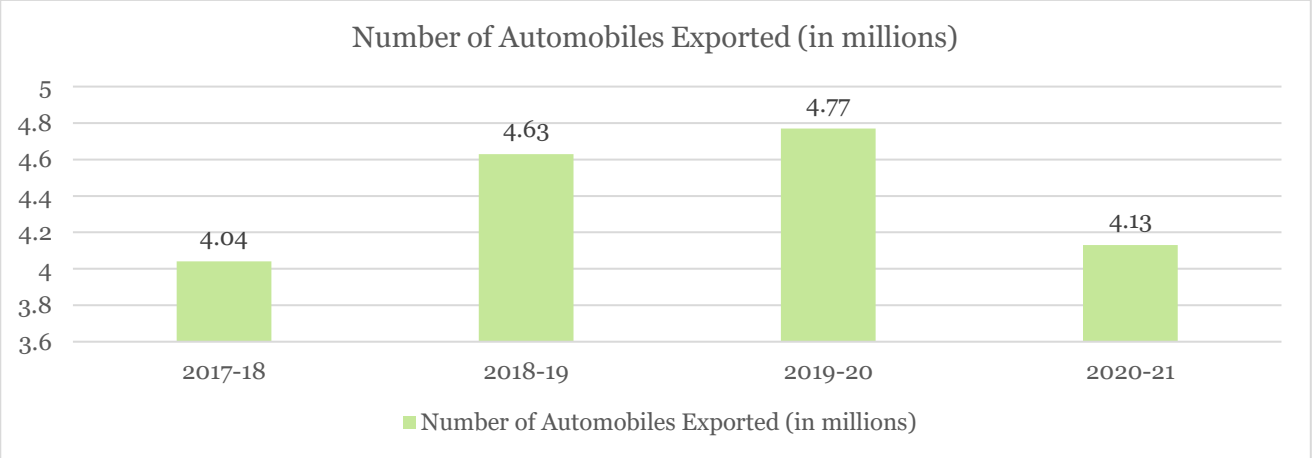


Figure 53: Number of Automobiles Exported in FY17-21

[69] Source: https://www.ibef.org/industry/automobiles-presentation
[70] Source: https://www.ibef.org/download/Automobile-September-2021.pdf

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.

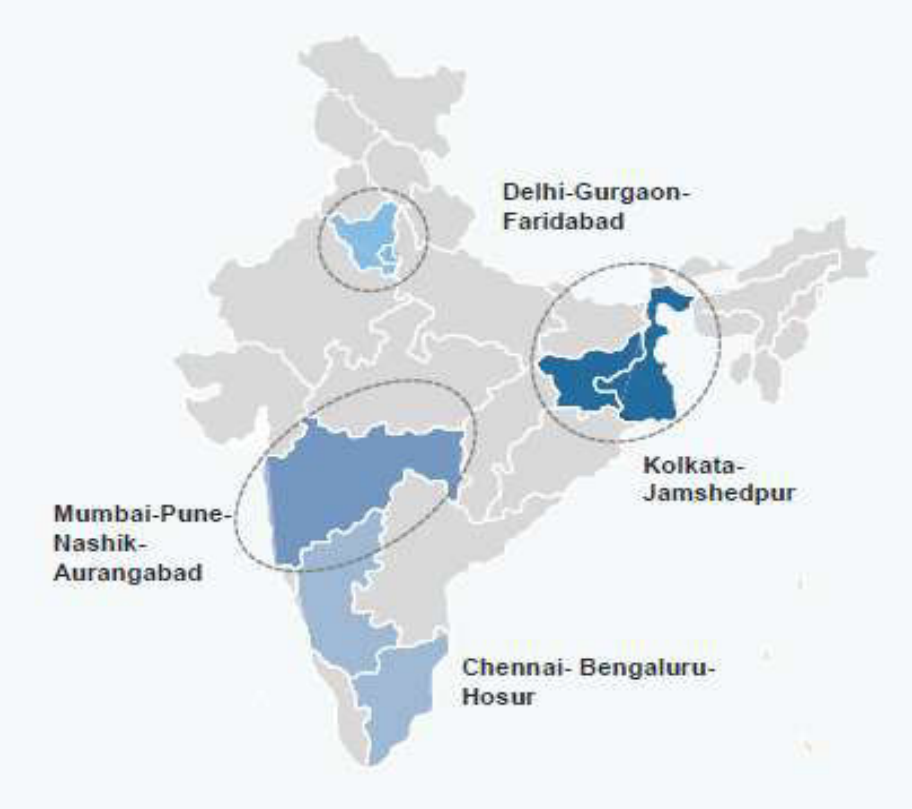


Figure 54: Major automobile manufacturing clusters in India

Table 57: Cluster wise leading companies[71]

	List of companies
North	Ashok Leyland, Force Motors, Piaggio, Swaraj Mazda, Amtek Auto, Eicher, Honda SIEL Maruti Suzuki, Tata Motors, Bajaj Auto, Hero Group, Escorts, ICML, JCB, Yamaha, Mahindra, Suzuki Motorcycles
West	Ashok Leyland, Bajaj Auto, FIAT, GM, M&M, Eicher, Skoda, Bharat Forge, Tata Motors, Volkswagen, Renault Nissan, John Deere
East	Tata Motors, Hindustan Motors, Simpson & Co, International Auto Forgings, JMT, Exide
South	Ashok Leyland, Ford, M&M, Toyota Kirloskar, Volvo, Sundaram Fasteners, Enfield, Hyundai, BMW, Bosch, TVS Motor Company, Renault Nissan, TAFE, Daimler, Caterpillar, Hindustan Motors

[71] Source: https://www.ibef.org/download/Automobile-September-2021.pdf

8.1. Vehicular pollution in India

Air pollution is one of the serious environmental concerns of the urban cities where majority of the population is exposed to poor air quality. The rapid urbanization in India has resulted in a tremendous increase in the number of motor vehicles, as showcased in the above section. As the number of vehicles continues to grow and the consequent congestion increases, vehicles are now becoming the main source of air pollution in urban India.

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, carbon monoxide (CO), nitrogen oxides (NOx), photochemical oxidants, air toxics, namely benzene (C6H6), aldehydes, 1,3 butadiene (C4H6), lead (Pb), particulate matter (PM), hydrocarbon (HC), oxides of sulphur (SO2) and polycyclic aromatic hydrocarbons (PAHs). 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.[72]

The vehicular emissions have damaging effects on both human health and ecology. There is a wide range of adverse health/environmental effects of the pollutants released from vehicles. The effects may be direct as well as in-direct covering right from reduced visibility to cancers and death in some cases of acute exposure to pollutants, especially carbon monoxide. These pollutants are believed to directly affect the respiratory and cardiovascular systems. In particular, high levels of Sulphur Dioxide and Suspended Particulate Matters are associated with increased mortality, morbidity and impaired pulmonary function.

As stated above, air pollution from motor vehicles is one of the most serious and rapidly growing problems in urban centers of India. The problem of air pollution has assumed serious proportions in some of the major metropolitan cities of India and vehicular emissions have

[72] Source: Status of the Vehicular Pollution Control Programme in India, CPCB

been identified as one of the major contributors in the deteriorating air quality in these urban centers. The problem has further been compounded by the concentration of large number of vehicles and comparatively high motor vehicles to population ratios in these cities. Reasons for increasing vehicular pollution problems in urban India are as below:

- High vehicle density in Indian urban centers
- Older vehicles predominant in vehicle vintage
- Predominance of private vehicles especially cars and two wheelers
- Absence of adequate land use planning in development of urban areas, thereby causing more vehicle travel and fuel consumption
- Inadequate inspection & maintenance facilities
- Adulteration of fuel & fuel products
- Absence of effective mass rapid transport system & intra-city railway networks
- High population exodus to the urban centers
- Increasing number skyrocketing buildings in the urban areas causes stagnation of the vehicular emissions to the ground level and preventing its proper dispersion.

However, the country has taken several measures for the improvement of the air quality in cities. These include, promoting electric mobility, improvement in fuel quality, formulation of necessary legislation and enforcement of vehicle emission standards, improved traffic planning and management etc. The non-technical measures taken include, awareness raising regarding the possible economic and health impacts of air pollution and available measures for improving air quality, increasing use of cleaner fuels and purchase of vehicles with advance emission control devices, increasing institutional framework and capacity building for the monitoring of vehicle emissions.

This section covers the fuel savings as well as the emission savings from CAFE norms that have been notified in India since 1st April 2017 and electric vehicles sold under the implementation of the FAME India scheme by the Department of Heavy Industries. A brief description of the energy saving initiatives under Railways in India is also mentioned in the section.

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

The Government of India, Ministry of Power, issued average fuel consumption standards for cars on 23rdApril 2015.This standard is applicable for the motor vehicle using petrol or diesel or liquefied petroleum gas or compressed natural gas, which carry passengers and their luggage and comprising not more than nine seats including driver's seat, and of Gross Vehicle Weight not exceeding 3,500 kilograms tested.

The fuel consumption standards would be effective from 2017-18 onwards, and a second set of standards would come into force from 2022-23. The standards relate the Corporate Average

Fuel Consumption (in liters/100 km) to the Corporate Average Curb Weight of all the cars sold by a manufacturer in a fiscal year.

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.

8.2.1. Methodology to calculate savings under CAFE norms

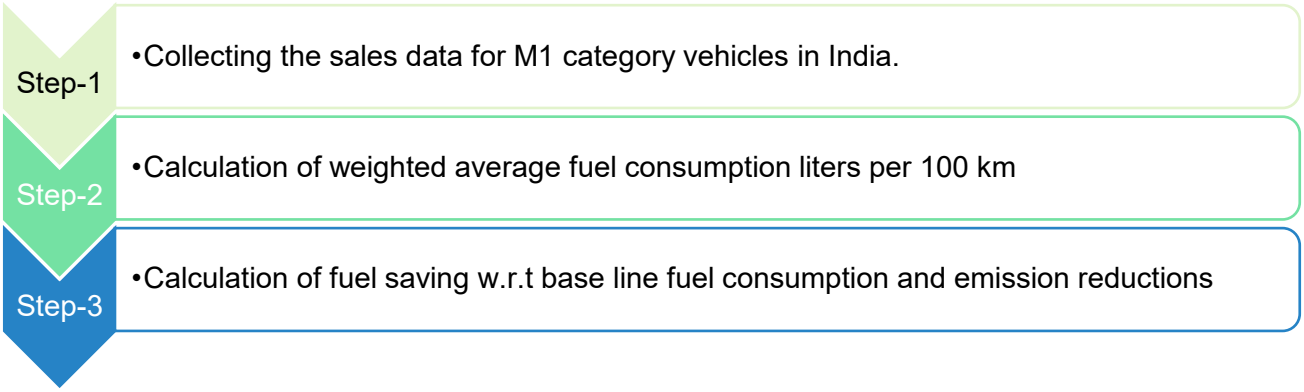


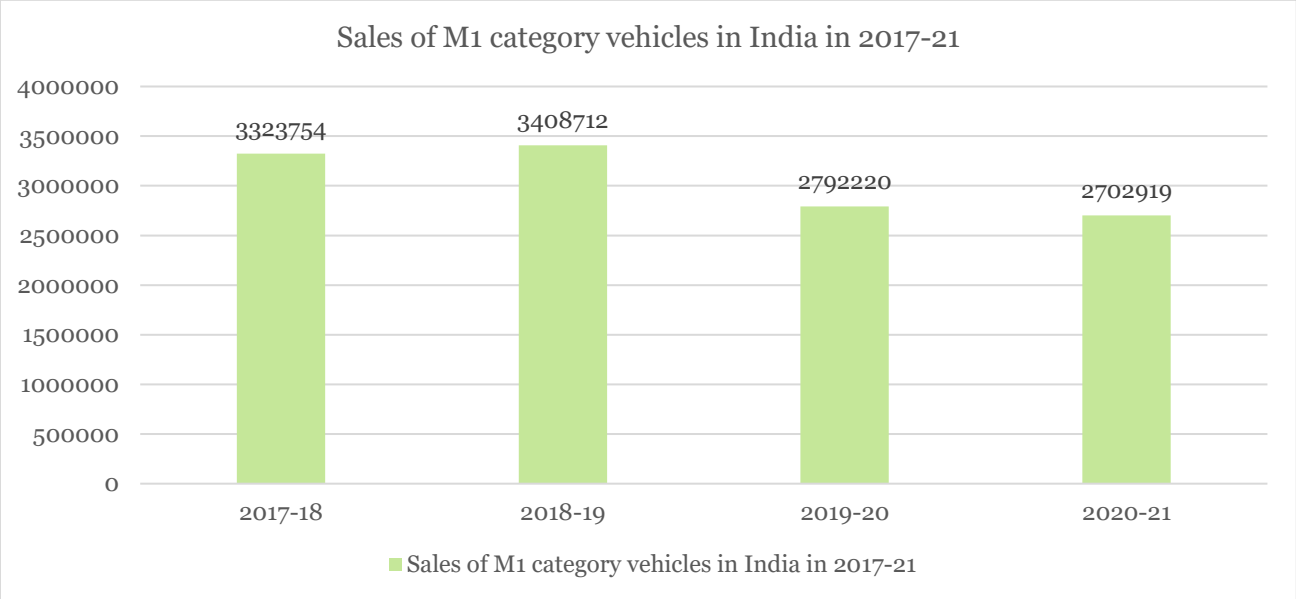
Figure 55 : Methodology for saving calculation under CAFE norms

8.2.2. Energy and emission saving calculations

Sales data for M1 vehicle category was received from ICAT and is presented in Table 58 and Figure 56 (including petrol, diesel, CNG, EVs including includes pure electric, plug in hybrid and strong hybrid models):

Table 58: Sales of M1 category vehicles in India in 2017-21

2017-18	2018-19	2019-20	2020-21
3323754	3408712	2792220	2702919



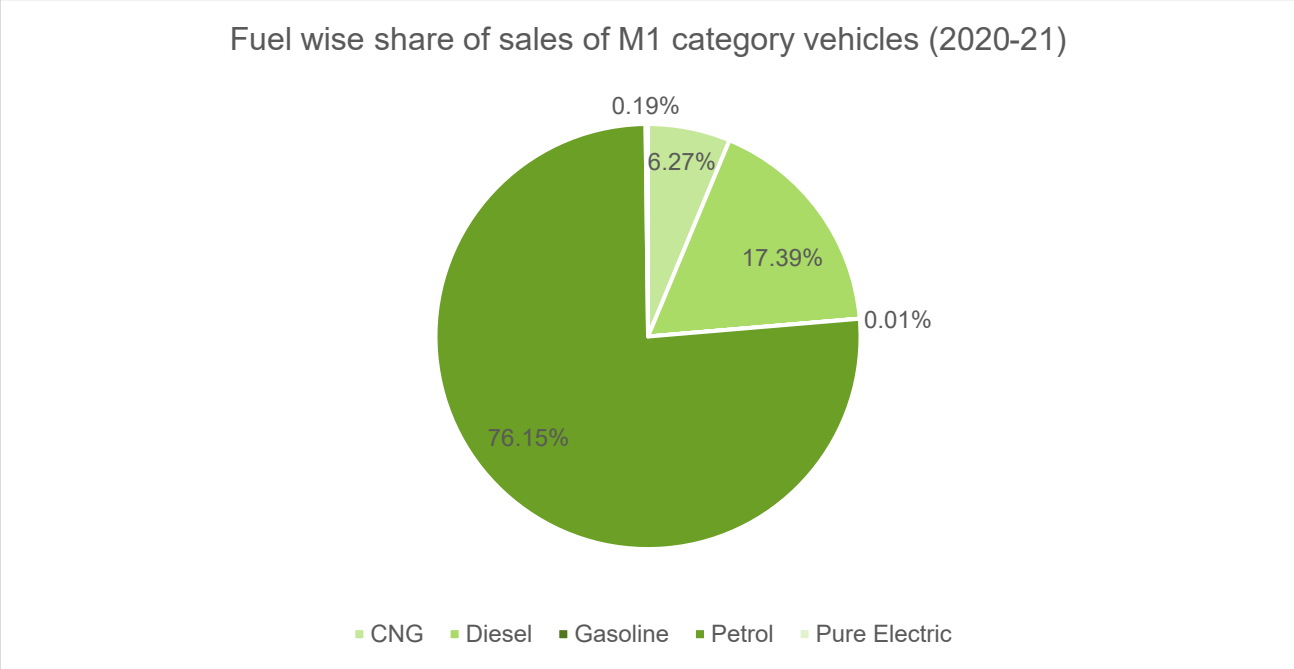


Figure 56: Fuel wise share of sales of M1 category vehicles (FY 2020-21)

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 2020-21.

Step-2: Calculation of fuel consumption per 100 km

The fuel consumption per 100 km for the vehicles sold during FY 2017-21 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 2020-21 in petrol equivalent is shown in Table 59.

Table 59: Fuel savings (in Mtoe) for the FY 2020-21

	Sales of M1 category vehicles (20-21)	Petrol saving for 10,000 Kms (Litres)[73]
Grand Total	**2702919**	**3890189.84**

The cumulative energy savings in TOE for the FY 2017-21 is showcased in the Table 60.

Table 60: Cumulative energy savings for FY 2017-21

Year	Savings in Mtoe
2017-18	0.42
2018-19	0.43
2019-20	0.35
2020-21	0.31
Cumulative 2017-21	**1.508**

The CO_2 emission savings for 2017-21 is presented in Table 61.

Table 61: CO_2 emission savings (in $MTCO_2$)

Year	CO_2 emission reductions (Million tCO2)
2017-18	1.28
2018-19	1.32
2019-20	1.08
2020-21	0.92
Cumulative 2017-21	**4.6**

8.3. Accelerating E-mobility adoption in India

In order to achieve the commitment for reducing the green house emission as committed by the GoI during COP21, transport sector will also play a vital role. Introduction of alternative means in the transport sector which can be coupled with India's rapid economic growth, rising urbanization, travel demand and country's energy security. Electric mobility presents a viable alternative in addressing these challenges, when packaged with innovative pricing solutions, appropriate technology and support infrastructure and thus, has been on the radar of Government of India. To boost the faster adopting of the EVs as mode of transportation, government plans to increase the share of the EV to 30% in the total sales by 2030.

[73] 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

Electric vehicles could help diversify the energy needed to move people and goods thanks to their reliance on the wide mix of primary energy sources used in power generation, greatly improving energy security.

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 thrust on electrification of India's fleet from all quarters is becoming profound, which is a clear indication of the fact that soon we will have a substantial number of electric vehicles in the country. However, the electric vehicle push is not new or sudden, India has been giving emphasis on electric vehicles for a long time. Despite all efforts, it was not that successful in the past. But with the recent push for e-vehicles by the government, the Indian auto industry is gearing up to make the electric vehicle mission 2030 a success.

Given the nascent market, over the past few years, the central government has created momentum through several policies that encourage the adoption of 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

The National Electric Mobility Mission Plan (NEMMP) 2020 is a National Mission document providing the vision and the roadmap for the faster adoption of electric vehicles and their manufacturing in the country. As part of the NEMMP 2020, Department of Heavy Industry formulated a Scheme viz. Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme in the year 2015 to promote manufacturing of electric and hybrid vehicle technology and to ensure sustainable growth of the same.

The Phase-I of this Scheme was initially launched for a period of 2 years, commencing from 1st April 2015, which was subsequently extended from time to time and the last extension was allowed up to 31st March 2019. The 1st Phase of FAME India Scheme was implemented through four focus areas namely:

i. Demand Creation
ii. Technology Platform
iii. Pilot Projects
iv. Charging Infrastructure.

Market creation through demand incentives was aimed at incentivizing all vehicle segments i.e. 2-Wheelers, 3-Wheelers Auto, Passenger 4-Wheeler vehicles, Light Commercial Vehicles and Buses.

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.

Figure 57: Snapshot of FAME I Scheme

Image Source: Niti Aayog

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.

The main objective of the scheme is to encourage faster adoption of Electric and hybrid vehicles by way of offering upfront Incentive on purchase of Electric vehicles and also by establishing the necessary charging Infrastructure for electric vehicles. The scheme will help in addressing the issues of environmental pollution and fuel security. The subsidies that have been provided under the scheme is presented in Table 62.

Table 62: 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, that includes shared transport

- Demand Incentives on operational expenditure model for electric buses will be delivered through State/city transport corporation (STUs).
- 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, focus will be on private vehicles.
- The Scheme aims to create demand by way of supporting 7090 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars and 10 lakh e-2 Wheelers.
- 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.

The Salient features of FAME India Scheme Phase II is depicted in the Figure 58:

Figure 58: Salient features of FAME India Scheme Phase II

So far, as of 31st March,2021, 31 OEMs have registered their 92 EV Models for availing benefit of demand incentives under Phase-II of FAME Scheme. About 44000 EVs have been incentivized to the eligible user of the electric vehicle under the FAME II Scheme[74].

Initiative for 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 government of India has taken several initiatives to expedite the development of public charging infrastructure across the country. Ministry of Power has designated Bureau of Energy Efficiency (BEE) as the Central Nodal Agency (CNA) to coordinate for rolling out of the public charging EV public charging infrastructure in various states across India. 26 states nodal agencies have also been designated by state governments for the National-level rollout of public charging infrastructure in the country.

As per SMEV, India had installed 1800 public charging points including fleet segment by end of FY 2020-21. The development of public charging infrastructure in India started gaining

[74] Source: Ministry of Heavy Industries and Public Enterprises Annual Report 2020-21

momentum slowly after the implementation of phase 2 of FAME India scheme in 2019-20. The government allocated a much higher budget of INR 1000 Crore under phase-2 of the scheme as compared to INR 43 crore spent under phase-1 of scheme for the development of 520 charging stations.

Under Phase II, the department of Heavy Industries (DHI) has already sanctioned 2,877 charging stations in 68 cities across 25 states/ UT's with a budget support of INR 500 Crore. Further, in December 2020, DHI floated an EOI for development of over 1500 charging stations on highways.

Apart from FAME, various state governments are also offering additional incentives for the development of charging infrastructure under their EV policies. Around 20+ states have already notified their EV policies including the draft policies.

Government has taken several steps for creating the public EV charging infrastructure and building the road map for cleaner transport for the Nation. Few of the key initiatives taken during the 2020-21 are:

- In January 2020, Department of Heavy Industries has sanctioned 2636 charging stations in 62 cities across 24 States/UTs under FAME India scheme II
- In September 2020, the government sanctioned setting up of 241 Charging Stations in Madhya Pradesh, Tamil Nadu, Kerala, Gujarat and Port Blair under Phase-II of FAME India Scheme. under FAME-II.
- Further in 2020, MoP again made key amendments under the guidelines and notified that:
    - The tariff for supply of electricity to EV PCS shall be determined by the appropriate commission. The applicable tariff shall not be more than the average cost of supply plus 15% unless otherwise specified by the tariff policy.
    - The definition of battery swapping station was included under the guidelines.
- Apart from the key initiatives taken by MoP, the ministry of Housing and Urban Affairs (MoHUA) has also made amendment in Model Building Byelaws (MBBL) 2016 to include the provision of EV charging in buildings. The key points under the amendment were following:
    1. 20% of all vehicles holding capacity/ parking capacity at the premise of a building shall be reserved for the charging of EVs.
    2. The building premises will have to have an additional power load, equivalent to the power required for all charging points to be operated simultaneously, with a safety factor of 1.25.
    3. The amendments are applicable to all buildings except independent residences.

8.3.1. Methodology to calculate fuel savings from adoption of EVs

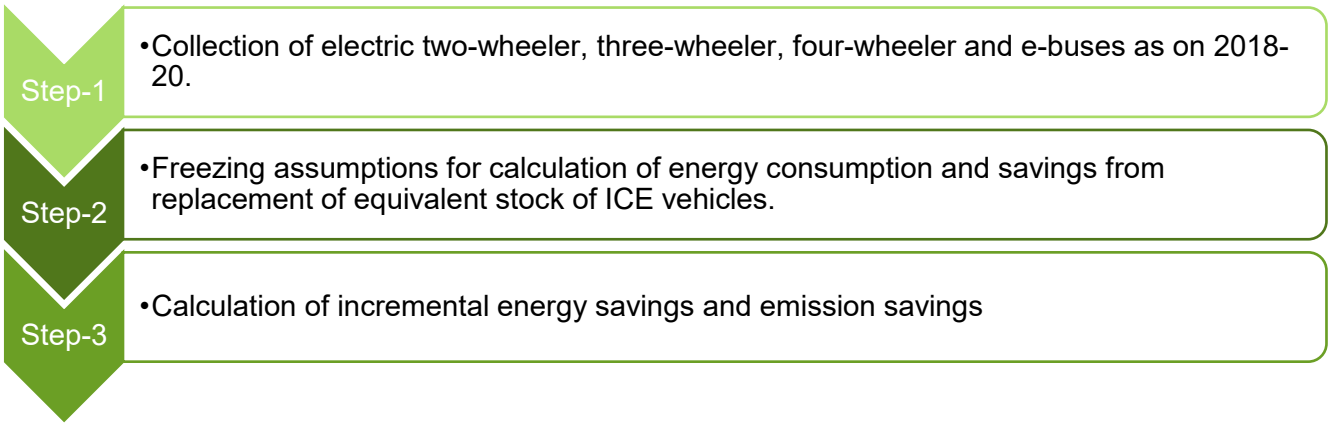


Figure 59 : Methodology for fuel saving estimation due to EVs

8.3.2. 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 2020-21 is presented in the Table 63:

Table 63: Number of EVs supported under FAME-I and FAME -II (as of March 2021)

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	2,598	20,420
e- 4-wheeler	12,447	5,080
e-buses	400	835
Total	**1,85,445**	**1,45,335**

As showcased in the table above, total 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 the FY 2020-21.

Step-2: Assumptions for various category 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 64.

Table 64: 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	0.79 tCO_2/MWh			

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 65.

Table 65: 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[75]	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 2018-21 are given in Table 66

Table 66: Energy and CO_2 savings in 2019-20[76]

Particular	Savings due to sales during 2018-19	Savings due to sales during 2019-20	Saving due to sales during 2020-21[77]
Energy savings in Mtoe	0.040	0.005	0.020
CO_2 emission savings in $MtCO_2$	0.070	0.007	0.052

[75] https://shaktifoundation.in/wp-content/uploads/2017/06/WRI-2015-India-Specific-Road-Transport-Emission-Factors.pdf
[76] Fame I savings are reflected
[77] Note: As around 928 e-buses are running on road out of sanctioned 6,265 e-buses, the energy and emission savings are calculated for these operational 928 buses for the FY 20-21.

8.3.3. Achievements under FAME India Scheme Phase II

As on January,2021 under FAME India Scheme Phase II, following has been achieved:

- **OEMs and Vehicle Models:** So far, 31 OEMs have registered their 92 EV Models for availing benefit of demand incentives under Phase-II of FAME Scheme. About 44000 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 6265 no of e-buses to 65 cities for intra-city and intercity operations across 24 states/ UT under the Scheme. These buses will run about 4.5 billion Kilometer distance during their contract period and are expected to save **cumulatively about 1.5 billion liters of fuel over the contract period, which will result in avoidance of 3.4 million tonnes of CO2 emission**.
- **Sanction of Charging Infrastructure:** To address the issue of range anxiety, 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 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 amounting to Rs. 500 Crore (Approx.) in 68 cities across 25 States/UTs under FAME India (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India) scheme phase II.
- **Publicity:** DHI conducted publicity activity of EVs in a few colleges/universities across the country.

8.4. Energy efficiency in the Railway Sector

Indian Railways is an Indian state-owned enterprise, owned and operated by the Government of India governed by the Ministry of Railways. It is one of the world's largest railway networks comprising 1,26,366 km of track over a route length of 67,956 km and about 8500 stations. Due to the high energy consumption of the various Production Units and Workshops in the Indian Railways, the Bureau of Energy Efficiency, and Ministry of Power has identified Indian Railways as one of the designated consumers under the Perform Achieve and Trade (PAT) Scheme.

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[78].

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.

Electric and Diesel traction constitute the principal modes of traction in Indian Railway. The total electricity and diesel consumption in traction energy in Indian Railways over the years is presented in the Figure 60 and 61.

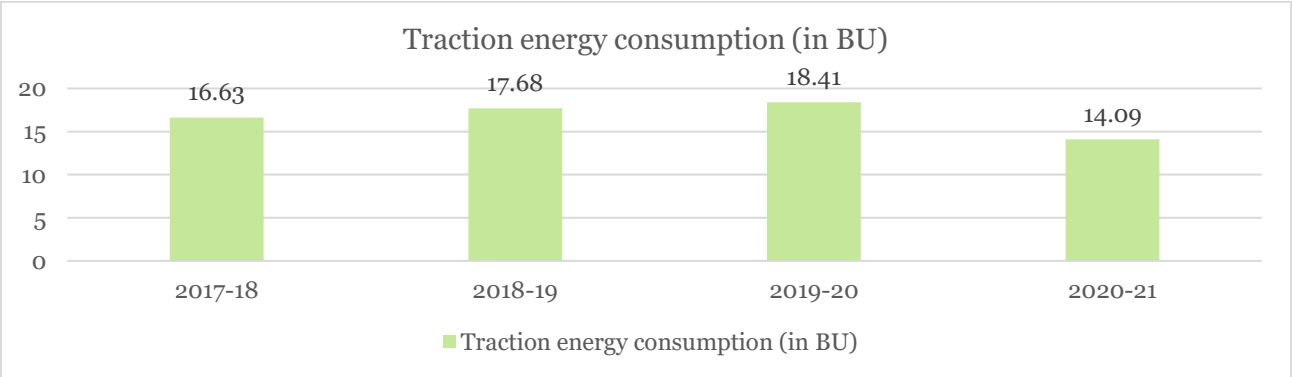


Figure 60: Traction energy consumption by Railways[79]

[78] http://www.indianrailways.gov.in/railwayboard/uploads/directorate/traffic_comm/RatesLetters/2017/Milind%20Deore_International_Conf_Railways_MD_27_10_2017(final).pdf

[79] Indian Railways Annual Report and Accounts 2020-21

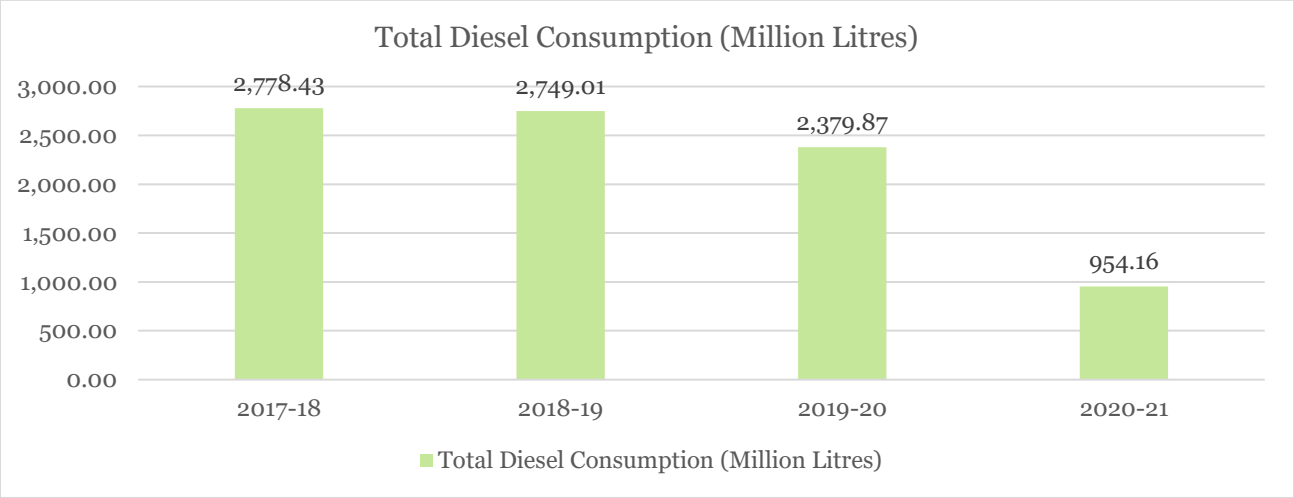


Figure 61: Consumption of Fuel by Locomotive[80]

The entire passenger and freight traffic, in terms of Gross Tonne Kilometres (GTKMs) for the year 2017-21 is showcased in the Figure 62:

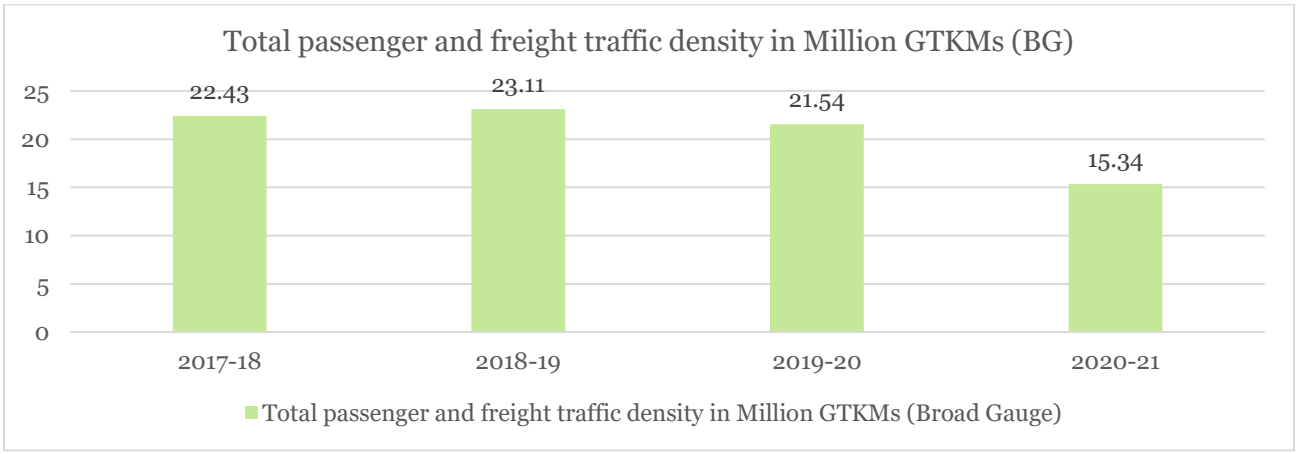


Figure 62: Total traffic density in Million GTKMs (Broad Gauge) for the year 2017-21

The Covid-19 pandemic severely impacted rail activities in the year 2020-21. Due to nationwide lockdown and limited number of trains running across the nation, the Gross Ton Km (GTKM) or Passenger Km (PKM) moved over the railway system in the year 2020-21 reduced from 21.54 Million GTKM in the FY 2019-20 to only 15.34 Million GTKM in the FY 2020-21 (as showcased in the figure above). The total decrease in GTKM value stood at 28.78% as compared to last year.

Due to reduced GTMK travelled by the Indian Railways, the total energy consumption of the locos also went down from 18.41 BU in the year 2019-20 to 14.09 BU in the year 2020-21, as showcased in the Figure 60 above. The percentage decrease in the energy consumption of the locos was around 23.47% in the year 2020-21 as compared to the previous year.

[80] Indian Railways Yearbook

The impact of COVID-19 pandemic has resulted into reduced energy consumption in the FY 2020-21 as compared to that of FY 2019-20 has also led to reduced CO2 emissions, as showcased in the table below:

FY	Traction Energy Consumed (BU)	GHG Emissions (MntCO2)	Impact of COVID-19 on GHG Emissions (MntCO2)
2019-20	18.41	14.54	**3.41**
2020-21	14.09	11.13	

Similarly, emission reduction from reduced diesel consumption in the FY 2020-21 is showcased in the table below:

FY	Traction Diesel Consumed (Million Liters)	GHG Emissions (MntCO2)	Impact of COVID-19 on GHG Emissions (MntCO2)
2019-20	2379.87	7.47	**4.48**
2020-21	954.16	2.98	

Non-traction energy

With a view to reduce energy consumption in non-traction area, Indian Railways has initiated various measures. IR consumed around 2.01 BU of electricity for its non-traction usage in the year 2020-21.

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. As a result, the total non-traction energy has come down to 2.01 BU in the year 2020-21 from 2.34 BU in the year 2019-20.

The non-traction energy consumption over the years is in presented in the Figure 63.

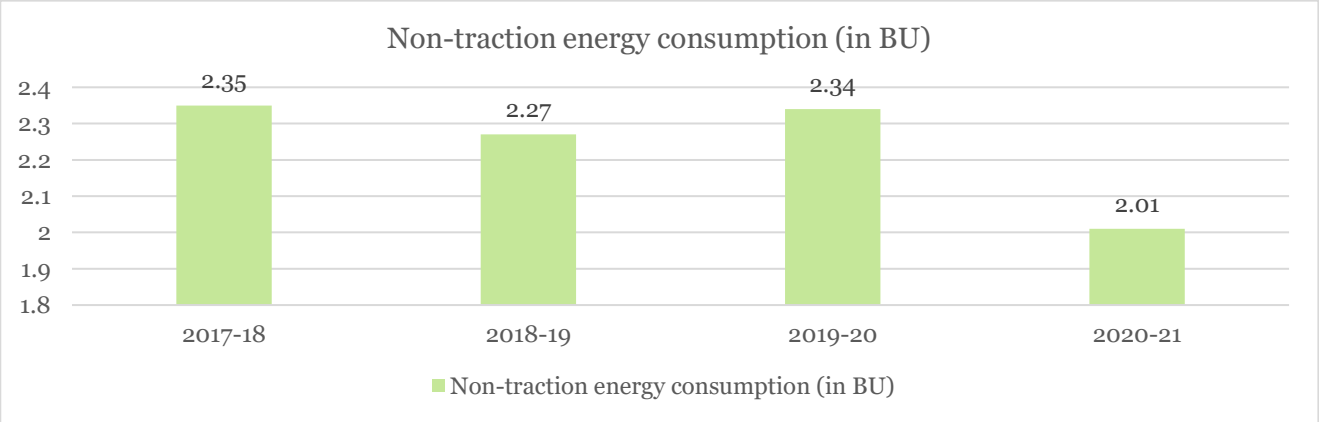


Figure 63: Non traction energy saving (BU)

However, 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. To reduce dependence on diesel fuel under mission electrification a total of 65.79% (44,802 RKMs out of total 68,103 RKM as of March 2021[81]) railway track has been electrified. The progress of electrification of the railway RKM in the last 2 decades is showcased in the table below[82]:

Year	Cumulative Electrified (RKM)
2001	14,856
2011	19,607
2018	29,228
2019	34,319
2020	39,329
2021	44,802

Total 6,015 RKM has been electrified during the year 2020-21. Total electrification of the railway track for the FY 2017-21 is showcased in the Figure 64:

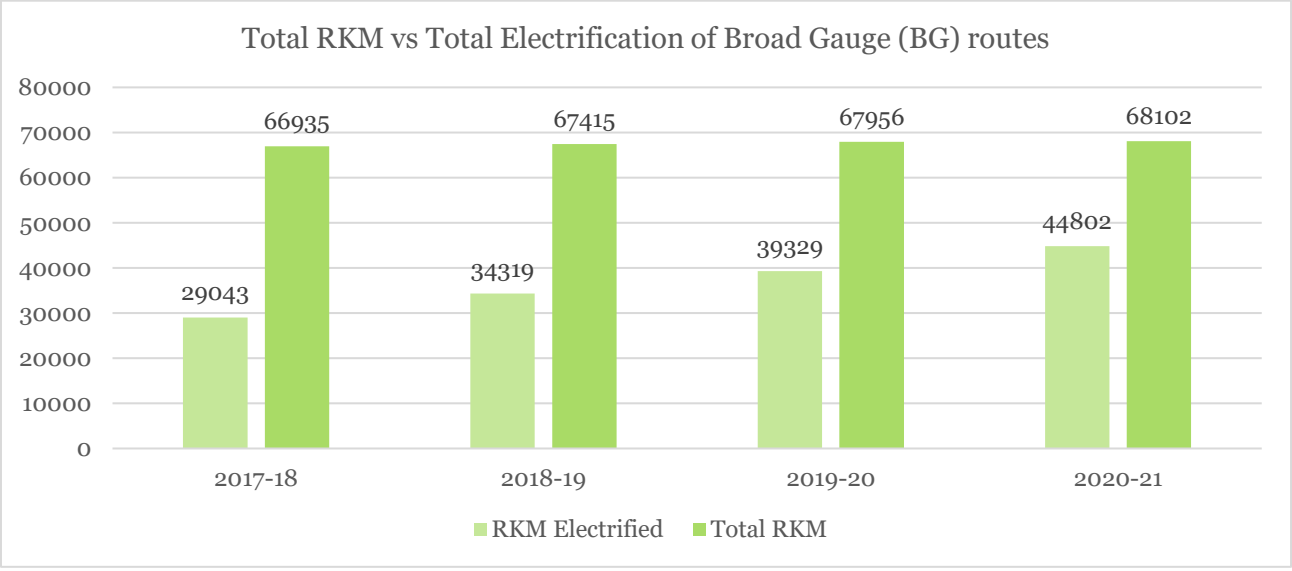


Figure 64: Route electrification in Indian Railways

[81] Source: Indian Railways Annual Report and Accounts 2020-21
[82] Indian Railways Annual Report and Accounts 2020-21

- The electrification of railway RKMs has resulted into reduced diesel consumption from ~ 2.3 billion litres (2019-20) to ~ 1.4 billion litres (2020-21).
- It is envisaged that after 100% electrification by Dec'2023, there will be a saving in diesel oil consumption to the tune of 2.8 Billion liters per annum and will also reduce CO2 emission of Railways 24% till 2027-28.

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.

Change in Policy: The Indian railways in its endeavor to bring in new technologies into the system had stopped the production of conventional locomotives since 31st March 2016 while the production of diesel locomotives has been discontinued from 31st March 2019. In view of the policy for complete electrification of Broad-gauge routes, Indian Railway has stopped manufacturing new diesel locomotives for its own use at DLW and DLMW plants in the year 2020-21.

Innovations and new initiatives of EMU, MEMU and Kolkata Metro

The details of innovations and new initiatives of EMU, MEMU and Kolkata Metro rakes during 2020-21 is as under:

- During 2020-21, Three Air-Conditioned EMU rakes with indigenously developed 3-phase IGBT based on-board propulsion systems have been turned out from ICF
- During 2020-21, 33 Main Line Electrical Multiple Unit (MEMU) rakes equipped with indigenously developed 3 phase IGBT based onboard propulsion system have been turned out from production units and commissioned in Railways
- During 2020-21, ICF has turned out 4 Kolkata Metro rakes with indigenous 3-Phase IGBT based propulsion system for Metro Railway Kolkata.

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 load and other passenger interface requirement working on electrical power supply. Currently Over 1398 trains have been taken on HOG scheme resulting in saving of over Rs 3397.14 Cr in operational costs. Projected saving in CO2 emission is 12 Lakh, 42 thousand Tonnes annually.:

- All LHB coaches have been made HOG complaint.
- All power cars have been made HOG Compliant.
- Reduction in diesel consumption on account of HOG operation 9,83,72,940 Ltrs.
- Reduction in fuel bill on account of HOG operation `737.79 crore.

- Reduction in CO_2 emission on account of HOG operation 2,59,705 Tonnes.

Green Environment

Following initiatives have taken by Mechanical Engineering (Traction) Directorate for improving Green Environment in diesel locomotives and train operation:

- Auxiliary Power Units: In APU System, Main Engine shuts down and small 25 HP Engine starts and charges batteries and air brake pipes, when locomotive idles for more than 10 minutes. The diesel engine of APU consumes only 3 liters of diesel per hour in comparison to 25 liters by the main engine of the locomotive. Expected savings per loco fitted with APU is INR 20 lakh/year on account of savings in fuel oil only. So far, APUs units have been fitted in 1,141 Diesel Locomotives. Further all the new diesel locomotives being manufactured at Marhowra plant have this unit.
- Multi-Genset locomotive: In a multi- genset locomotive, single large engine is replaced by three smaller engines. An on-board computer monitors the power requirement and shuts down/starts engines as per load demands, which makes it more fuel-efficient. Three such locomotives have been turned out by DMW/PTA. Trials at Itarsi Diesel shed have shown saving up to 17% fuel in shunting and passenger operations. Besides fuel saving, there is a reduction of 85%-90% in NOx and particulate emissions compared to uncontrolled locomotive emissions

Training of loco pilots: Regular counselling of Loco Pilots for resorting to maximum coasting and use of regenerative breaking. Continuous monitoring of regeneration is done in Crew Management System (CMS) for each Loco pilot. Electric loco idling in sheds and yards are kept to minimum. Regular counselling of Loco Pilots for switching 'OFF' blower in case yard detention is more than 15 minutes. Refresher training imparted to 1,52,288 employees during the year 2020-21

100% LED initiative: To increase the energy efficiency and reduce the electricity consumption all Railway stations, buildings and residential quarters have been provided with LED lights leading to an estimated emission reduction of ~ 200 Thousand Tons per annum. Along with railway stations 63,000 Coaches are also fitted with LED lights leading to an estimated emission reduction of ~ 51 Thousand Tons per annum. In the year 2020-21, total 26,500 coaches have been retrofitted with Led fittings. Per coach per annum saving on account of LED lights is likely to be INR 25,500. For coaches converted in 2020-21, there is likely saving of INR 67.57 crore annually.

Through implementing the various energy efficiency measures stated above, the Indian railways has also improved its specific energy and fuel consumption over the past years. The specific energy and fuel consumption for the year 2020-21 as compared to that of year 2019-20 is showcased in the tables below[83]:

[83] Source: Indian Railways Year Book 2020-21

Specific Energy Consumption (Consumption per 1000 GTKMs) – (BG)	Unit	2019-20	2020-21
Passenger service- Electricity	kWh/1000 GTKMs	18.4	15.6
Goods services -Electricity	kWh/1000 GTKMs	6.3	7.09

Specific Fuel Consumption (Consumption per 1000 GTKMs) – (BG)	Unit	2019-20	2020-21
Passenger service- Diesel	Litres/ 1000 GTKMs	3.59	3.31
Goods services -Diesel	Litres/ 1000 GTKMs	1.92	1.92

As per the data provided in the above table, the specific energy consumption of passenger services has improvement efficiency of 15.22% as compared with last FY, while the specific fuel consumption has improved by 7.80% as compared to last FY 2019-20.

The energy savings and emission reductions in the sector have been accounted for under the PAT and S&L section of the report.

Chapter 9: Agriculture

9. *Agriculture*

Agriculture plays a vital role in India's economy over 70 per cent of the rural households depend on agriculture. Agriculture is an important sector of Indian economy as it contributes about 17% to the total GDP and provides employment to over 60% of the population. Gross Value Added (GVA) by agriculture, forestry and fishing was estimated at Rs. 19.48 lakh crore (US$ 276.37 billion) in FY20 (PE). Growth in GVA in agriculture and allied sectors stood at 4% in FY20.[84]. The electricity consumption in the sector over the last 9 years is presented in Figure 65

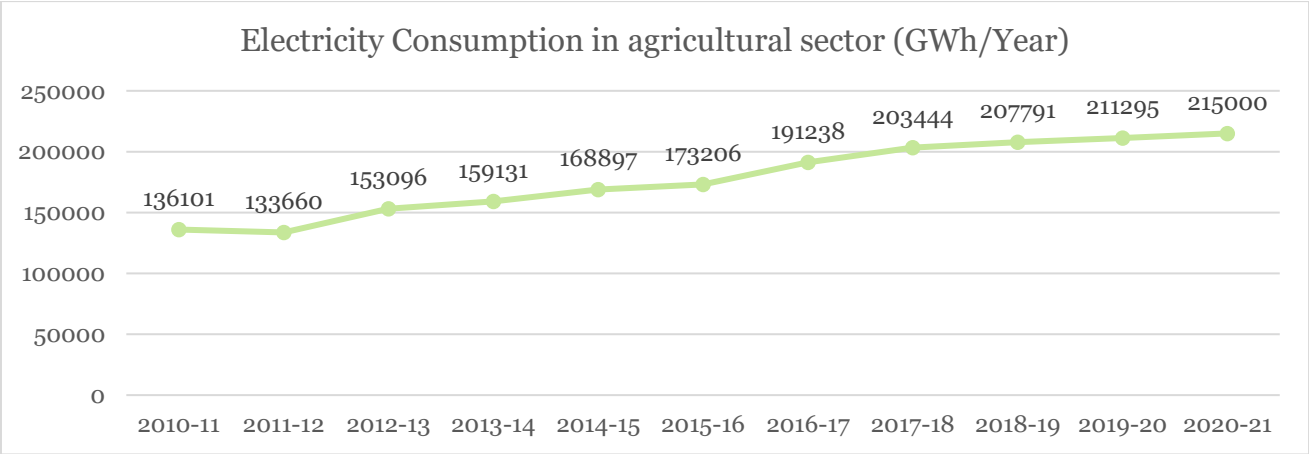


Figure 65: Energy consumption in agriculture sector[85]

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 173,206 GWh to 215,000 GWh. An increase in energy consumption by around 24.13%.

As per CEA annual report of 2020-21 total 22.05 million pump sets/tube wells were energized at end of March 2021[86]. Most of the energized pump sets on agriculture sector are non-standard and locally made. In comparison to the commercially available BEE star rated energy efficient pump sets, the existing pumps are consuming more power for delivering similar quantity of water.

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

[84] https://www.ibef.org/industry/agriculture-india.aspx
[85] https://www.ceicdata.com/en/india/electricity-consumption-utilities/electricity-consumption-utilities-agriculture
[86] https://cea.nic.in/wp-content/uploads/notification/2021/12/CEAAnnualReport_final.pdf

saving energy. This has resulted in a huge financial burden on the distribution utilities and has resulted in higher tariffs for industrial and commercial consumers.

Along with higher energy consumption, existing pump sets are indirectly leading to wastage of ground water, as currently there is little or no motivation for farmer to monitor the pump sets operation or regulate operating hours as per actual water demand of the crops under irrigation. Under these circumstances, Agricultural Demand Side management is an attractive option for limiting wastage of water and energy in agriculture sector.

Energy efficiency and DSM in agriculture in India has been driven by pump set replacement programs. A timeline of major Agriculture DSM programs is showcased in the Figure 66.

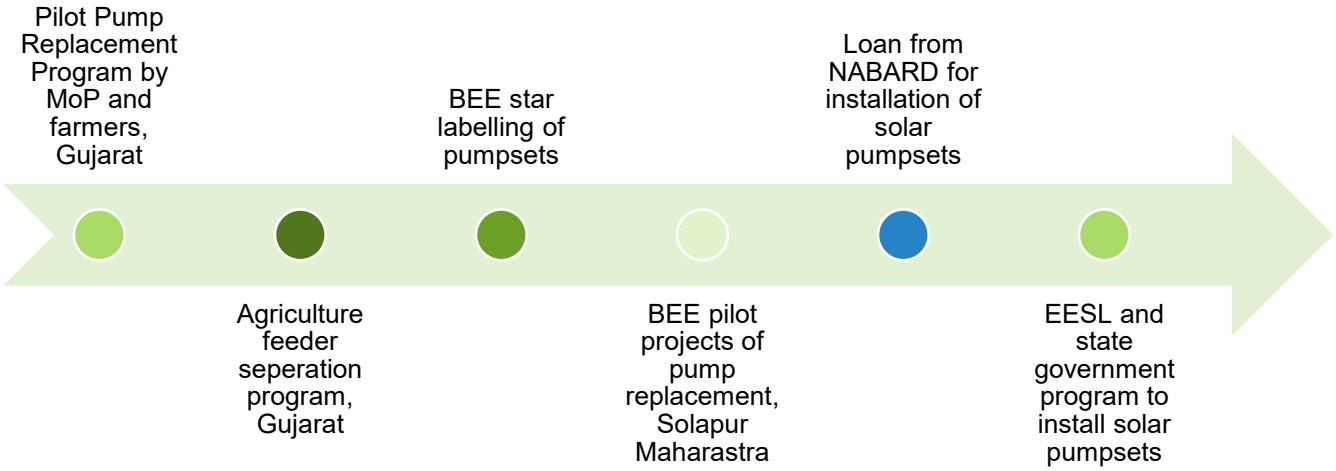


Figure 66: Timeline of major Agriculture DSM programs in India

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.

The objective of the program is to reduce the energy intensity of agriculture pumping sector by carrying out efficiency up gradation of agricultural pump sets.

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.

9.1. AgDSM programme

AgDSM consists of methodologies and policies aimed at bringing a change in the power consumption patterns of consumers (farmers). The objective of the AgDSM programme is to reduce peak electricity demand, and, ultimately, the total energy consumption of the agriculture sector. All project implemented under AgDSM in India have focused on

replacement of existing inefficient agricultural pump sets with BEE star-rated energy efficient pump sets along with creating awareness for using Energy Efficient pump sets.

Under subsidized power supply scenario, farmer does not have any commercial benefit of installing energy efficient pumps, therefore in almost all AgDSM projects DISCOMs are paying for replacement of pump sets either by sharing energy savings (in ESCO mode) or through capital investment.

Before ongoing state level AgDSM projects at Andhra Pradesh and Uttar Pradesh, four pilot projects were undertaken in India at Maharashtra (1 Nos.), Karnataka (2 Nos.) and Andhra Pradesh (1 Nos.). Details regarding mentioned pilot projects is summarized in Table 67.

Table 67: Pilot projects in AgDSM

S. No	Particulars	BEE – Solapur	EESL- Hubli	EESL – Mysore	EESL – Rajanagaram
1	No. of pumps replaced	2,209	590	1,337	973
2	Type of pumps replaced	• Submersible • Monoblock • Open well	• Submersible • Monoblock	• Submersible • Monoblock	• Submersible
3	Rating	3 to 20 hp	2 to 7.5 hp	2 to 7.5 hp	4 to 30 hp
4	Project implementation model	ESCO mode	ESCO mode	ESCO mode	ESCO mode
5	Energy sharing ratio – ESCO: DISCOM	85:15	95:5	90:10	85:15
6	Repayment Period (Years)	5	6	6	5
7	Repair and maintenance	Free for 5 years	Free for 5 years	Free for 6 years	Free for 5 years
8	Implementation period (months)	36	10	9	22
9	Percentage Energy savings (%)	25%	35.18% (2014) 33.3% (2015)	36.15% (2015)	33%

As a part of Demand Side Management Programme, Bureau of Energy Efficiency, under AgDSM programme, imparts training & awareness programmes to the agricultural farmers, agricultural universities/ officials of Krishi Vigyan Kendra's (KVKs)/ equipment technology providers and other concerned stakeholders. Till now, over 500 farmer training workshops have also been conducted by SDAs with support of KVKs on "Energy and Water Conservation" and around 25,000 farmers have been benefitted by these programs.

Benefit derived by the farmers from KVK's -

- Awareness on energy efficiency and conservation in agricultural practices, particularly in using agriculture pump sets, tractors and other machines.

- Improving fuel efficiency and water resource use efficiency thereby reducing the cost of cultivation so as to increase farmers' income in harmony with strategies of "Per drop more crop" etc.

- Development of Fuel Economy norms for Agricultural tractors is also under process, by BEE. BEE is working to develop the S&L for the tractors and it will be rolled out in coming years.

Activities carried out by BEE under AgDSM 2017-till 31st March 2021:

Under AgDSM programme, organized by BEE capacity building workshops for the Farmers/ Stakeholders and pump-technicians were conducted in several states. The details of such capacity building and training workshops conducted from the year 2017-18 to FY 2020-21 is given in Figure 67.

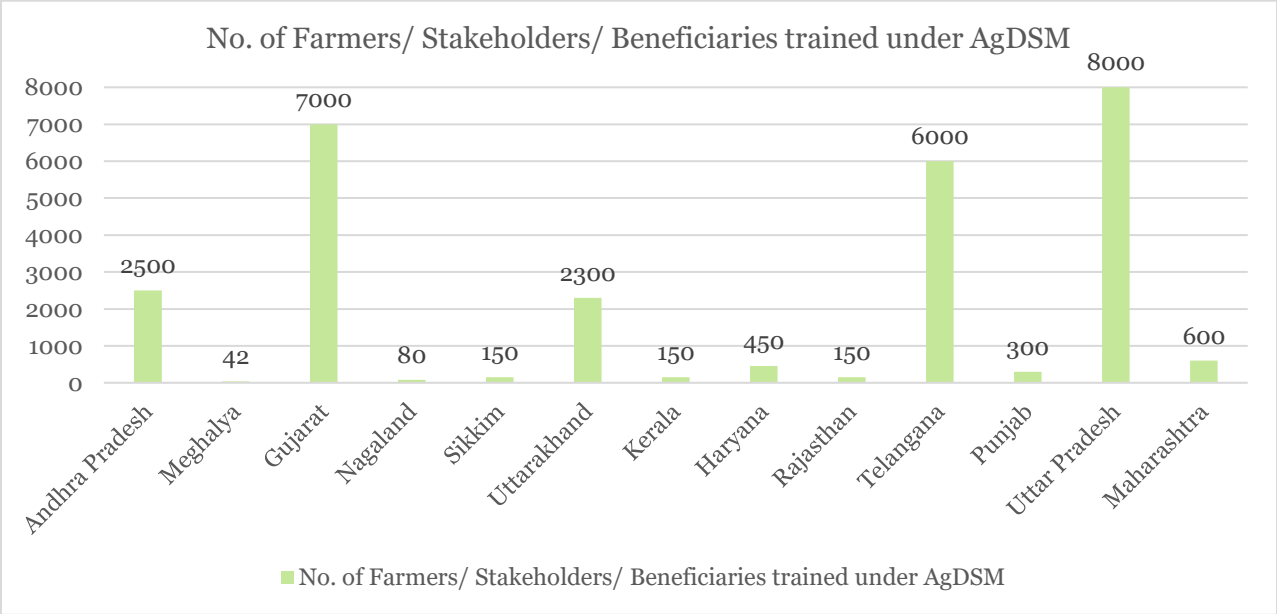


Figure 67: Capacity Building under AgDSM

Benefits to various stakeholders under the programme

The AgDSM programme involves several stakeholders such as farmers (the main beneficiary), Discoms (implementing agency/project owner) the State Electricity Regulatory Commission (SERCs) and ESCOs. Benefit accrued by various stakeholders by implementation of AgDSM are presented in Figure 68.

Farmers	State Government	DISCOM
• Free of cost BEE 5 star rated energy efficient submersible pump • Free R & M for 5 years • Ease of operation through smart control panel • Improved awareness regarding water conservation • Improved safety	• Reduction of subsidy burden • Reduction in CO2 emission. • Conservation of state gound water resources due to prudent use by farmers. • Reduced energy intensity of state GDP and contribution in meeting INDC targets.	• Reduction in energy and peak demand • Improved financial health • Improved power system reliability • Reduction in CO2 emissions

Figure 68: Benefits of the AgDSM programme

9.1.1. Recent efforts by BEE to promote AgDSM scheme

Over the last year, the Bureau of Energy Efficiency has taken various measures to promote the usage of energy efficient pumps by spreading awareness about the programme and building strategic alliances with key institutions working in the field of agriculture. Given below are some of the major initiatives that were taken during the last year:

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

BEE being the nodal training agency of the country is focusing towards conducting large scale awareness programs for farmers to promote the adoption of EE pumps by them. BEE is exploring different kinds of outreach channels such as local print and electronic media (including television and local radio channels), village cultural events, Grameen sabhas or other panchayat initiated public events, etc.

Organizing technical training programs for equipment technicians

Under AgDSM programme, BEE is organizing training programs for pump technicians who have a major role to play in replacing old inefficient pumps with BEE star rated pump sets.

The current status of the number of pumps installed in state of Andhra Pradesh and Uttar Pradesh and summary of these installations for the FY 2017-21 is presented in Table 68.

Table 68: Number of pump-set installations under AgDSM in the FY 2017-21

Particular	2017-18	2018-19	2019-20	2020-21
Pump-set installation (Number)	18,018	40,488	10,784	2,500

9.1.2. Methodology adopted to calculate energy savings and CO_2 emission savings

Around 2500 BEE 5 star rated pumps which were distributed during FY 2020-21 to replace inefficient pumps. For the purpose of energy saving calculations in 2020-21, 50% of the total number of installations in the year 2020-21 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:

- **Energy Savings**: This is calculated by considering the number of pumps installed and considering an overall efficiency factor of 30% to calculate the energy savings per pump. The number of hours the pump is used per day and number of days the pump is operational in a year is assumed to be 6 hours and 270 days respectively based on ground surveys carried out for AgDSM programme implementation in AP.

- **CO_2 emission savings**: To calculate the reduction in total CO_2 emission, conversion factor of CO_2 for electricity is considered (1 MWh = 0.79 t CO_2)

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

9.1.3. Impact of the scheme

Prior to the FY 2020-21, total 74,399 BEE five star rated 5 HP pumps were installed across India. In the financial year 2020-21, there were total 2500 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 69.

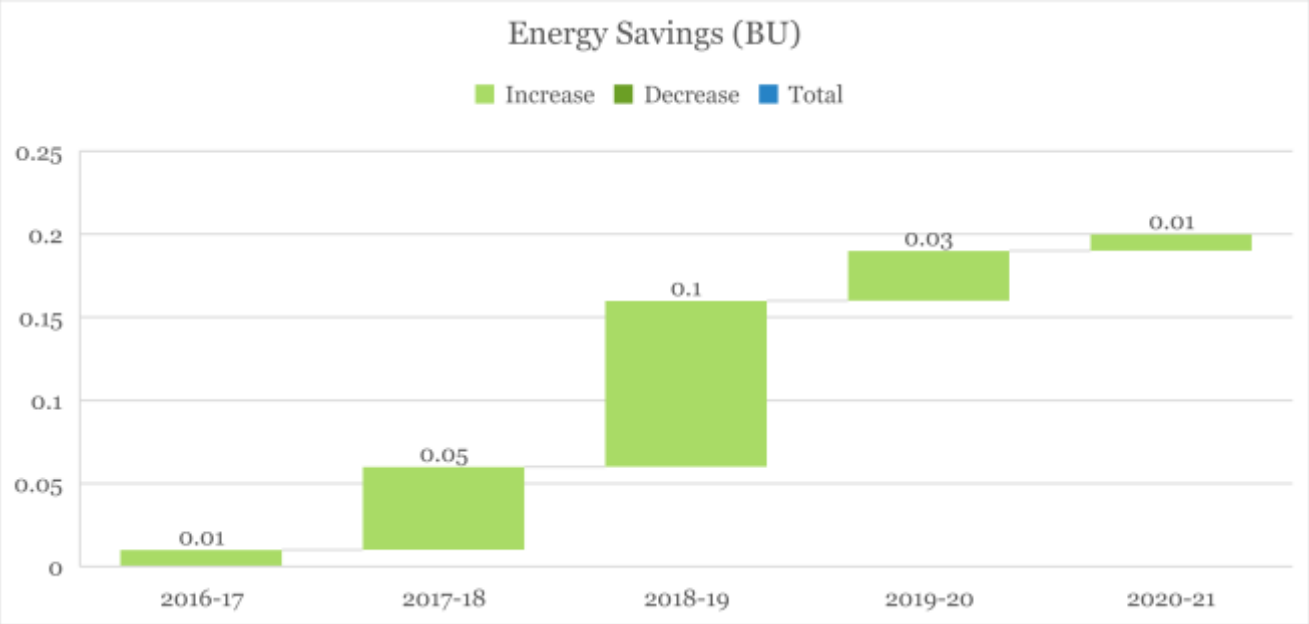


Figure 69: Energy saving from AgDSM

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 2020-21 is 0.2 BU and reduction in emission of CO_2 is 0.164 Million Tonnes.

Chapter 10: State Designated Agencies

10. 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.

At present, there are total 36 SDAs in the country 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 who 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.

10.1. 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.

10.1.1. 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 the SDAs in the areas of street lighting, water pumping (drinking water supply systems, agricultural water pumping systems, etc.), 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. I**nstitutionalization of Enforcement Machinery at State level** – BEE provides financial assistance to the SDAs under this head for the purpose of establishment of an enforcement machinery at the State level and for development of a robust mechanism to enable this machinery to discharge its duties / tasks effectively.

4. **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.

5. **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.

6. **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.

7. **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.
8. **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.
9. **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.

10.1.2. 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 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. Till date, 31 states have constituted SECF out of which about 26 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.

10.2. Key highlights of activities of SDAs during FY 2020-21

10.2.1. Andaman & Nicobar

The A&N Islands SDA completed the conversion of GLS/ CFL into LED lights at 10 Nos. Temples/ religious places.

The SDA undertook replacement of conventional luminaries and fans with energy efficient luminaries and fans in 13 Nos. Govt. schools across the State.

10.2.2. Andhra Pradesh

Andhra Pradesh State Energy Conservation Mission (APSECM), the SDA of Andhra Pradesh has undertaken installation of Internet of Things (IoT) systems in 65 Nos. MSME units.

The SDA has developed 52 Nos. model schools and 4 Nos. model villages by carrying out therein, the replacement of existing inefficient lighting system and fans with energy efficient luminaries and fans.

10.2.3. Arunachal Pradesh

Arunachal Pradesh Energy Development Agency (APEDA), the SDA of Arunachal Pradesh completed replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in 16 Nos. Govt. schools.

The SDA has developed Energy Conservation & Energy Efficiency Park at Seijosa, Arunachal Pradesh by installing therein EE equipment for demonstrating it to concerned authorities and public at large.

10.2.4. Assam

The Assam SDA implemented demonstration projects in Akaya Mahapurusia Satra and Powa Mecca, Hajo by retrofitting of energy efficient equipment/appliances therein.

The SDA undertook replacement of conventional luminaries and fans with energy efficient luminaries and fans in 100 Nos. Govt. schools across the State.

10.2.5. Bihar

Bihar Renewable Energy Development Agency (BREDA), the SDA of Bihar has implemented Model Energy Efficient Village Campaign in 5 nos. of villages, converting them into model energy efficient villages by replacing existing conventional household lamps, streetlights, and fans with energy efficient ones.

10.2.6. Chandigarh

SDA has taken up replacement of LED Fixtures and outdoor lights in the following Public & Heritage Buildings.
a) Government Press Building Sector-18

b) High Court Building Chandigarh
c) Government Senior Secondary School, Sector-23

10.2.7. Chhattisgarh

Chhattisgarh State Renewable Energy Development Agency (CREDA), the SDA of Chhattisgarh has implemented energy efficiency demonstration projects at Chhattisgarh Swami Vivekanad Technical University – Dist. Durg, PNB Farmers Training Center (Labhandi) – Dist. Raipur, and 72 Nos. Govt. schools by replacing therein, the existing conventional lights and ceiling fans with energy efficient ones.

The SDA has carried out implementation of energy efficiency measures as pilot project in 4 Nos. Govt. hospitals across the State.

10.2.8. Daman and Diu

SDA has completed making 1 no. Government building, Government school, and village each model energy efficient by retrofitting of energy efficient appliances/equipment therein.

10.2.9. Delhi

Energy Efficiency and Renewable Energy Management Centre (EEREMC), the SDA of Delhi carried out Model Energy Efficient Village Campaign for the implementation of energy efficiency measures in Village Majra Bajitpur Thakran, Bawana, Narela zone through North Delhi Municipal Corporation.

10.2.10. Goa

Goa SDA through M/s. EESL converted 16 Nos. Government Schools and 7 Nos. Kendriya Vidyalayas to Model Energy Efficient Schools by replacing therein, all existing conventional appliances by energy efficient ones.

10.2.11. Gujarat

Gujarat Energy Development Agency (GEDA) has conducted energy audit of 6 Nos. Govt. hospitals located in Vadodara district. Implementation of recommendations of said energy audits is in process.

10.2.12. Haryana

Haryana SDA has implemented Demonstration Project of installation of 180 Nos. High Mast energy efficient fixtures at Brahama Sarovar, Kurukshetra district.

Haryana SDA has also developed Karnal Jail as Model Energy Efficient Jail by retrofitting of energy efficient equipment/appliances therein, including installation of solar PV plant in the premises.

Haryana SDA completed replacement of conventional appliances by energy efficient ones in 220 Nos. Government Schools. The SDA has carried out implementation of energy efficiency measures as pilot project in 21 Nos. District Civil Hospitals and 20 Nos. Primary Health Centers in Panipat district.

10.2.13. Himachal Pradesh

Himachal Pradesh SDA has implemented Demonstration Project in the Himachal Pradesh University by retrofitting 500 Nos. existing streetlights and 5000 Nos. in-house (Classrooms, Hostels, Residences) luminaries with LEDs.

10.2.14. Karnataka

Replacement of Conventional Street lights by Energy Efficient LED streetlights in the premises of "Sri Adi Chunchanagiri Kshethra, Malemahadeshwara temple hilly place, Sri kengal Anjaneya temple, channapatna".

The Replacing the existing low efficient electrical gadgets by the energy efficient electrical gadgets like LED bulbs, Tube lights, EE fans at selected 100 no. Government schools across the state.

Replacing the existing low efficient HPSV/ MV / FTL / CFL / Incandescent streetlights by appropriate capacity Energy Efficient LED lights on the existing ESCOM poles with control units at the 5 nos. selected backward villages across the state

10.2.15. Kerala

Ranni Grama Pnachayat, Pathanamthitta was selected for the implementation of Model Energy Efficient Village campaign programme.

Making one old and famous temple in Kerala as energy Efficient namely Guruvayur Dewasom Board Temple and associated buildings is selected for the project

Implementation of EE activities in selected 20 Govt. Schools by Replacement of inefficient electrical appliances with energy efficient ones.

10.2.16. Madhya Pradesh

Madhya Pradesh Urja Vikas Nigam (MPUVN) Limited, the SDA of Madhya Pradesh completed replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in 350 Nos. Govt. schools.

The SDA has implemented Model Energy Efficient Village Campaign in 2 Nos. villages, converting them into model energy efficient villages by replacing existing conventional household lamps, streetlights, and fans with energy efficient ones.

10.2.17. Maharashtra

Maharashtra Energy Development Agency (MEDA), the SDA of Maharashtra completed replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in 131 Nos. Govt. schools.

Implementation of EE activities under Model EE Village Campaign in 4 Nos. villages has been completed.

10.2.18. Mizoram

The Mizoram SDA implemented 3 Nos. demonstration projects at Mizoram Polytechnic, Lunglei, Women's Polytechnic, Aizawl, and District Jail, Lunglei by retrofitting of energy efficient equipment/appliances therein.

The SDA undertook Model Energy Efficient Village Campaign by implementing energy efficiency measures in 2 Nos. villages viz. Rawpuichhip, Mamit District and Chhingchhip, Serchhip District.

10.2.19. Nagaland

Nagaland SDA has completed the replacement of conventional luminaries and fans with energy efficient luminaries and fans in 23 Nos. Govt. schools across the State.

Further, they have completed implementation of Model Energy Efficient Village Campaign in 2 Nos. villages.

10.2.20. Odisha

Odisha SDA completed the EE streetlighting project at Mukhiguda and Khatiguda colonies of Upper Indravati Hydro-electric project.

Further, they have completed implementation of EE measures involving retrofitting of energy efficient appliances/equipment in 44 Nos. Govt. schools.

10.2.21. Puducherry

Renewable Energy Agency Puducherry (REAP), the SDA of Puducherry has implemented demonstration projects in 100 Nos. Anganwadi centers, 79 Nos. Temples, 15 Nos. Govt./ public buildings, and 102 Nos. Govt. schools by retrofitting of energy efficient equipment/ appliances therein.

The SDA has implemented EE streetlighting demonstration project at Beach Road, Puducherry. Further, the SDA has undertaken Model Energy Efficient Village Campaign for the implementation of EE measures in 18 Nos. villages across their territory.

10.2.22. Punjab

Punjab Energy Development Agency (PEDA), the SDA of Punjab has completed replacement of existing 50HP, 75HP, and 150HP drinking water pumps with energy efficient pumps in Doong (Salari Kad), Bakhtpur and Chakki, Pathankot district.

The SDA has completed replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in 65 Nos. Govt. Primary and Middle Schools of Dist. S.A.S. Nagar (Mohali).

The SDA has carried out implementation of energy efficiency measures as pilot project in 6 Nos. Govt. hospitals and Medical Colleges across the State.

10.2.23. Sikkim

Sikkim SDA completed replacement of inefficient water pumps with star rated water pumps at 2 Nos. Nagar Panchayats i.e., Rangpo, East Sikkim, and Jorethang, South Sikkim.

The replacement of conventional lights & fans with the energy efficient ones has been completed in 95 Nos. of schools across the State.

Sikkim SDA completed replacement of existing lights & fans with energy efficient ones at Geyzing District Hospital, West Sikkim and Namchi District Hospital, South Sikkim.

Sikkim SDA completed replacement of conventional Lights with LED Bulbs and Tube-lights at common property resources in 2 Nos. villages namely Okharey-Ribdi, West Sikkim and Wok, Poklok- Kamrang, South Sikkim.

10.2.24. Tamil Nadu

Existing 2600 Nos. Fans, 2600 Nos. Tube lights, and 700 Nos. CFLs in 100 schools were replaced with energy efficient star rated 28W fans, 20W Tube lights, and 9W LED bulbs respectively.

10.2.25. Telangana

Telangana State Renewable Energy Development Corporation (TSREDCO) Limited, the SDA of Telangana undertook distribution of 204 Nos. 28W Brushless Direct Current (BLDC) Fans to the White Ration card holders in the villages across State.

The SDA completed replacement of conventional luminaries (bulbs and tube-lights) and ceiling fans with energy efficient luminaries and fans in 99 Govt. schools.

10.2.26. Uttarakhand

Uttarakhand Renewable Energy Development Agency (UREDA), the SDA of Uttarakhand has completed the replacement of existing streetlights, luminaries, and fans with energy efficient ones in 26 Nos. villages under Model Energy Efficient Village Campaign.

10.2.27. West Bengal

West Bengal State Electricity Distribution Company Limited (WBSEDCL) completed the replacement of 4 Nos. existing old pumps with star rated energy efficient ones at Power-House Complex, Siliguri.

The replacement of conventional lights & fans with the energy efficient ones has been completed in 29 Nos. of schools in the districts namely Jhargram, Purulia, Bankura, Paschim Medinipur, and Purba Medinipur.

LED tube lights & bulbs have been distributed among the residents of different 16 Nos. remote villages namely, Saldhi, Baralaher, Ranga, Tarpania, Purna Tarpania, Hatinada, Teliabhasa, Pathardi, Gosaidi, Barriya, Bandghutu, Bhitpani, Kusumtikri, Sahebdih, Bhui Ghora and Pitidr located in the vicinity Purulia Pump Storage Project (PPSP) and Bandu Pump Storage Project in Purulia District.

Chapter 11: Conclusion

11. *Conclusion*

Energy sector in India has experienced considerable growth in the last two decades encompassing demand sectors from industrial to transport as well as residential. High urbanization levels, improved electricity access and electrification and increased economic activities impacting these demand sectors have been some of the contributing factors for growth in the power demand. While continued economic growth is an area of focus for the nation, India has also been aware of the importance of sustainable development.

The tentative findings of the report reflect that the adoption of energy efficiency schemes/programs presented in Table 69 has led to the overall thermal energy savings in the order of **21.40 Mtoe**, while overall electricity savings are to the tune of **239.77 BU**. Total, these energy savings translated into monetary savings of worth **INR 152,241 crores** and contributed in reducing **267.98 Million Tonnes of CO_2 emission.**

Table 69: Summary of Energy Saving (2020-21)

Program/ Scheme	Sector	Electricity Savings (BU)	Thermal Savings (MTOE)	Total Energy Savings (MTOE)	GHG Reduction (MtCO2)	Monetary Savings (INR Crore)
PAT- III	Large Industry	0.61	1.69	1.75	6.43	3,483.59
PAT- II		36.47	10.95	14.08	68.43	42,020.59
PAT- I		3.01	8.41	8.67	31.00	9,500.00
PRSF	MSME	0.08	-	0.01	0.06	48.25
BEE-GEF-EESL				0.0019	0.009	3.45
BEE-UNIDO				0.010	0.064	17.84
BEE-FLCTD		0.00015	0.00001	0.000026	0.00080	0.11
ECBC	Commercial Buildings	0.1410	-	0.0121	0.1114	22.31
BEE Star Rating		0.2492	-	0.0214	0.1969	39.43
ENS	Residential Buildings	0.0024	-	0.00021	0.0019	0.38
S&L	Multiple (Appliances)	61.57	0.02	5.29	50.16	36,942.00
	Others (AgDSM, SEAC, etc.)	0.46		0.04	0.36	275.01
UJALA	LED Lamps	47.78	-	4.10	38.70	19,112.00
	LED (Private Market)	82.00	-	7.05	67.00	32,800.00
SLNP	Municipal	7.40	-	0.64	6.00	5,069.27
FAME	Transport		0.02	0.02	0.05	183.50
CAFE			0.31	0.31	0.92	2,723.13
Total		**239.77**	**21.40**	**42.00**	**267.98**	**1,52,240.80**

Highlights from each scheme / programme in FY 2020-21:[87]

Industry Sector

PAT Scheme[88]

Interventions in large industries, DISCOMs, Railways, & Buildings under PAT Scheme has led to total energy savings of 24.50 Mtoe (Thermal energy savings of 21.89 Mtoe and 40.09 BU of the electrical energy savings) under PAT cycle I, II and III as seen in Table 70.

Table 70: Energy Savings under PAT Cycle I, II and III

PAT Cycle	Electricity Savings (BU)	Thermal Savings (MTOE)	Total Energy Savings (MTOE)	GHG Reduction (MtCO2)
PAT- III	0.61	1.69	1.75	6.43
PAT- II	36.47	10.95	14.08	68.43
PAT- I	3.01	9.25	8.67	31.00

MSME sector

BEE-SME program was focused in four clusters (Gujarat, Assam, West Bengal, Punjab, Tamil Nadu) during FY 20-21. Energy efficiency and technology upgradation interventions carried out by BEE have led to savings of 1,876 toe and emission reduction of 8,924 tonnes of carbon dioxide annually.

BEE-UNIDO program was operational in 23 clusters during FY 20-21. Under the program, several energy efficiency and renewable energy initiatives have led to energy savings of over 9,695 toe and has contributed to reduction of 64,952 tonnes of carbon dioxide emissions annually due to interventions carried out during 2017-21.

Standards and Labeling

BEE initiated the Standards and Labeling (S&L) scheme for appliances and equipment in the year 2006, starting with voluntary appliances. During FY 20-21, there are 10 Mandatory appliances and 18 voluntary appliances. This scheme has led to savings of 62 BU of energy annually and remains the largest contributor to electrical energy savings. Color television, Room Air conditioner, and Refrigerator contribute to the maximum share of energy savings, among the labeled appliances. This programme has led to a reduction of 50.16 Mn tonnes of carbon dioxide emissions annually. Sales of the some of the appliances might be impacted due to national lock down during 2020-21.

[87] M&V data for 100 DC under PAT III has been considered
[88] Updated data for Energy saving of PAT Cycle – II is consolidated data for 544 DCs.

Table 71 Energy Savings in FY 20-21 for appliances sold during FY 2017-21 [89]

S. No	List of Appliances	FY: 2017-18 (MU)	FY: 2018-19 (MU)	FY: 2019-20 (MU)	FY 2020-21 (MU)	FY: 2017-21 (MU)
Mandatory Appliances						
1.	**Frost Free Refrigerator**	1967	2178	1558	1279	6982
2.	**TFL**	570	365	176	179	1290
3.	**RAC (Fixed Speed)**	3329	1794	1367	688	7178
4.	**Direct Cool Refrigerator**	4459	5072	3634	2374	15539
5.	**Distribution Transformer**	403	628	244	425	1700
6.	**Color Television**	3806	3749	2412	2023	11990
7.	**Stationary Type Water Heater**	472	563	437	380	1852
8.	**Room Air Conditioner (Variable Speed)**	1461	999	807	1092	4359
9.	**LED Lamps***	65	695	939	810	2509
	Voluntary Appliances					
10.	**Pump set (Submersible and open well)**	2347	3017	1505	480	7349
11.	**Ceiling Fan**	191	156	90	168	605
12.	**Washing Machine**	-	-	17	29	46
13.	**Computer**	-	-	-	0	0
14.	**Mono-set Pump**	46	50	28	18	142
15.	**Chiller**	-	-	1	4	6
Total Savings (BU)		**19**	**19**	**13**	**10**	**62**

Saving of domestic LPG stoves is presented in in Table 72.

Table 72: Energy saving due to sale of Domestic LPG stoves during 2017-21

Year	Q1	Q2	Q3	Q4	Total (toe)
2017-18	490	562	345	238	1635
2018-19	330	450	279	308	1367
2019-20	793	1453	487	145	2879
2020-21	879	1445	847	298	3469
Total (2017-21)	**2492**	**3910**	**1958**	**989**	**9350**

[89] Energy saving estimated form LED considered under UJALA programme during 2018-20 are discounted tin the total saving figure

Buildings

ECBC

Energy Conservation Building Codes - ECBC 2017 for new commercial building construction in India is estimated to lead to a 50% reduction in electricity use by 2030. As on 31st March 2021, 227 buildings have been registered under ECBC. The 227 constructed and ECBC compliant buildings with total area of 3.52 Million square meter have led to energy savings of 141.65 MU as seen in Table 73.

Table 73: Energy Savings from ECBC Compliant Buildings

Financial Year	No. of Buildings	Energy Savings in MU	Total Area in Mn. Sqm
2017-20	54	115.50	1.62
2020-21	154	26.15	1.90
Total	**227**	**141.65**	**3.52**

BEE Star Rating for Buildings

Under the BEE star rating scheme, existing buildings are being labeled as per their actual Energy Performance Indices (EPI) on a scale of 1 to 5 stars. The sets of standard EPI bandwidths developed to rate buildings under this scheme for different climatic zones indicate the range of variations. As on 31st March 2021, 264 buildings have been labeled under the programme. During FY 16-21, 63 Offices, 17 BPOs, 4 Hospitals, and one shopping mall have been certified with star label leading to energy savings of 249.2 MU as seen in Table 74.

Table 74: Energy Savings and Carbon Emissions Reduction from BEE Star Rated Buildings

Building Type	Energy Savings in MU						CO_2 Emission Reductions (MntCO2)
	2016-17	2017-18	2018-19	2019-20	2020-21	Total	
Offices	0.5	6.2	7.9	51.5	14.3	80.4	0.0635
BPO	0.0	28.6	40.8	86.2	0.0	155.6	0.1229
Hospital	0.0	0.0	3.5	0.9	0.0	4.3	0.0034
Mall	0.0	0.0	8.9	0.0	0.0	8.9	0.0070
Total	**0.5**	**34.8**	**61.0**	**138.6**	**14.3**	**249.2**	**0.1969**

UJALA

EESL, under UJALA programme, is promoting energy efficiency through LED lamps, Energy efficient tube lights and energy efficient fans. EESL has sold 15.5 crore LED lamps during the FY 2017-21. This programme has saved over 25.42 BU and has led to avoidance of 20.84 million tonnes of carbon dioxide emissions annually.

Table 75: Energy savings from UJALA programme[90]

Year	Energy savings (MU): LED lamps	Energy savings (MU): LED Tube lights	Energy savings (MU): EE Fans
FY 17-18	10,195	153	99
FY 18-19	7,436	57	55
FY 19-20	1,533	9	10
FY 20-21	630	5	3.96
Total	**19,794**	**224**	**168.0**

SLNP

Street Lighting National Programme (SLNP) is being implemented in 28 States/UTs, to replace the conventional street-lights with BEE star rated energy efficient street-lights with no upfront cost to the ULBs. Working on an ESCO based model, EESL will recover the cost from the savings generated by the replacement of street-lights. This programme has saved over 6.47 BU and has led to avoidance of 4.46 Mn tonnes of carbon dioxide emissions annually.

Agriculture

BEE has made significant efforts towards mandating the use of EE pumps in agriculture by involving state regulatory commissions. Under AgDSM programme, BEE is organizing training programs for pump technicians who have a major role to play in replacing old inefficient pumps with BEE star rated pump sets. BEE and ICAR has signed an MoU to conduct training and awareness programs for farmers to promote the use of EE agricultural pump sets

Under AgDSM programme EESL has been retrofitting BEE star rated pump sets in Andhra Pradesh, Karnataka, and Uttar Pradesh, during FY17-21. A total of 76,899 energy efficient star rated pump sets have been installed, which has led to energy savings of 0.2 BU and avoidance of 0.164 Mn tonnes of carbon dioxide emissions.

Transport

Corporate Average Fuel Economy (CAFE)

Several initiatives in improving the fuel efficiency norms for vehicles had been carried out in recent years. In 2015, the government of India established corporate average fuel consumption standards for passenger cars taking effect as two-phase targets for FY 2017–2018 and for FY 2022–2023 onward. In August 2017, CAFÉ Norms were established for Heavy Duty Vehicles (HDV), and in 2019 these Norms were established for light commercial vehicles.

The standard for a manufacturer is set in terms of gasoline-equivalent liters per 100 kilometers (L/100 km) based on vehicle curb weight. This intervention has led to energy saving of 0.31 Mtoe during FY 20-21 and 0.92 million tonnes of CO_2 reduction.

Faster Adoption and Manufacturing of Electric Vehicles (FAME)

[90] Energy Savings due to fans is considered under S&L programme

FAME I and FAME II have been developed to promote electric vehicles (EV) and Public EV charging infrastructure towards cleaner road transport. This program has led to energy savings of 0.02 Mtoe and 0.052 Mn tonnes of carbon dioxide emission reductions during FY 20-21.

BEE is also supporting various projects to promote Public EV charging infrastructure across the country. These initiatives aim to provide impetus for Indian e-vehicle manufacturers, charging infrastructure companies, service providers, etc. to gain efficiencies of scale and drive down costs in the electric mobility ecosystem.

11.1. Impact of various energy efficiency measures undertaken during 2020-21

Energy consumption across all the sectors of the economy has increased in the past few years and with growing economy & rapid urbanization, it is expected to increase further in the coming years. Per capita energy consumption of India is estimated as 0.6557 Mtoe and the energy intensity of Indian economy is 53.4 kcal per INR.[91]

Energy Savings (Demand Side)

The energy efficiency schemes at national as well as state level carried out by BEE and other agencies has led to the reduction of 23.72 Mtoe in the demand side energy consumption. A summary of the energy savings across various sectors of the economy is presented in Table 76.

Table 76: Sector wise energy savings in demand-side section

Sector	Energy[92] savings in FY 2020-21 (Mtoe)
Industry (Excluding TPP, DISCOMs, and Refineries)[93]	13.29
Domestic (S&L and UJALA)	9.42
Commercial Buildings	0.034
SLNP	0.64
Transport	0.33
Total	**23.72**

[91] "Energy statistics, 2022 of India (Table 8.4)". CSO, GoI. Retrieved 27 January 2022.
[92] Total energy including thermal and electrical energy
[93] Energy Savings from TPP, Refineries & DISCOMs is not considered for demand side energy savings

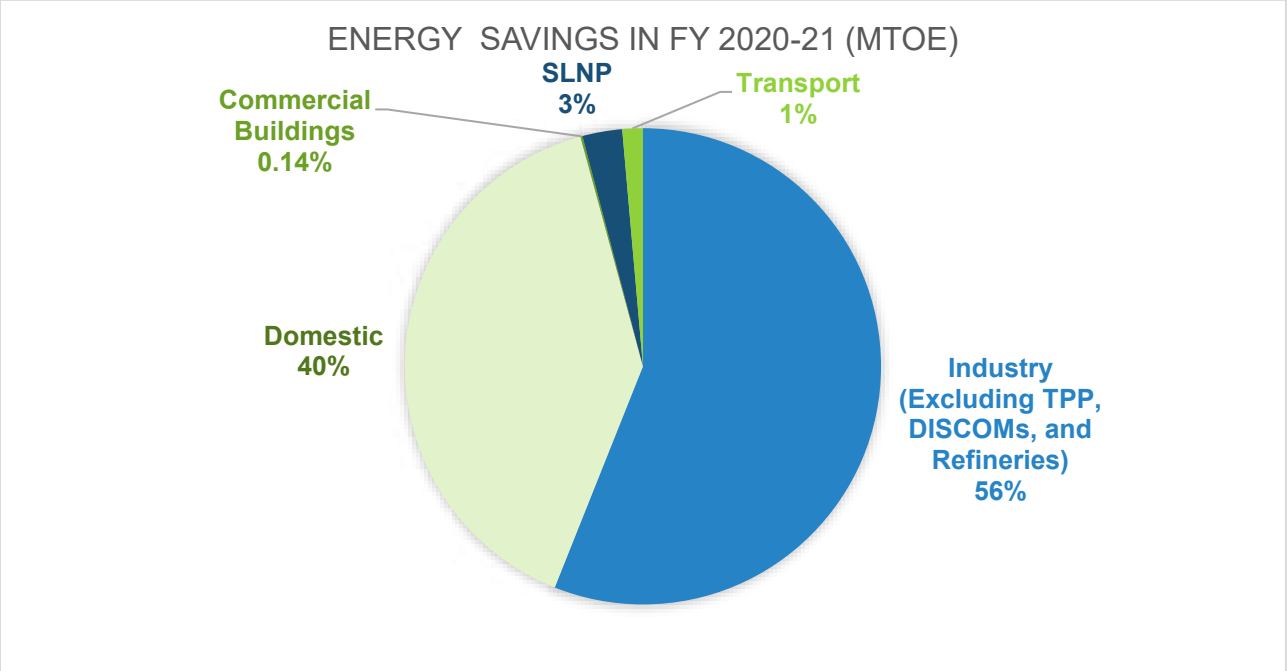


Figure 70: Share of Energy Savings across sectors of the economy

Industry sector has contributed to 56% of the total energy savings while domestic sector has contributed to 40% of the total savings achieved during FY 20-21. While remaining sectors contributed to around 4.14% of total energy savings for 2020-21.

Electrical energy Savings (Consumption Side)

Adoption of energy efficiency schemes/programmes as considered for this study has reduced the overall electricity consumption by 210 BU. This has led to the reduction of 9.71% of the electrical energy requirement (1186 TWh)[94] across various sectors of the economy in 19–20.

Table 77: Sector wise electrical energy savings (BU) in demand-side section

Sector	Electrical Energy Savings 2020-21 (BU)
Industry (Excluding TPP, DISCOMs, & Refineries)[95]	10.40
Domestic (S&L and UJALA)	109.81
Commercial Buildings (Including buildings under PAT)	0.39
Agriculture (Star Rated Pumps)	0.20
Others (Including Municipal)	89.40
Total	**210.00**

[94] 1186 is calculated by inflating the energy consumption values of 2018-19 by CAGR of 2.4 (2016-17 to 2017-18) as reported in MoSPI 2019 statistics. (Table 6.9: Consumption of Electricity by Sectors in India)
[95]Electrical savings from DISCOMs, & Refineries are considered for supply side and not considered here

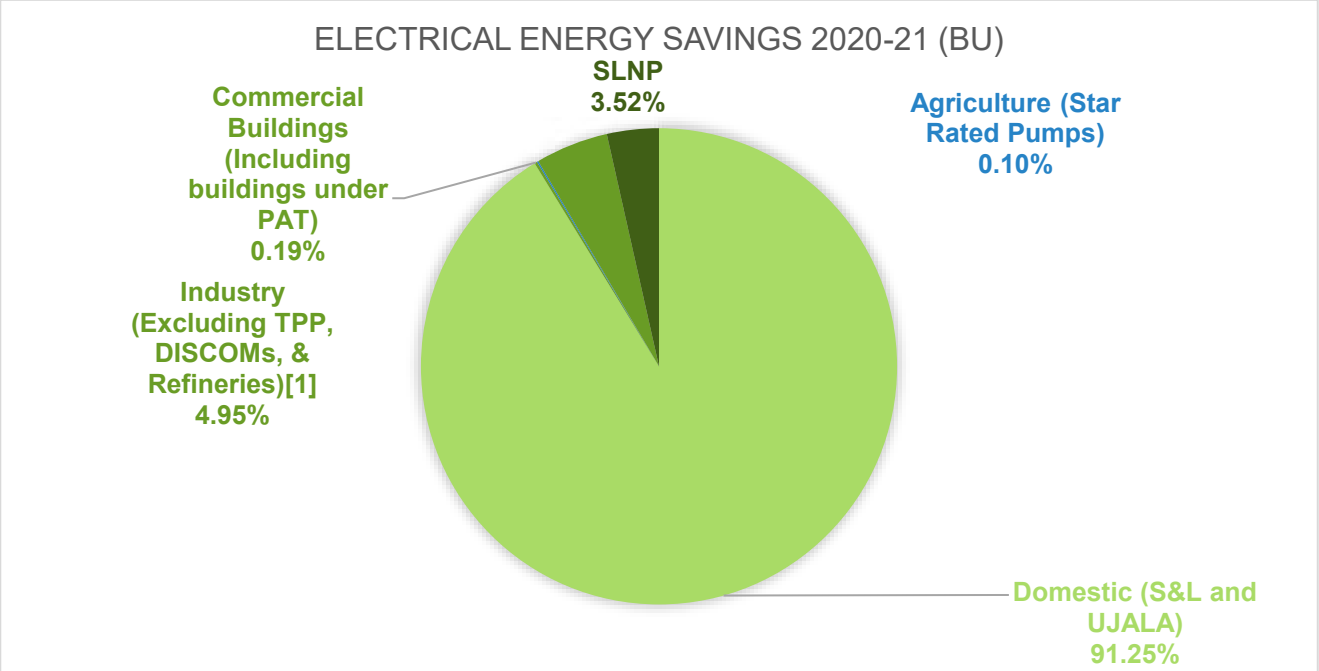


Figure 71: Share of Electrical Energy Savings across sectors of the economy

Domestic sector has the highest contribution (91.25%) in the total electrical energy savings from all energy efficiency interventions carried out during FY 2020-21.

11.1.1. Way Forward

India ratified the Paris Agreement on Climate Change in 2016 under which its member countries have given commitments to keep global average temperatures rise below 2-degree C by the end of century. India in its Nationally Determined Contributions (NDCs) has committed that it will reduce the emission intensity of its GDP by 33% to 35% by 2030 from 2005 level.

In the recent Conference of Parties (COP -26) held in Glasgow, UK, the enhanced ambitions announced by India are as given below:

I. India will meet 50 per cent of its cumulative electric power installed capacity with non-fossil fuel sources by 2030. This will include achieving 500 GW of power capacity from non-fossil sources.
II. By 2030, India will reduce the carbon intensity of its economy to less than 45 per cent from 2005 level. This will be achieved by additional reduction of 1 billion tonne of CO2 emissions from now onwards.
III. By 2070, India will achieve the target of net zero emissions

To achieve these enhanced targets, it would be necessary to continue aggressively with its ongoing interventions and also enhance the policy coverages. Ministry of Environment, Forests and Climate Change (MoEFCC) had requested that all the Climate change Missions be revised to ensure fulfilment of the commitments made by India under the NDCs. Accordingly, Bureau of Energy Efficiency (BEE) under the guidance of Ministry of Power, had developed a strategic

plan to contribute towards India's NDCs by 2030 through a systemic Energy Transition programme.

Further for assessing the potential of emission reduction from various sectors of the economy, a document namely 'Unlocking National Energy Efficiency Potential (UNNATEE) was prepared in which different scenarios for achieving the NDC goals were analyzed. UNNATEE lays a framework as well as implementation strategy, in the short and medium term, to establish a clear linkage between energy demand scenarios and energy efficiency opportunities. The national target for energy efficiency savings and implementable roadmap to be achieved in the next ten years has been established through the UNNATEE document. Building on the potential areas identified in the UNNATEE and taking into account the existing schemes of the Bureau, a detailed action plan till 2030-31 has been worked out.

To align objectives of the erstwhile NMEEE with the revised goals under the NDCs, the mission is revised with the title Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE). Mission ROSHANEE has a broader vision and takes into account all the potential areas of energy efficiency in key sectors of the economy, covering the macro level in policy and further delineating the respective schemes. The revised mission includes all existing activities of BEE that have contributed significantly towards enhancing energy efficiency and consequent CO2 mitigation and the activities proposed in future, some of which have been identified and others which need to be explored. Mission ROSHANEE clearly outlines the strategies that needs to be adopted for achieving India's Nationally Determined Contribution commitments made under the Paris Agreement.

The current policy and program implementation landscape of the country shapes the energy consumption of the demand sectors. Current schemes/programs were largely successful in achieving significant energy savings across various sectors viz. Industry, building (domestic and commercial), municipal, agriculture, and transport. However, in 2020, the coronavirus pandemic has exacerbated many of the existing challenges the energy sector faces to its financial and physical resilience.

India has suffered the devastating impacts of Covid-19, raising health, economic and social challenges. However, when the Indian economy will come back to pre-Covid levels by the next financial year (2021-22), the resilience of the power sector has become critical. It is this crisis and the government's response BEE's National Strategic Plan on Energy Efficiency includes these relatively new technologies such as E-mobility, fuel cell vehicles (FCVs), integration of renewables & storage, net zero buildings, district cooling, smart meters, internet of things, active appliance feedback, blockchain technologies etc. for decarbonizing various sectors of the economy. Energy saving through adoption of new technologies, increasing the scope of the wide gamut of energy related policies and programs and sensitizing the consumers towards the importance of saving energy in their day to day lives would go a long way in making India energy secure, self-reliant and resource efficient.

Acknowledgement and Notice to reader

The study “Impact of Energy Efficiency Measures for the year 2020-21” is the outcome of the collaborative efforts of the Bureau of Energy Efficiency (BEE) and KPMG India Services LLP (‘KPMG India’) subsequent to engagement between BEE and KPMG India. The performance of KPMG India’s services and the report issued to BEE are based on and subject to the terms of the engagement contract with BEE.

The KPMG India- ESG team extends its profound thanks to **Mr. Abhay Bakre**, Director General (BEE), for his leadership and guidance during the execution of the assignment. KPMG India acknowledges the co-operation and the support extended by **Mr. Arijit Sengupta,** Director (BEE) for supervising the assignment throughout the execution phase. The team appreciates Project Engineers (BEE), **Mr. Siddarth Dhar, Mr. Manish Kumar** and **Mr. Sumit Mudgal**, for their support in coordination with various ministries and agencies.

This study was carried out under the guidance of Mr. Manpreet Singh (Partner, KPMG India), Ms. Apurba Mitra (Associate Partner, KPMG India), Ms. Amrita Ganguly (Technical Director, KPMG India) and Ms. Sohini Ghosh Mukherjee (Manager, KPMG India) who led the project activities, and under their leadership, KPMG Consultants, Mr. Akash Vajpai, Mr. Puneet Khare and Mr. Saqib Khan carried out the stakeholder consultations, data collection, and energy saving estimations for measuring the impact of energy efficiency measures for the FY 2017-21.

KPMG India would like to acknowledge and express our gratitude to all the stakeholders who have provided valuable inputs, suggestions and support during the course of the study. Their insight and suggestions have helped us put together the findings and results of the energy savings obtained through various EE programmes/schemes being implemented in India.

KPMG India also acknowledges the support provided by the government ministries and agencies during the stakeholder consultation. The list of Ministries and agencies include Ministry of Power (MoP), Central Electricity Authority (CEA), Ministry of Micro, Small and Medium Enterprises (MoMSME), Ministry of Statistics and Programme Implementation (MOSPI), Ministry of Railways, Department of Heavy Industries (DHI), International Centre for Automotive Technology (ICAT), Energy Efficiency Services Limited (EESL), and others.

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