सत्यमेव जयते
Government of India

A REPORT ON

IMPACT OF ENERGY EFFICIENCY MEASURES

FOR THE YEAR 2017-18

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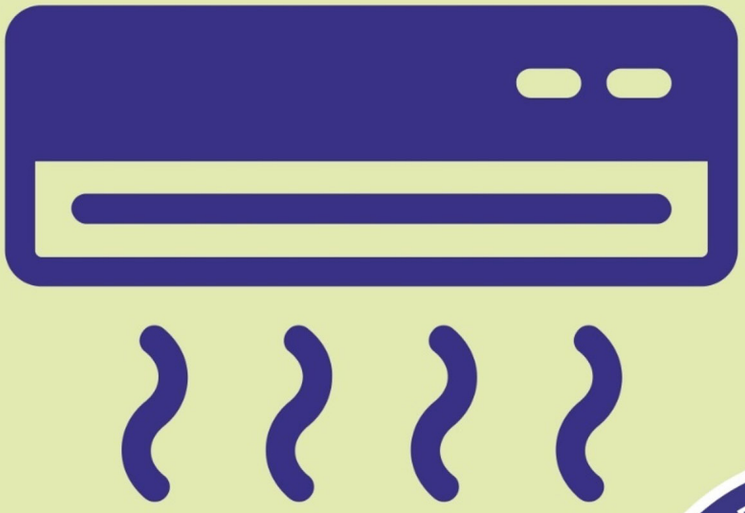
MAKING OUR PLANET
HEALTHIER

MONTHLY BUDGET PAR NAHI ZOR

WHEN AC @ 24°C



- Every increase of 1°C in temperature setting saves 6% on your electricity bill
- Running AC at 24°C instead of 18°C saves 36% of electricity and bill
- 24°C is more comfortable

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Preface

Energy efficiency provides 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 then initiating National Mission for Enhanced Energy Efficiency (NMEEE).

Rolling out several schemes to conserve energy is one aspect, but assessing their impact on ground help to understand their actual effectiveness. Therefore, an impact assessment of all the schemes related to energy efficiency is required. In FY 2016-17, BEE had conducted a third party assessment of annual energy savings of its own set of schemes for the last 10 years (2007-2017). Along with BEE, there are other organisations at national level that are also supporting in energy efficiency by launching its own set of schemes.

With respect to the related energy efficiency schemes, the Government has directed BEE to **conduct a study comparing the actual energy consumption in 2017-18 with the estimated energy consumption had the current energy efficiency measures were not been undertaken i.e. counterfactual.**

In compliance to this direction, BEE hired the services of an expert agency through competitive bidding to conduct the study. The overall objective of this study was to assess the impact of all the energy efficiency schemes/programmes in India in terms of total energy saved and reduction in the amount of CO_2 emissions in 2017-18. This assignment has taken energy efficiency estimation based on impact of the schemes/ programmes since FY 2014-15.

The objective of this study is to assess the overall impact of all the energy efficiency schemes at national as well as state level for the FY 2017-18 and compare it with a situation where the same were not been implemented. This study focused on following schemes/programmes, viz. Perform, Achieve and Trade Scheme, Standards & Labeling Programme, UJALA Programme, ECBC – Commercial Buildings Programme, BEE Star rated buildings, Building Energy efficiency Programme, 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/programmes have led to the overall electricity savings to the tune of 86.60 BU in 2017-18, which is 7.19% of the net electricity consumption (1204.7 BU). Similarly, total energy (electrical + thermal) saved is to the tune of 15.06 MTOE, which is 2.69% of the net total energy consumption (559 MTOE) and, 16.62 MTOE, which is 1.97% of the net energy supply (843.8 MTOE). Overall, this study has estimated that various energy efficiency measures have translated into savings worth INR 53,627.78 crores (approximately) and contributed in reducing 108.29 Million Tonnes of CO_2 emission.

February 2019
New Delhi

Abhay Bakre
Director General, BEE

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Abbreviations

AC	Air Conditioning
AEA	Accredited Energy Auditors
AgDSM	Agriculture Demand Side Management
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BEE	Bureau of Energy Efficiency
BEEP	Building Energy Efficiency Programme
BPO	Business Process Outsourcing
BU	Billion Unit
CCMS	Central Control Monitoring System
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CESC	Chamundeshwari Electricity Supply Corporation Limited
CGTMSE	Credit Guarantee Fund Trust for Micro and Small Enterprises
CII	Confederation of Indian Industry
DC	Designated Consumer
DISCOM	Distribution Company
DPR	Detailed Project Report
EC Act	Energy Conservation Act
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EEPS	Energy Efficiency Pump Sets
EESL	Energy efficiency Services Limited
ELCOMA	Electric Lamp and Component Manufacturers
EPF	Envelope Performance Factor
EPI	Energy Performance Index
ESCerts	Energy Saving Certificates
ESCO	Energy Service Company
FY	Financial Year
GBCI	Green Business Certification Incorporation
GEF	Global Environment Facility
GRIHA	Green Rating for Integrated Habitat Assessment
GST	Goods and Service Tax
GTKM	Gross Tonne Kilo Meters
HP	Horse Power
HVAC	Heating, Ventilation and Air Conditioning
IAME	Independent Agency for Monitoring and Evaluation
IEX	Indian Energy Exchange
IGBC	Indian Green Building Council
IGEA	Investment Grade Energy Audit
INDC	Intended Nationally Determined Contributions
kcal	Kilo Calories
kWh	Kilowatt Hour
LED	Light Emitting Diode

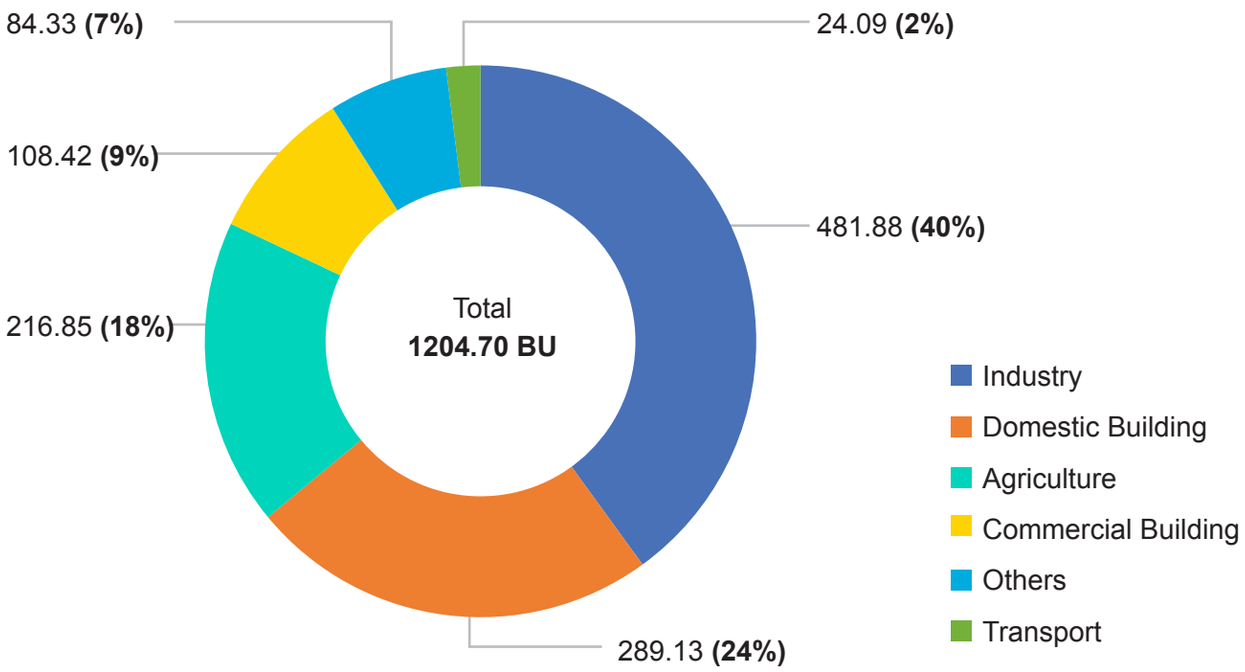
LEED	Leadership in Energy and Environmental Design
LPG	Liquid Petroleum Gas
LSP	Local Service Providers
MBL	Million Barrels
MBN	Million British thermal unit per thousand barrels per energy factor
MEEP	Municipal Energy efficient Programme
MNRE	Ministry of New and Renewable Energy
MoMSME	Ministry of Micro, Small and Medium Enterprises
MoP	Ministry of Power
MoPNG	Ministry of Petroleum & Natural Gas
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSME	Micro Small & Medium Enterprises
MtCO2	Million tonne of Carbon di Oxide
MTOE	Million Tonne of Oil Equivalent
MU	Million Unit
MuDSM	Municipal Demand Side Management
MWh	Megawatt Hour
NAPCC	National Action Plan on Climate Change
NECA	National Energy Conservation Award
NHR	Net Heat Rate
NMEEE	National Mission for Enhanced Energy efficiency
NTKM	Net Tonne Kilo Meters
OBF	On Bill Financing
PAT	Perform, Achieve and Trade
PCRA	Petroleum Conservation Research Association
PMC	Project Management Consultancy
POSOCO	Power System Operation Corporation Limited
PXIL	Power Exchange of India
S&L	Standards & Labeling
SDA	State Designated Agency
SEC	Specific Energy Consumption
SEEP	Super Energy Efficient Programme
SERC	State Electricity Regulatory Commission
SHGC	Solar Heat Gain Coefficients
SIDBI	Small Industries Development Bank of India
SLNP	Street Lighting National Programme
TFL	Tubular Fluorescent Lamps
TOE	Tonne of Oil Equivalent
TPP	Thermal Power Plant
UDD	Urban Development Department
UJALA	Unnat Jyoti by Affordable LEDs and Appliances for All
ULB	Urban Local Body
UNIDO	United Nations Industrial Development Organization
UNNATEE	Unlock National Energy Efficiency Potential
UNSDG	United Nations Sustainable Development Goals
UT	Union Territories
VLT	Visible Light Transmittance
W	Watt
WBP	Whole Building Performance

Executive Summary

The rapid urbanisation that India has been experiencing off late has made significant structural changes across all the sectors. Such developments have also positively impacted the economic situation of the country and led to increased energy consumption across all the sectors. The net electrical energy consumption and total energy consumption of India in FY 2017-18 was 1204.70 Billion Units (BU) and 559 Million Tonne of Oil Equivalent (MTOE) respectively. The share of total energy (Thermal & Electrical) consumed across all the sectors, viz. Industry, building (domestic and commercial), municipal, agriculture, transport (railways) and others (municipality and miscellaneous open access users) is seen in figure 1 & 2.

Figure 1: Sector wise electrical energy consumption of India (2017-18)

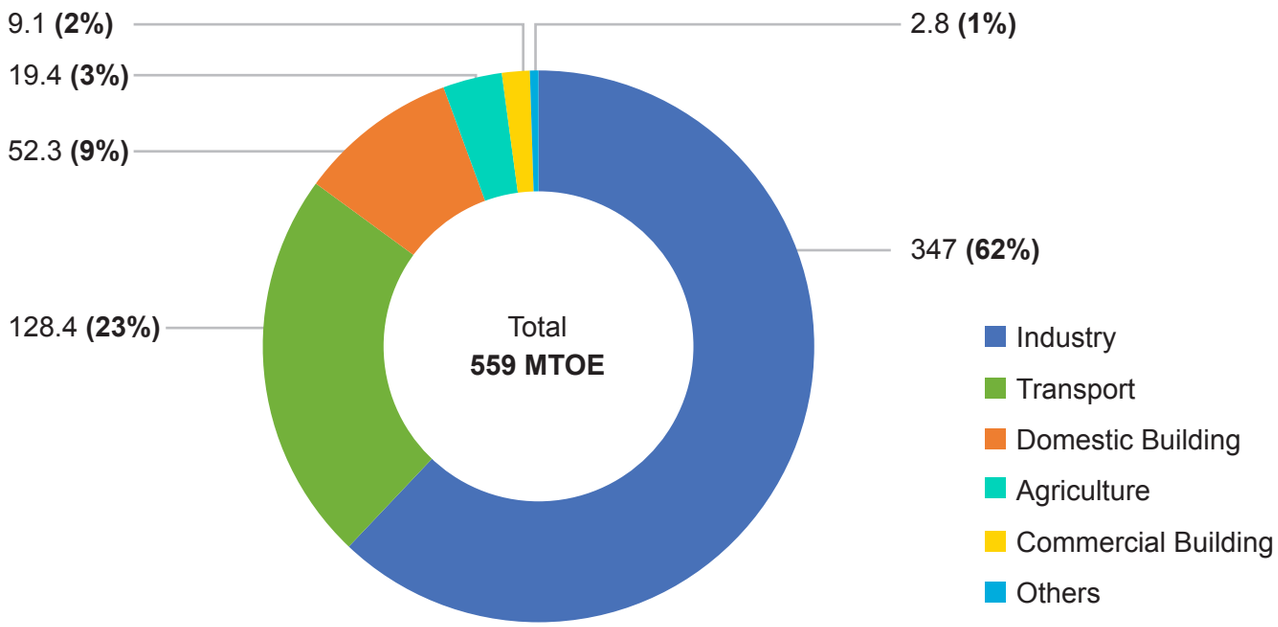
Share of electrical energy consumption (value in BU, %)



[1]Source: Load Generation Balance Report 2018-19, Central Electricity Authority

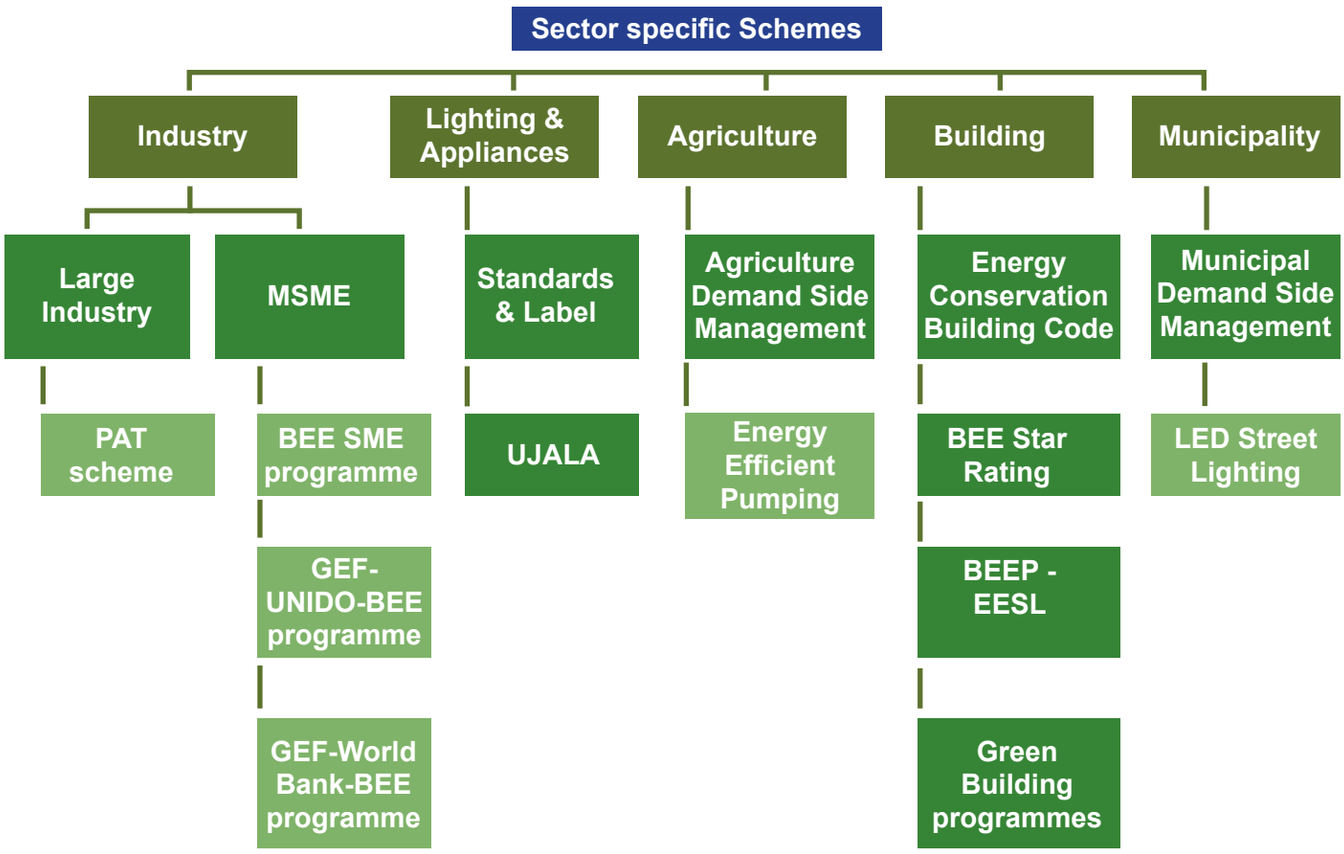
Figure 2: Sector wise total energy consumption of India (2017-18)

Share of total energy consumption (value in MTOE, %)



Energy consumption across all the sectors has increased in the past few years and with rapid urbanisation it is expected to increase further in the coming years. 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 design several policies to curb the unnecessary energy consumption across all the sectors. Hence, in the last few years, the Government of India has launched several schemes/programmes (as seen below) for various sectors to manage the excessive energy consumption.

Figure 3: List of energy efficiency schemes across India



With respect to the related energy efficiency schemes, in the last infrastructure review meeting held under the Chairmanship of Hon'ble Prime Minister on 07.08.2018, one of the action points related to BEE was to **conduct a study comparing the actual energy consumption in 2017-18 with the estimated energy consumption had the current energy efficiency measures were not been undertaken i.e. counterfactual.**

In compliance to this direction, BEE hired the services of an expert agency through competitive bidding to conduct the study. The overall objective of this study was to assess the impact of all the energy efficiency schemes/programmes in India in terms of total energy saved and reduction in the amount of CO_2 emissions in 2017-18. This assignment has taken energy efficiency estimation based on impact of the schemes / programmes since FY 2014-15.

In order to meet the objective of this study, the expert agency had detailed consultations with all departments / agencies / bodies involved in implementing energy saving measures across the country. The expert agency reviewed the data provided by BEE, Energy efficiency Services Limited (EESL), Petroleum Conservation Research Association (PCRA), Electric Lamp and Component Manufacturers (ELCOMA), World Bank, Small Industries Development Bank of India (SIDBI), United Nations Industrial Development Organization (UNIDO), Indian Green Building Council (IGBC), Green Business Certification Incorporation (GBCI), and Green Rating for Integrated Habitat Assessment (GRIHA).

The tentative findings of the report reflects that the adoption of energy efficiency schemes/programmes as seen in Figure 3 has led to the overall **electricity savings in the tune of 86.60 BU, which is 7.19% of the net electricity consumption (1204.7 BU) in 2017 – 18.**

Similarly, total energy saved is in the order of 15.06 MTOE, which is 2.69% of the net total energy consumption (559 MTOE) and 16.62 MTOE, which is 1.97% of the net total energy supply (843.8 MTOE). Overall, this translated into savings worth INR 53,627.78 crores (approximately) and contributed in reducing 108.29 Million Tonnes of CO_2 emission.

Table 1: The summary of impact of each programme/scheme is as seen in the table below:

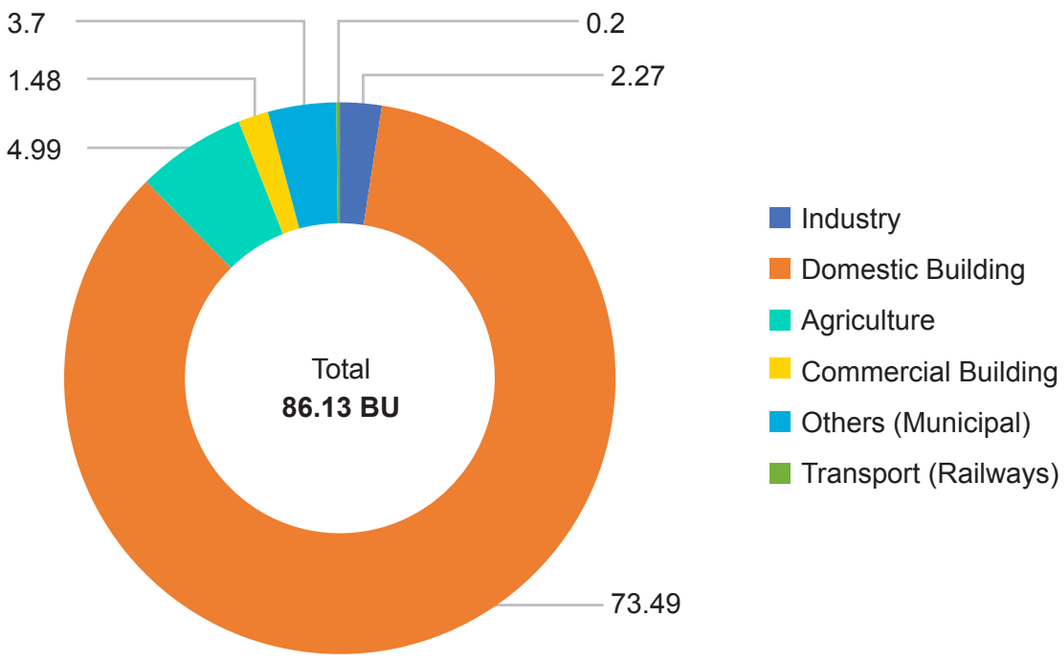
Name of the scheme / programme		Energy Saved		Reduction in CO_2 emission ($MtCO_2$)	Monetary Savings (INR in Crore)
		Thermal (MTOE)	Electrical (BU)		
PAT Scheme	Energy Consumption side (all sectors excluding TPP)	7.821	2.47	30.66	9,813.07
	Energy supply side (TPP)	1.56	0.54	6.31	1,981.00
BEE – SME Programme		0.00117	0	0.00393	1.28
GEF – UNIDO – BEE Programme		0.00912	0	0.11	10.00
GEF – World Bank Programme – BEE		0.021	0	2.12	23.03
UJALA Programme		0	31.43	26	15,715.00
Standards & Labeling Programme		0	48.46	40.03	24,231.60
ECBC – Commercial Buildings Programme		0	0.0056	0.0046	2.80
BEE Star rated buildings*		0	0.2	0.18	100.00
Building Energy Efficien Energy efficiency Programme*		0	0.053	0.044	26.50
AgDSM Programme*		0	0.07	0.056	35.00
MuDSM Programme		0	3.7	3.05	1,850.00
TOTAL		**9.41**	**86.60**	**108.29**	**53,627.78**

*- Electrical energy savings (BU), reduction in CO_2 emission ($MtCO_2$) and Monetary Saving (INR in Crores) are already included under S&L programme. Hence in the TOTAL savings (energy, emission and monetary), the respective values of BEE Star rated building scheme, BEEP and AgDSM programme are not considered.

As most of these schemes/programmes are cross-sectoral in nature, they have successfully managed to save electrical energy across all the sectors as compared to total electrical energy consumed by them in FY 2017-18, as seen in Figure 4. The total electrical energy saved is 7.14% of the net total electrical energy consumption (1204.7 BU).

Figure 4: Impact of energy efficiency schemes and programmes in saving Electrical Energy across the sectors in 2017-18

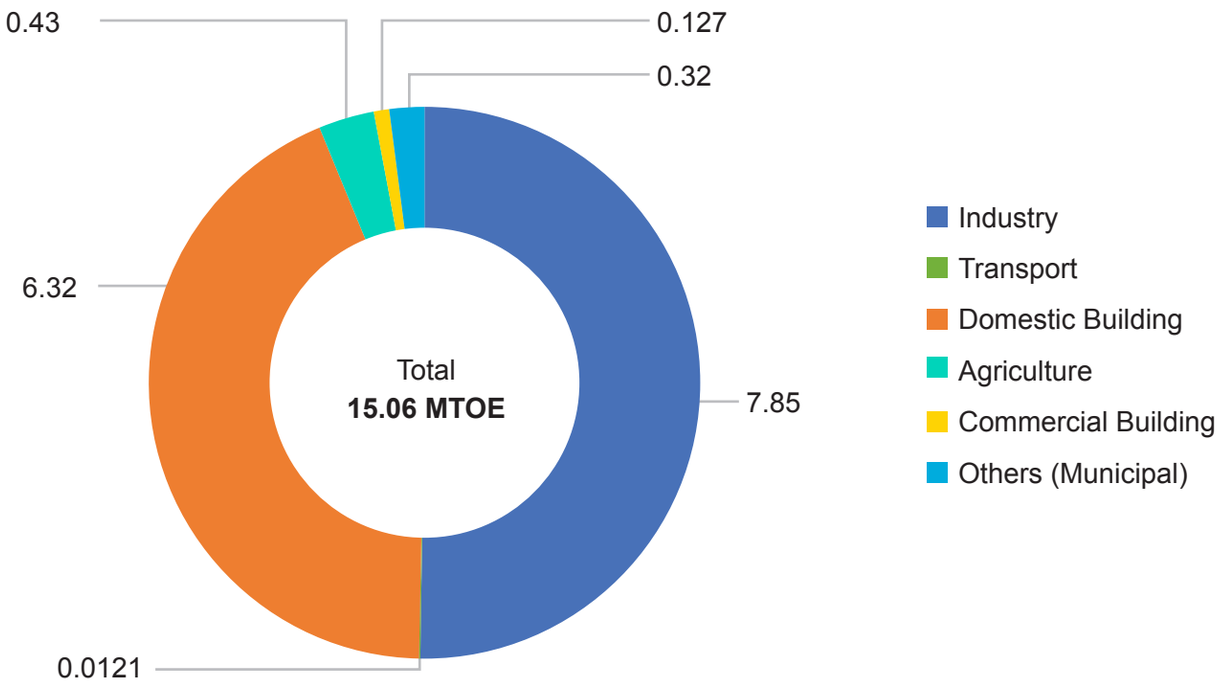
Share of electrical energy saved (value in BU)



Similarly, total energy saved across all the sectors in FY 2017-18 is 2.69% of the net total energy consumption (559 MTOE). The share of same is seen in Figure 5.

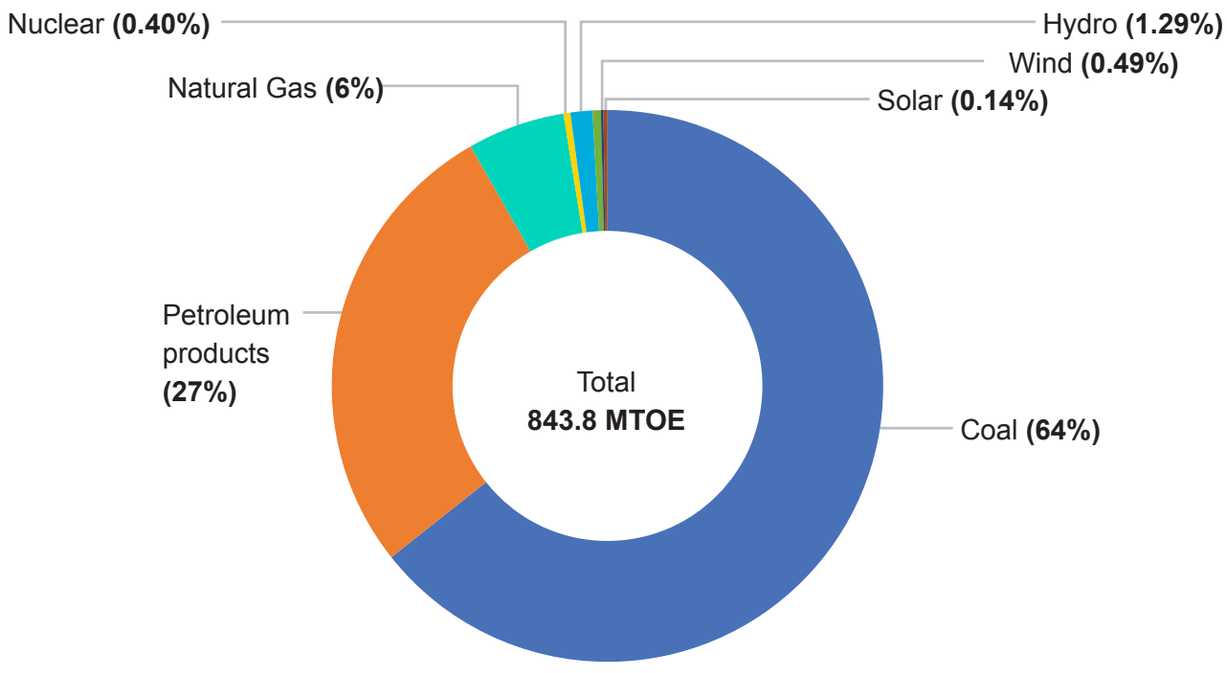
Figure 5: Impact of energy efficiency schemes and programmes in saving total energy across the sectors in 2017-18

Share of total energy saved (value in MTOE)



Also, along with the consumption side, total 1.97% of the net energy supply (843.8 MTOE) has been saved as compared to total energy supplied by different fuel sources in FY 2017-18. The share of same is seen in Figure 6.

Figure 6: Share of energy supply in 2017-18



Energy Supply (2017-18)

The important highlights from each energy efficiency scheme /programme in FY 2017-18 is as below:

1.0 **Perform Achieve and Trade Scheme (PAT):** Total energy (thermal) saved by notified designated consumers equals to 9.381 MTOE. This saving is worth INR 11,794.08 crore and it has contributed to the reduction of 36.97 Million Tonne of CO_2.

The share of sector specific energy saving is as seen below:

Sr. No	Sector	Energy (Thermal) saved (MTOE)	% Share of energy saved
1	**Iron & Steel**	3.664	39%
2	**Thermal Power Plant**	1.56	17%
3	**Refinery**	1.115	12%
4	**Aluminum**	1.092	12%
5	**Cement**	0.924	10%
6	**Paper & Pulp**	0.404	4%
7	**Railways**	0.211	2%
8	**Fertilizer**	0.2	2%
9	**Textile**	0.149	2%
10	**Chlor Alkali**	0.061	1%
Total Energy Saved (up to FY 2017-18)		**9.381 MTOE**	**100%**

2.0 **Standards & Labeling Scheme:** The major 14 appliances[2] under this scheme have shown energy (electrical) savings of 48.46 BU. This saving is worth INR 24,231.60 crores and it has contributed to the reduction of 40.03 Million Tonne of CO_2. Contribution of remaining appliances in energy savings is negligible.

The share of energy saving by each appliance is as seen below:

Sr. No	Products	Energy savings (MU) 2017-18
1	**Direct Cool Refrigerator**	13,893.89
2	**Room Air Conditioner (Fixed Speed)**	13,161.42
3	**Color Television**	5,150.30
4	**Frost Free Refrigerator**	5,496.75
5	**Submersible Pump Set**	3,702.50

[2]Note: Direct Cool Refrigerator, Room Air Conditioner (Fixed Speed), Color Television, Frost Free Refrigerator, Submersible Pump Set, Tubular Florescent Lamps, Room Air Conditioner (Variable Speed), Stationary Type Water Heater, Open well Submersible Pump Set, Distribution Transformer, Ceiling Fan, LED Lamps, Mono set Pump, and Computers.

Sr. No	Products	Energy savings (MU) 2017-18
6	**Tubular Florescent Lamps**	2,353.58
7	**Stationary Type Water Heater**	1,269.65
8	**Distribution Transformer**	1,224.39
9	**Open well Submersible Pump Set**	1,155.16
10	**Room Air Conditioner (Variable Speed)**	439.01
11	**Ceiling Fan**	472.88
12	**Monoset Pump**	133.49
13	**LED Lamps**	66.81
14	**Computer**	6.42
TOTAL Energy (electrical) Saved in MU		**48,526.27**

The total energy (electrical) saved by LED Lamps that equals to 66.81 MU has been subtracted from the total energy (electrical) savings as seen above. The reason is to avoid any duplication as the same has been considered in the UJALA scheme. Therefore, the total energy (electrical) saved under S&L programme in FY 2017-18 is 48.46 BU.

3.0

UJALA Scheme: Total 29.73 crore of LED bulbs and 54.77 lakhs of LED Tube lights were distributed and installed upto 31.03.2018. It has shown energy (electrical) savings of 31.43 BU. This saving is worth INR 15,715 crores and it has contributed to the reduction of 26 Million Tonne of CO_2.

4.0

In the MSME sector, following three programmes were launched in India:

4.1 BEE SME Programme: This programme catered to four sectors, viz. Food, Forging, Bricks and Textile. Total energy (thermal) saved (based on the collected data) is 0.00117 MTOE. This saving is worth INR 1.28 crore and it has contributed to the reduction of 0.00393 Million Tonne of CO_2.

4.2 GEF – UNIDO - BEE Programme: This programme catered to five sectors, viz. Brass, Ceramics, Dairy, Foundry, and Hand tools. Total energy (thermal) saved is 0.0091 MTOE. This saving is worth INR 10 crores and it has contributed in reduction of 0.11 Million Tonne of CO_2.

4.3 GEF – World Bank Programme – BEE: This programme catered to five sectors, viz. Forging, Chemical, Lime Kiln, Foundry, and mixed industries. Total energy (thermal) saved (based on the collected data) is 0.021 MTOE. This saving is worth INR 23.03 crores and it has contributed in reduction of 2.12 Million Tonne of CO_2.

5.0

In the Building sector, following three programmes were launched in India:

5.1 Energy Conservation Building Code (ECBC) – Commercial buildings: Total 10 ECBC compliant buildings were constructed, and 58 more ECBC compliant buildings are either in design or construction stage. Total energy (electrical) savings of 0.0056 BU is estimated. This saving is worth INR 2.80 crores and it has contributed in reduction of 0.0046 Million Tonne of CO_2. 10 states and 1 Union Territories (UT) have notified the code till 31.03.2018.

5.2 BEE Star Rating programme for commercial buildings: Total 212 buildings achieved BEE Star Ratings. This has led to total energy (electrical) savings of 0.20 BU. This saving is worth INR 100 crores and it has contributed to the reduction of 0.18 Million Tonne of CO_2. However in order to avoid any duplication, the savings under this scheme is already included under S&L programme.

5.3 Building Energy efficiency Programme: Total 2901 buildings were a part of this scheme. Central Govt. Buildings, District Courts, PWD Buildings and Railway Station buildings were included. This has led to total energy (electrical) saving of 0.053 BU. This saving is worth INR 26.50 crores and it has contributed to the reduction of 0.044 Million Tonne of CO_2. However in order to avoid any duplication, the savings under this scheme is already included under S&L programme.

5.4 GRIHA Certification: More than 1200 project are registered under GRIHA rating. This has led to total energy saving of 0.65 BU (estimated) and total CO_2 emission reduction is 0.54 Million Tonne of CO_2 (estimated).

5.5 IGBC Certification: 1185 project are completed under IGBC rating. This has led to total annual energy saving of 4.94 BU per million sq.ft and total annual reduction in CO_2 emission of 0.41 Million Tonne of CO_2

6.0 **Agriculture Demand Side Management:** Total 23,123 number of BEE 5 star rating pumpsets (5HP) & smart control panel were distributed in India. This has led to total energy (electrical) savings of 0.070 BU. This saving is worth INR 35 crores and it has contributed to the reduction of 0.06 Million Tonne of CO_2. However in order to avoid any duplication, the savings under this scheme is already considered under S&L programme.

7.0 **Municipal Demand Side Management:** Total 54.77 Lakhs of LED street lights were replaced. This has led to total energy (electrical) savings of 3.70 BU, which is worth INR 1,850 crores and it has contributed to the reduction of 3.05 Million Tonne of CO_2.

All the aforementioned savings are due to the schemes/programmes adopted by the Central Government, even at the state level, the State Designated Agencies (SDAs) have executed most of these schemes. Along with these schemes/ programmes, the SDAs are also working towards building the capacity of local agencies by organizing workshops.

Such savings have encouraged the market to develop a vision of making India as one of the most energy efficient nations in the world.

Way Forward

All these schemes/programme, in totality, were largely successful in creating institutional readiness and strong public awareness of Energy efficiency in India. Advances in technological excellence and, engineering & project management capability helped many industrial sectors to achieve the global benchmark in energy efficiency and steadily reduce energy intensity of operations. Moreover, the future landscapes, driven by disruptive technologies and economic mega-trends (such as smart cities, e-mobility etc.) is fast changing the dynamics of energy sector.

With this understanding, the Bureau of Energy efficiency has developed a National Strategic Plan to **Unlock National Energy efficiency potential (UNNATEE).** This plan aims to create a futuristic vision, mission and roadmap of energy-efficiency in India, clarify institutional roles but also ensure coordination among concerned ministries and other non-governmental stakeholders to achieve the national goals of Energy efficiency.

In addition, this plan also aims to align the country's energy efficiency measures with the international commitment of Intended Nationally Determined Contributions (INDCs) targets and, United Nations Sustainable Development Goals (UN-SDG).

CHAPTER 1

Introduction

India is the fastest growing major economy in the world and is expected to witness strong economic growth in the years to come. (Business Today, 2018) The fact that India surpassed France to become the 6th largest economy in the world in 2018 is a testament of this remarkable growth story. (India Today, 2018) While continued economic growth is an area of focus for the nation, India has also been aware of the importance of sustainable development. The Nationally Determined Contribution (NDC) to the Paris Agreement, effective from 2015, exemplifies the commitment of India to achieve sustained economic growth by undertaking a low carbon transformation of its economy.

Energy efficiency provides 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 and amended 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 National Mission for Enhanced Energy efficiency (NMEEE).

1.1 About the Energy Conservation Act 2001

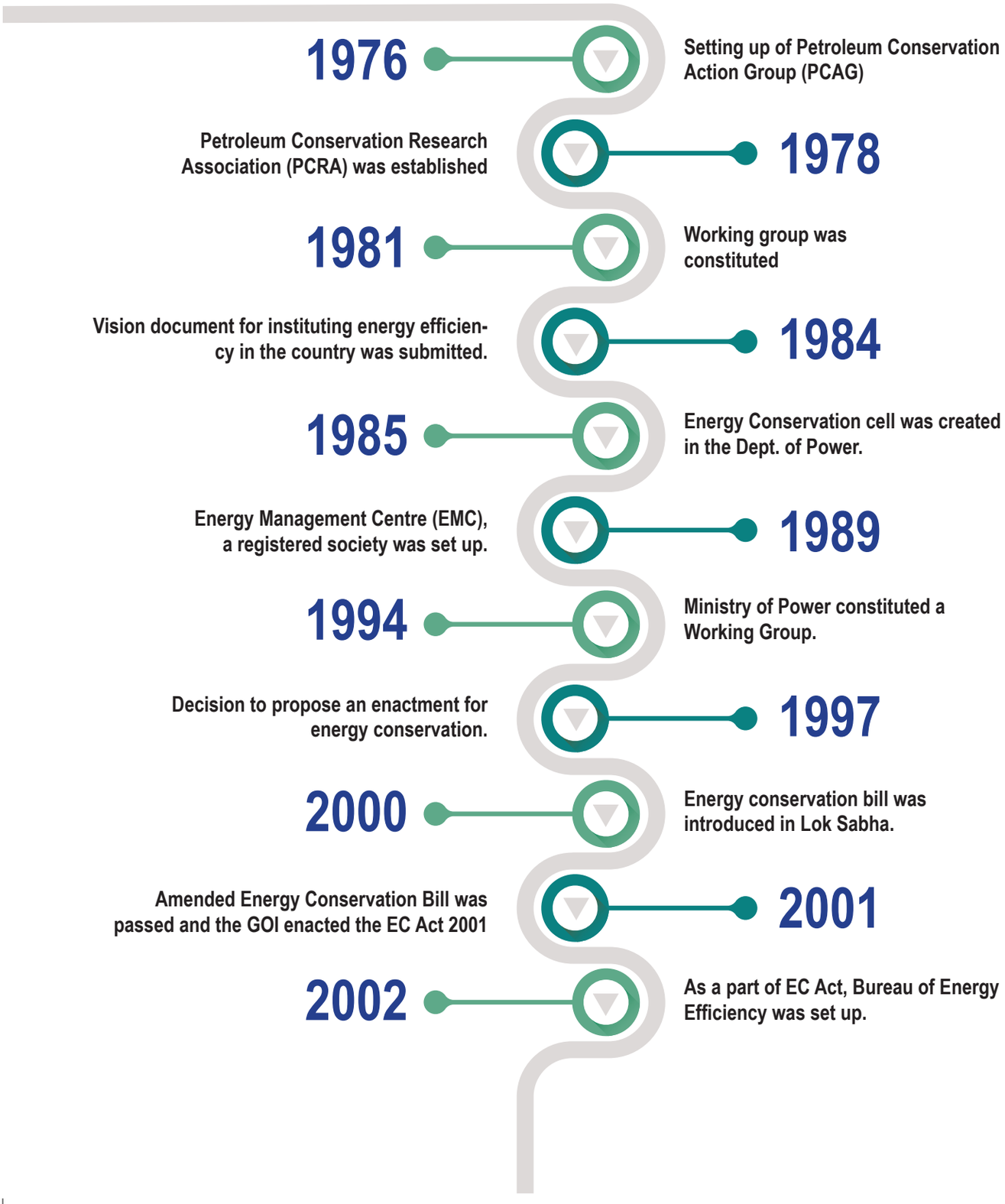
The erstwhile Department of Power, which was under the Ministry of Irrigation and Power, was responsible about energy conservation in its power generating stations. However, once the potential for energy efficiency and conservation in the end use of energy was recognized, a holistic and systematic view was taken and accordingly Energy Conservation Act (EC Act) was enacted. The timeline of the enactment of EC Act is presented in Figure 8.

The EC Act 2001, which provides for the efficient use of energy and its conservation and for matters connected therewith or incidental thereto, is spread over 22 pages and divided into the following 10 chapters:

- **Chapter 01:** Short title, extent and commencement
- **Chapter 02:** Establishment and incorporation of the Bureau of Energy efficiency
- **Chapter 03:** Transfer of assets, liabilities and employees of Energy Management Centre
- **Chapter 04:** Powers and functions of Bureau

- **Chapter 05:** Power of Central Government to enforce efficient use of energy and its conservation
- **Chapter 06:** Power of State Government to enforce certain provisions for efficient use of energy and its conservation
- **Chapter 07:** Grants and loans by Central Government
- **Chapter 08:** Penalty
- **Chapter 09:** Establishment of Appellate Tribunal
- **Chapter 10:** Power of Central Government to issue directions to Bureau

Figure 7: Timeline of Energy Conservation Act 2001



Under the provisions of the act, BEE has been established with effect from 1 March 2002 by merging into it, the erstwhile Energy Management Centre - a registered society under the Ministry of Power.

Working to achieve its objective, BEE has recommended the central government to initiate several schemes to conserve energy and promote energy efficiency in the country. All such schemes to promote energy conservation and energy efficiency are presented in Table 2. This table also discusses its status in FY 2017-18.

Table 2: Sector specific energy efficiency schemes/programmes and their status as in FY 2017-18

Sectors	Sub – Sectors	Schemes / Programmes	Status as in FY 2017-18
Industry	Large Industry	Perform, Achieve and Trade(PAT) Scheme	• PAT cycle 1 had notified 478 designated consumers across 8 energy intensive sectors viz. Aluminum, Cement, Chlor Alkali, Fertilizer, Iron & Steel, Paper & Paper, Thermal Power Plant, and Textile. The overall energy saving targets for PAT Cycle –I was 6.686 Million Tonne of Oil Equivalent (MTOE) by the end of 2014-15. The achievement in PAT Cycle-I is 8.67 MTOE which is excess achievement of about 30 percent in comparison to the assigned targets. • PAT cycle 2 has added three more sectors (Refinery, Railways and DISCOMs). • PAT cycle 3 and PAT cycle 4 are launched. • Total number of Designated Consumers (DCs) up to PAT cycle 4 = 846.
	Micro, Small & Medium Enterprises (MSME)	BEE SME Programme	• Total 4 MSME clusters (Varanasi, Pali, Indore and Ludhiana) are part of this programme. • It caters to sectors such as forging, textile, food, brick kilns
		GEF – UNIDO – BEE Programme	• Total 12 clusters are part of this programme • It caters to sectors such as Brass, Ceramics, Dairy, Foundry and Hand Tools
		GEF – World Bank – BEE Programme	• Total 14 clusters are part of this programme. • It caters to sectors such as Forging, Chemical, Lime kiln, Foundry, and Mixed Industries.

Sectors	Sub – Sectors	Schemes / Programmes	Status as in FY 2017-18
Lighting & Appliances	Lighting & Appliances	Standards & Labeling (S&L)	• There are a total of 21 appliances in this programme. • 10 appliances are under Mandatory regime • 11 appliances are under voluntary regime.
		Unnat Jyoti by Affordable LEDs and Appliances for All (UJALA)	• 29.73 crores LED bulbs (9W) were distributed to replace ICL (100W) and CFL (18W). • 58.28 lakhs LED tube lights (20W) were distributed to replace 40 W TFL
		Super Energy Efficient Programme (SEEP)	• 16.57 lakhs ceiling fans (50W) were distributed to replace 75W of inefficient fans.
		Other LED programme	• Apart from UJALA scheme, 63.25 crore LED bulbs were sold out in the private market.
Building	Commercial Establishments	Energy Conservation Building Code – Commercial Building	• Voluntary Stage: 11 States and 1 Union Territory (UT) have notified the code.
		BEE – Star Rating Programme	• 212 existing commercial buildings across India have adopted BEE Star ratings • Offices, Hospitals, Shopping malls and BPOs are a part of this programme.
		Building Energy Efficiency Programme (BEEP)	• 2901 existing commercial buildings across India were part of the BEEP programme. • Replacement of Lighting & Air Conditionings (ACs) were considered in this programme.
	Commercial & Residential	Green Building Programme	• There are 3 major Green Building Rating Systems in India, viz. IGBC, LEED and GRIHA. • Energy Efficiency is a major component of these rating systems.
Agriculture	Energy Efficient Pumping	Agriculture Demand Side Management (AgDSM)	• 23,127 (5 HP) pumps along with smart control panels were installed.
Municipality	LED Street Lighting	Municipal Demand Side Management (MuDSM)	• 54.77 lakhs LED street lights were distributed/replaced.

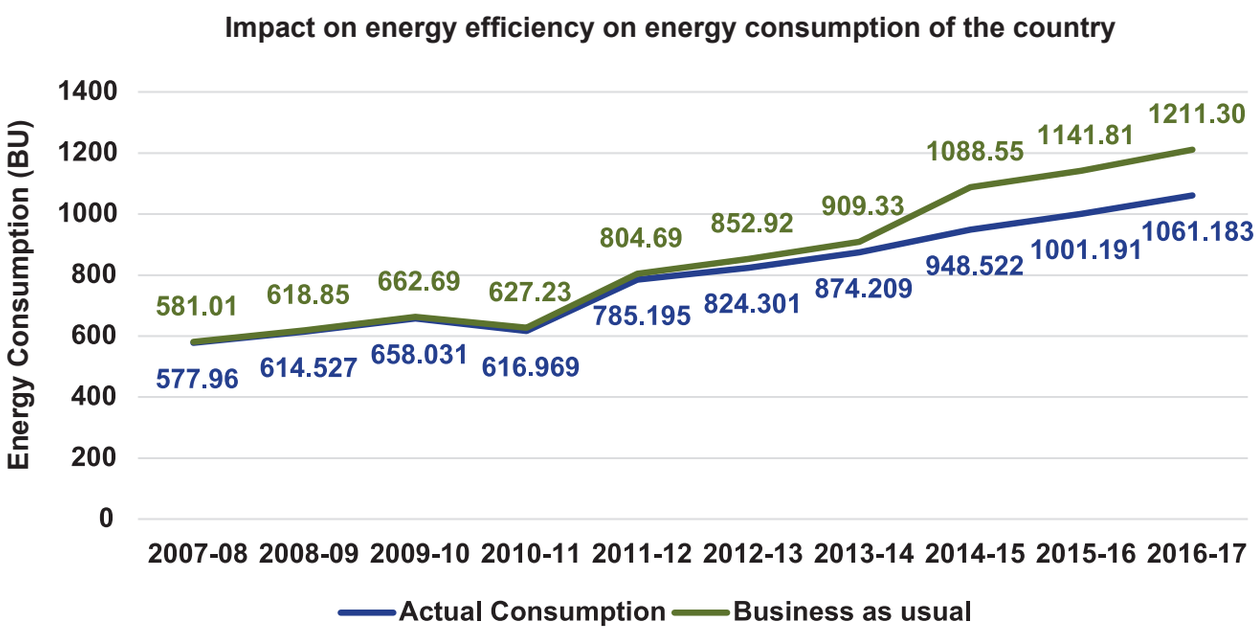
1.2 Rationale & objective

Rolling out several schemes to conserve energy is one aspect, but assessing their impact on ground helps to understand their actual effectiveness. Therefore, an impact assessment of all the schemes related to energy efficiency, as mentioned above, is required. In 2016-17, BEE had conducted a third party assessment of annual energy savings of its own set of schemes for the last 10 years (2007-2017). This study has assessed following schemes. The outcome of that study is as below:

Table 3: Sector specific energy efficiency schemes / programmes and its status till FY 2016-17

Energy Savings (MU)										
Scheme	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
S&L	1425.87	2106.16	2209.06	8172.3	16078.47	24443.79	30770.65	33765.17	36899.74	41422.76
PAT								101050.57	101050.57	101050.57
NECA	1620	2216	2451	2085	3421	4177	4354	5197	2598	7378
ECBC				193.4						
SME								12.70	72.10	72.10
AgDSM*										
SDA**										

*Saving due to AgDSM are accounted in S&L Program hence are not considered separately.
**Saving due to SDAs are accounted in NECA Program hence are not considered separately.



Along with BEE, there are other organisations at national level that are also supporting in energy efficiency by launching its own set of schemes. The objective of this study is to assess the overall impact of all the energy efficiency schemes at national as well as state level for the year 2017-18 and compare it with a situation where the same were not been implemented.

1.3 Scope of work

This study aims to assess the impact (in terms of energy saved) of the schemes mentioned in Table 1. In order to assess the impact, following tasks are required to be undertaken:

1. Review of National and state level schemes to encourage the adoption of energy efficiency across all the sectors (Agriculture, Buildings, Industries, Municipality and others as applicable) in India
2. Stakeholder consultation, data collection and analysis
3. Present the findings to BEE and then submit the Final report to the Ministry of Power (MoP) through BEE

1.4 Structure of the study

The report covers the energy efficiency schemes across India undertaken by both private and public sector. As implementation of all the schemes are independent of each other, each individual scheme has been discussed in a separate sections. Chapters 2, 3, 4, 5, 6, 7 and 8 discusses about all the sector specific energy efficiency schemes/programmes. These chapters provide the overview of the schemes/ programmes and their impact due to energy savings in FY 2017-18. Finally, chapter 9 concludes along with the way forward.

In order to calculate the impact, certain assumptions have been taken in consultation with respective stakeholders. A list of assumption is as seen in table 4.

Table 4: List of assumptions/considerations

Assumptions/Considerations
• 1 TOE = 11,630 kWh
• 1 MTOE = 1 Million TOE
• 1 $MtCO_2$ = 1 Million tonne of CO_2
• 1 BU = 1 Billion Unit =10^9 kWh = 1TWh
• Cost/TOE = INR 10,968.00
• Cost/kWh = INR 5.00
• Net energy (Total) consumption in 2017-18 = 559 MTOE
• Net energy (electrical) consumption in 2017-18 = 1204.7 BU.
• Net energy supply in 2017-18 = 843.8 MTOE

CHAPTER 2

Industry

2.1 Large scale Industry – Perform, Achieve and Trade (PAT) Scheme

2.1.1 Overview of the scheme

Perform, Achieve and Trade Scheme (PAT) is an innovative market based mechanism which has been developed to enhance the energy efficiency in energy intensive industries through issuance of tradable energy saving certificates. The scheme was announced under the National Mission on Enhanced Energy efficiency (NMEEE) in the National Action Plan on Climate Change (NAPCC).

The scheme targets the Designated Consumers (DCs) which are industrial units from energy intensive industrial sectors identified in the EC Act 2001.

Under this scheme, certain targets are provided to Designated Consumers (DCs) to reduce their specific energy consumption. These targets are plant specific, wherein targets are lower for energy efficient and higher for inefficient plants. The DCs which surpass targets are issued Energy Savings Certificates (ESCerts) with 1TOE savings being equal to 1ESCert. DCs, to whom the ESCerts are issued, can sell them at Power exchanges to other DCs which are unable to reach their energy reduction targets or can be utilized for compliance of their next cycle.

Any DC not complying with the stipulations of the PAT scheme is liable to be penalized as per section 26 of EC Act.

In order to calculate the energy requirements of a plant, a process of normalization of the energy and production data is undertaken to consider the impact of quantifiable external variables that are beyond the control of a DC. This ensures that a DC is not placed in a position of advantage or disadvantage when compared to baseline scenario. The normalization process is finalized after several technical committee meetings and various consultation workshops identifying the issues of DCs, and finding out ways to address them.

The scheme is divided in to 'cycles' of 3 year duration, and the stakeholders involved in the cycle along with their role is provided below:

1. **Bureau of Energy efficiency:** It is the administrating body for the scheme which undertakes development, launch and overall monitoring of the scheme. This includes setting the baseline for the industries, sector specific target for energy consumption, pro-forma and normalization factors. The Bureau also acts as the administrator of ESCerts trading as per the Central Electricity Regulatory Commission (Terms and Conditions for Exchange of Energy Savings Certificates) Regulations, 2016.
2. **Designated Consumers (DCs):** As per the provision of the clause (e) and (f) of section (14) of the EC Act 2001, the Central Government notified the 'Designated Consumers' based on the 4 criteria mentioned below:
   a. Intensity of quantity of energy consumed
   b. Amount of investment required for switching over to energy efficient equipment
   c. Capacity of industry to invest in energy efficient equipment
   d. Availability of energy efficient machinery and equipment required by the industry

   Based on the above criteria, 13 energy intensive sectors (Aluminum, Cement, Chlor-Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Railways, Thermal Power and Textile) have been notified as Designated Consumers.

Participation in the scheme is mandatory for Designated Consumers under the EC Act 2001. The Government notified the mandatory Energy Audit vide S.O 1378 (E) dated 27th May, 2014 for the Designated Consumers to help in identifying various energy saving opportunities in energy intensive industries & other establishments.

3. **State Designated Agency (SDA):** SDAs are statutory bodies' setup at state level to implement the activities of the EC Act under the overall supervision and guidance of BEE. They are the nodal agencies at state level and need to coordinate with BEE to ensure a smooth and speedy implementation of the Act across the country. Specifically for PAT scheme, SDAs gather, monitor and analyses data reported by

DCs, enable tracking, monitoring and reporting energy reduction details.

4. **Accredited Energy Auditors (AEA):** These are individual professionals who fulfill the qualification criteria laid down by the Bureau. The AEA is responsible to carry out the monitoring and verification of the energy efficiency activities undertaken by the Designated Consumer. The AEA submits the report to SDA for compliance and based on the report of the AEA, the performance of DC is assessed.

5. **Central Electricity Regulatory Commission (CERC):** CERC, a key regulator of power sector in India, is a statutory body functioning with quasi-judicial status under Section 76 of the Electricity Act 2003. In relation to PAT scheme, the commission has approved the procedure for interface activities between power exchanges, registry, administrator and designated consumers in accordance with the Energy Conservation Rules. It also monitors operations and performance of power exchanges, issue directions to the Bureau regarding discharging its functions related to exchange of ESCerts.

6. **Power System Operation Corporation Limited (POSOCO):** Constituted by the Ministry of Power, POSOCO is authorized to function as a Registry for ESCerts.

7. **Trading Exchange:** Trading of the ESCerts can be made over 2 power exchanges in India viz. Indian Energy Exchange (IEX) and Power Exchange of India (PXIL). These are electronic system based power trading exchange which are regulated by the Central Electricity Regulatory Commission (CERC).

The institutional mechanism of this scheme is follows:

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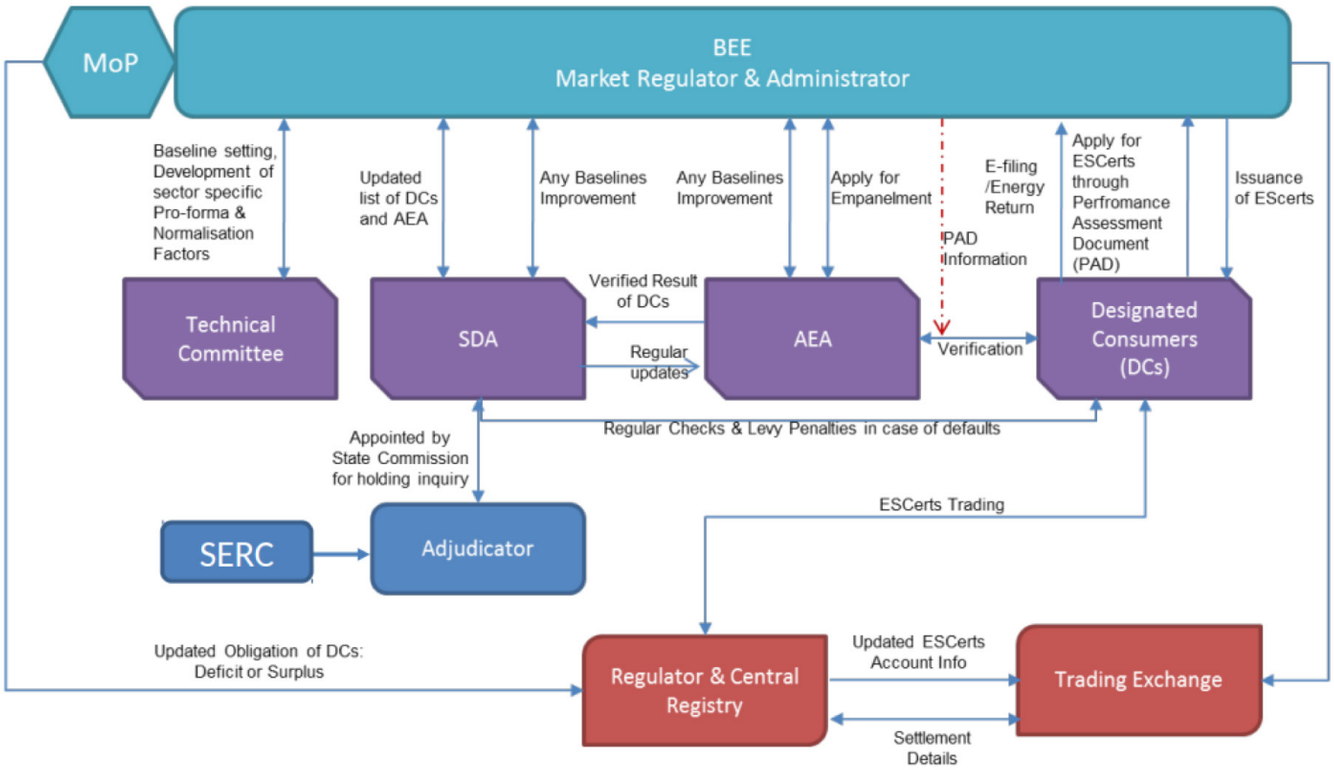


In **"Cycle 1" of PAT, 478 industries units in 8 sectors** (Aluminum, Cement, Chlor-Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power Plant, Textile) were mandated to reduce their specific energy consumption (SEC) i.e. energy used per unit of production. Overall, the SEC reduction targets envisaged to secure 4.05 % reduction in energy consumption in these industries aiming for an energy saving of 6.686 million tonne of oil equivalent (MTOE). The implementation of PAT in large industries has led to energy saving of 8.67 MTOE by year 2014-15 which is about 1.25% of total primary energy supply to the country in "Cycle 1". This energy saving also translates in to mitigation of about 31 million tonne of CO_2 emission. The energy savings of the Designated Consumers (DCs) of PAT Cycle-1 have been converted to tradable Energy Saving Certificates (ESCerts). Ministry of Power, Government of India had issued about 38.25 lakh ESCerts to 306 designated consumers while 110 Designated Consumers have to purchase about 14.25 lakh ESCerts for their compliance. Trading of ESCerts at Power Exchange had commenced from 26th September, 2017. The total volume of ESCerts traded is about 12.98 lakhs resulting into a business of about INR 100 crores.

The **"Cycle 2" of PAT was notified in March, 2016 covering 621 DCs from 11 sectors** which include eight existing sectors and three new sectors viz. Railways, Refineries and DISCOMs. PAT in its second cycle seeks to achieve an overall energy consumption target of 8.869 MTOE. Since PAT scheme is currently based on a rolling cycle i.e. inclusion of new sectors/designated consumers every year, **the "Cycle 3" of PAT was notified in March 2017 and it seeks to achieve an overall energy consumption reduction of 1.06 MTOE for which SEC reduction targets have been assigned to new 116 DCs from six energy intensive sectors. Targets for the "Cycle 4" of PAT have been notified in March 2018 under which additional 109 DCs have been notified from existing sectors and two new sectors** i.e. Petrochemical and Commercial Buildings (Hotels) with an overall SEC reduction target of 0.6998 MTOE.

Presently, in total 846 designated consumers under PAT Cycle–2, 3 and 4 are undergoing implementation of energy efficiency projects to achieve the assigned targets. These 846 DCs constitute about 60% industrial consumption. The methodology of energy saved and reduction in the CO_2 emission is discussed next.

2.1.1.1 Methodology adopted to calculate the savings

In order to calculate the savings under the PAT scheme, the DCs of PAT Cycle 2 (except[2] DISCOM) and their data till FY 2017-18 have been considered. Using this data, there are two sets of calculations that are performed in this report for PAT scheme. In the CASE 1, in order to find the energy savings the production data of the base year i.e. 2014-15 has been taken into consideration, and in the CASE 2, the production data of the assessment year of PAT Cycle 2, i.e. 2017-18 has been taken into consideration.

2.1.1.1.1 Estimation of energy savings

The following calculations were adopted for each of the below mentioned sectors:

a. **Step 1:** Obtain the Specific Energy Consumption (SEC) for the base year 2014-15 = $SEC_{2014-15}$
b. **Step 2:** Obtain the SEC for the year 2017-18= $SEC_{2017-18}$
c. **Step 3:** $SEC_{2014-15}$ - $SEC_{2017-18}$ (Improvement in Energy Efficiency)
d. **Step 4**$_{CASE\ 1}$**:** 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.
   Therefore formula =
   i. $ES_{Plant\ 1} = (SEC_{2014-15} - SEC_{2017-18}) \times Production_{2014-15}$
   ii. $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +----------+ ES_{Plant\ N}$
e. **Step 4**$_{CASE\ 2}$**:** 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 2017-18.
   Therefore formula =
   i. $ES_{Plant\ 1} = (SEC_{2014-15} - SEC_{2017-18}) \times Production_{2017-18}$
   ii. $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +----------+ ES_{Plant\ N}$

[2]Note: DISCOM is a part of a PAT scheme and it has showcased less savings comparatively, therefore the same has not been considered in this report.

Similarly for the **Thermal Power Plant (TPP)**, following steps were considered:

a. **Step 1:** Identify Net Heat Rate (kcal/kWh) of the notified plant for 2014-15, ($NHR_{2014-15}$) kcal/kWh
b. **Step 2:** Identify Net Heat Rate (kcal/kWh) of the notified plant for 2017-18, ($NHR_{2017-18}$) kcal/kWh
c. **Step 3$_{CASE\ 1}$:** Identify kWh generated by the notified plant for 2014-15, $Production_{2014-15}$ Unit
d. **Step 4$_{CASE\ 1}$:** Adopt the following formula to calculate the Energy Savings (ES)
   i. $ES_{Plant\ 1} = (NHR_{2014-15} – NHR_{2017-18}) \times Production_{2014-15}$
   ii. $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +---------+ ES_{Plant\ N}$
e. **Step 5$_{CASE\ 2}$:** Identify kWh generated by the notified plant for 2017-18, $Production_{2017-18}$ Unit
f. **Step 6$_{CASE\ 2}$:** Adopt the following formula to calculate the Energy Savings (ES)
   i. $ES_{Plant\ 1} = (NHR_{2014-15} – NHR_{2017-18}) \times Production_{2017-18}$
   ii. $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +---------+ ES_{Plant\ N}$

Similarly for the **Refinery sector**, following steps were considered:

a. **Step 1:** Identify Million British Thermal Unit per Thousand barrels per Energy Factor (MBN) of the notified plant for 2014-15 ($MBN_{2014-15}$).
b. **Step 2:** Identify Million British Thermal Unit per Thousand barrels per Energy Factor (MBN) of the notified plant for 2017-18, ($MBN_{2017-18}$).
c. **Step 3$_{CASE\ 1}$:** Identify the crude throughout by the notified plant for 2014-15, $Production_{2014-15}$ in Million Barrels (MBLs)
d. **Step 4:** 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. $NRGF_{plant\ 1}$
e. **Step 5$_{CASE\ 1}$:** Adopt the following formula to calculate the Energy Savings (ES):
   i. $ES_{Plant\ 1} = (MBN_{2014-15} – MBN_{2017-18}) \times Production_{2014-15} \times NRGF_{plant\ 1} \times 0.0252$ (Conversion Factor for TOE)
   ii. $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +----------+ ES_{Plant\ N}$
f. **Step 6$_{CASE\ 2}$:** Identify the crude throughout by the notified plant for 2017-18, $Production_{2017-18}$ in Million Barrels (MBLs)
g. **Step 7$_{CASE\ 2}$:** Adopt the following formula to calculate the Energy Savings (ES):
   i. $ES_{Plant\ 1} = (MBN_{2014-15} – MBN_{2017-18}) \times Production_{2017-18} \times NRGF_{plant\ 1} \times 0.0252$ (Conversion Factor for TOE)
   ii. $\Sigma ES = ES_{Plant\ 1} + ES_{Plant\ 2} + ES_{Plant\ 3} + ES_{Plant\ 4} +----------+ ES_{Plant\ N}$

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 2. The 16 zones consume diesel and electricity for its operation (passenger and goods) purposes.

a. **Step 1:** In this sector, in order to calculate the energy savings, it is important to identify fuel consumption in the base year (2014-15) and 2017-18 as Fuel Consumption$_{2014\text{-}15}$ and Fuel Consumption$_{2017\text{-}18}$ respectively. The unit of fuel consumed is Litre/1000 GTKM. The GTKM means KM earned with the gross tonnage hauled including the weight of the locomotive.
b. **Step 2:** Identify 1000GTKM value for each zone.
c. **Step 3$_{CASE\ 1}$:** The energy saved for all the zones are calculated as:
   i. ES Zone 1 = (Fuel Consumption$_{2014\text{-}15}$ - Fuel Consumption$_{2017\text{-}18}$) x Utilization (1000GTKm)$_{2014\text{-}15}$
   ii. $\Sigma ES = ES_{Zone\ 1} + ES_{Zone\ 2} + ES_{Zone\ 3} + ES_{Zone\ 4} +----------+ ES_{Zone\ N}$
c. **Step 3$_{CASE\ 2}$:** The energy saved for all the zones are calculated as:
   i. $ES_{Zone\ 1}$ = (Fuel Consumption$_{2014\text{-}15}$ - Fuel Consumption$_{2017\text{-}18}$) x Utilization (1000GTKm)$_{2017\text{-}18}$
   ii. $\Sigma ES = ES_{Zone\ 1} + ES_{Zone\ 2} + ES_{Zone\ 3} + ES_{Zone\ 4} +----------+ ES_{Zone\ N}$

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

a. **Step 1:** Identify SEC of base year 2014-15 in (kgoe/No of equivalent units) as SEC$_{2014\text{-}15}$
b. **Step 2:** Identify SEC of 2017-18 in (kgoe/No of equivalent units) as SEC$_{2017\text{-}18}$
c. **Step 3$_{CASE\ 1}$:** Identify production in terms of no of equivalent units in the base year 2014-15 as Production$_{2014\text{-}15}$
d. **Step 4:** The energy saved is calculated as:
   i. $ES_{production\ unit\ 1}$ = (SEC$_{2014\text{-}15}$ - SEC$_{2017\text{-}18}$) x Production$_{2014\text{-}15}$
   i. $\Sigma ES = ES_{production\ unit\ 1} + ES_{production\ unit\ 2} +----------+ ES_{production\ unit\ N}$
f. **Step 5$_{CASE\ 2}$:** Identify production in terms of no. of equivalent units in the base year 2017-18 as Production$_{2017\text{-}18}$
g. **Step 6$_{CASE\ 2}$: The energy saved is calculated as:**
   i. $ES_{production\ unit\ 1}$ = (SEC$_{2014\text{-}15}$ - SEC$_{2017\text{-}18}$) x Production $_{2017\text{-}18}$
   i. $\Sigma ES = ES_{production\ unit\ 1} + ES_{production\ unit\ 2} +----------+ ES_{production\ unit\ N}$

2.1.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, a list and percentage of fuel consumed in each sector for each DC is identified. Post that the kcal values, density of respective fuels and CO_2 conversion factor is considered as proposed by the BEE.

Table 5: List of assumptions to calculate the CO_2 emissions

Assumptions	
Type	**Value**
Calorific Value of Coal (if not available)	3500 kcal
CO_2 in 1 kg Coal	1.52 kg
Calorific Value of Oil (if not available)	10,050 kcal (at density 0.9337 kg/litre) or as notified by MoPNG Stat
CO_2 in 1 kg Oil	3.06 kg
Calorific Value of Gas (if not available)	9,000 kcal
Calorific Value of 1 kg LPG	12,500 kcal or as notified by MoPNG stat
Calorific Value of 1 kg Kerosene	11,110 kcal (density of SKO=0.7782 kg/litre) or as notified by MoPNG Stat
Calorific Value of 1 kg Petrol	11,200 kcal (at density 0.7087 kg/litre) or as notified by MoPNG Stat
Calorific Value of 1 kg High Speed Diesel	11,840 kcal (at density 0.8263 kg/litre) or as notified by MoPNG Stat
CO_2 in 1 kg Gas	1.76 kg
1 MWh	0.826 t CO_2

Based on the results as obtained, the impact of the energy savings by DCs under the PAT scheme is discussed next.

2.1.2 Impact of the PAT scheme

The impact under the PAT scheme for this report was calculated based on the data of 474 DCs. The share of data analysed of 474 DCs for each sector is as seen in Table 6. The share of the same is as below:

Table 6: Share (number) of DCs analysed from each sector under PAT scheme

Sr. No	Sector	Data analysed (No. of DCs)	Share of Counts
1	Thermal Power Plant	123	25.95%
2	Cement	105	22.15%
3	Iron & Steel	59	12.45%
4	Textile	59	12.45%
5	Fertilizer	32	6.75%
6	Paper & Pulp	29	6.11%
7	Chlor Alkali	20	4.22%
8	Refinery	18	3.8%
9	Railways	18	3.8%
10	Aluminum	11	2.32%
TOTAL		**474**	**100%**

The sectors mentioned in table 4 is further divided as energy consumption side and energy supply side. Except the Thermal Power Plant, all the other sectors are considered as energy consumption (demand) side.

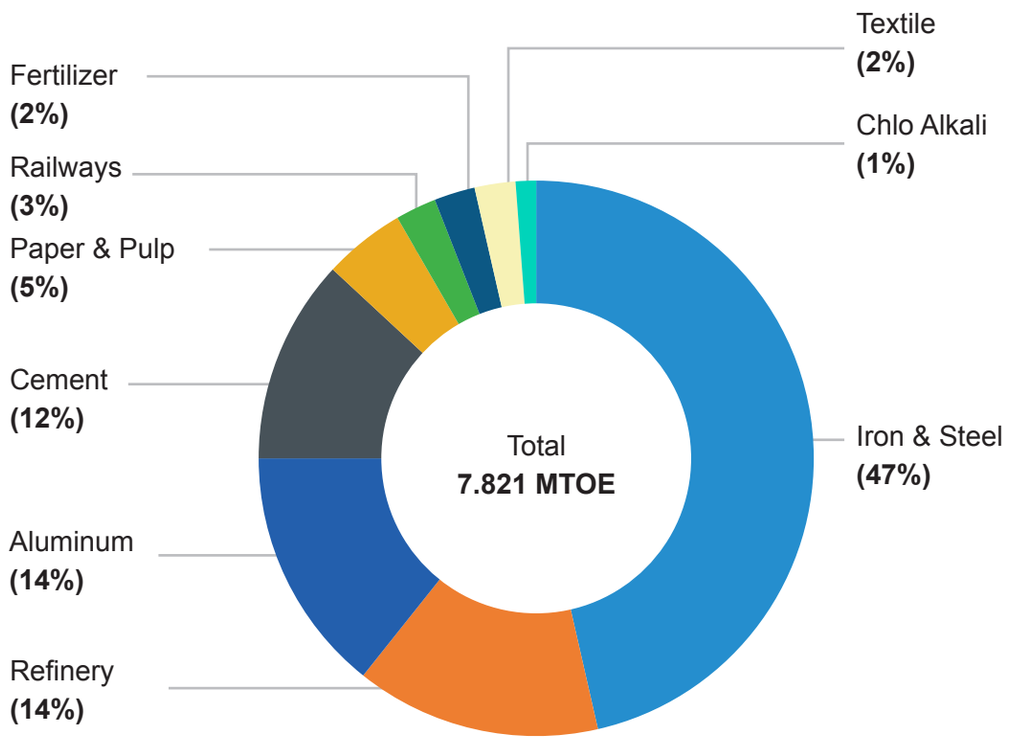
Analysis under CASE 1

The analysed data of sector under the consumption side demonstrates the total energy savings of 7.821 MTOE w.r.t baseline of FY 2014-15. The share of energy saved by each sector is as seen in Table 7.

Table 7: Share (numbers) of energy saved by each sector of PAT Cycle 2 (production data of base year FY 2014-15)

Sr. No	Sector	Energy (Thermal) saved (MTOE)	% Share of energy saved
1	Iron & Steel	3.664	46.85%
2	Refinery	1.115	14.26%
3	Aluminum	1.092	13.96%
4	Cement	0.924	11.82%
5	Paper & Pulp	0.404	5.17%
6	Railways	0.211	2.70%
7	Fertilizer	0.200	2.56%
8	Textile	0.149	1.91%
9	Chlor Alkali	0.061	0.78%
Total Energy Saved (in FY 2017-18)		**7.821 MTOE**	**100%**

Figure 8 : Share (%) of energy (thermal) saved by notified sectors under PAT Cycle 2 (production data of base year FY 2014-15)



Share of energy (thermal) saved

Along with thermal energy savings, the consumption side also saved **electrical energy of 2.47 BU.** The share of each sector is seen in Table 8.

Table 8: Electrical energy saved (production data of base year FY 2014-15)

Sr. No	Sector	Electrical Energy Saved (BU)
1	Iron & Steel	1.279
2	Aluminum	0.381
3	Cement	0.322
4	Paper & Pulp	0.141
5	Fertilizer	0.070
6	Textile	0.052
7	Chlor Alkali	0.021
8	Refinery	0
9	Railways	0.199
Net Savings		**2.47 BU**

On the energy supply side, the energy (thermal) savings achieved via Thermal Power Plant (TPP) equals to **1.560 MTOE.**

Overall, this savings under PAT Cycle 2 has resulted in reduction of **36.95 MtCO$_2$**. In order to calculate the reduction in CO_2 emission, following assumptions and considerations were taken:

- **Assumption:** As the share of fuel consumption was not readily available, it was assumed (in consultation with BEE) that the following sectors consume 90% coal, 5% High Speed Diesel, 2% Oil and 3% electricity to run their plant and produce the required product:
  - Iron & Steel
  - Aluminum
  - Cement
  - Paper & Pulp
  - Fertilizer
  - Textile
  - Chlor Alkali
  - Thermal Power Plant

The calorific values and CO_2 conversion factor were considered as mentioned in Table 5.

- **Consideration:** In order to calculate the reduction in CO_2 emission; Railway Production Units consume electricity as a fuel. For the Zonal Railways, Diesel & Electricity get consumed as a fuel.

The share of reduction in CO_2 emission for all the considered sectors is given in Table 9.

Table 9: Share (Value) of reduction in CO_2 emission by each sector in PAT 2 (production data of base year FY 2014-15)

Sr. No	Sector	Reduction in CO_2 emission ($MtCO_2$)
1	Iron & Steel	14.82
2	Thermal Power Plant	6.30
3	Aluminum	4.41
4	Cement	3.74
5	Refinery	3.40
6	Paper & Pulp	1.63
7	Railways	0.99
8	Fertilizer	0.81
9	Textile	0.60
10	Chlor Alkali	0.25
Total		**36.95 $MtCO_2$**

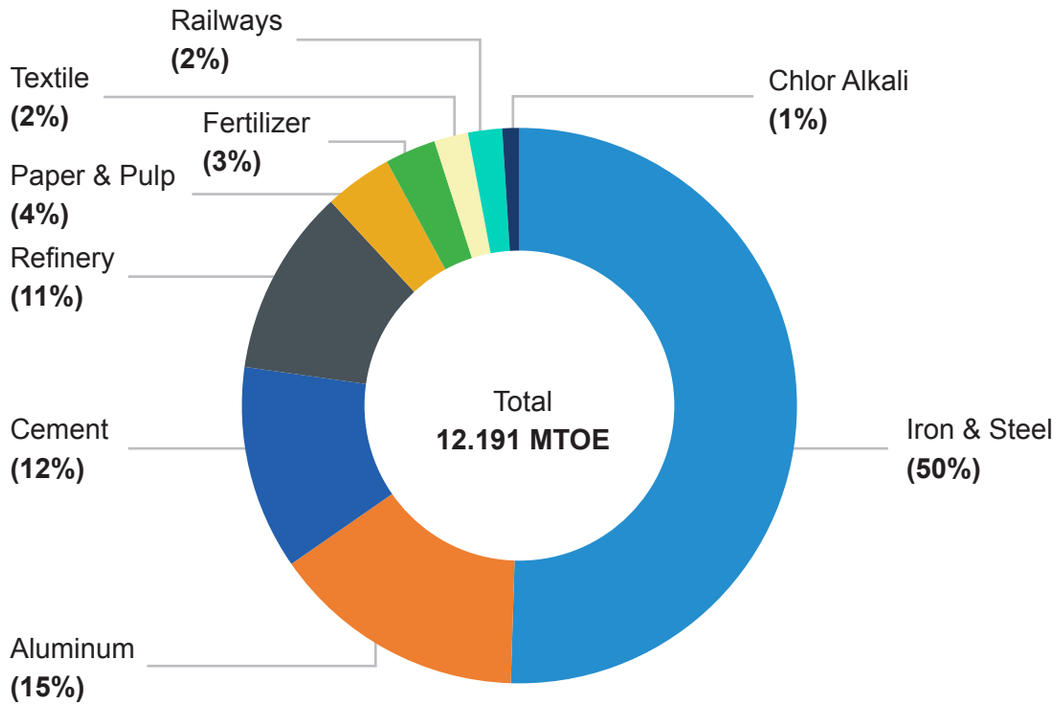
Analysis under CASE 2

The analysed data of the sectors under the consumption side provides the total thermal energy savings of 12.191 MTOE. The share of energy saved by each sector is as seen in Table 10.

Table 10: Share (numbers) of energy saved by each sector of PAT Cycle 2 (production data of FY 2017-18)

Sr. No	Sector	Energy (Thermal) saved (MTOE)	% Share of energy saved
1	Iron & Steel	6.2591	51%
2	Aluminum	1.8459	15%
3	Cement	1.4203	12%
4	Refinery	1.3354	11%
5	Paper & Pulp	0.4995	4%
6	Fertilizer	0.3107	3%
7	Textile	0.2299	2%
8	Railways	0.2119	2%
9	Chlor Alkali	0.0786	1%
Total Energy Saved (in FY 2017-18)		**12.191 MTOE**	**100%**

Figure 9: Share (%) of energy (thermal) saved by notified sectors under PAT Cycle 2 (production data of FY 2017-18)



Along with thermal energy savings, the consumption side also saved **electrical energy of 3.74 BU.** The share of each sector is seen in Table 11.

Table 11: Share of electrical energy saved (production data of base year FY 2014-15)

Sr. No	Sector	Electrical Energy Saved (BU)
1	Iron & Steel	2.18
2	Aluminum	0.64
3	Cement	0.50
4	Paper & Pulp	0.17
5	Fertilizer	0.11
6	Textile	0.08
7	Chlor Alkali	0.03
8	Refinery	0
9	Railways	0.02
Net Savings		**3.74 BU**

On the supply side, the energy (thermal) savings achieved via TPP equals to **5.632 MTOE** and electrical energy saved equals to **1.97 BU.**

Overall, this savings under PAT Cycle 2 has resulted in reduction of **70.86 $MtCO_2$.**The share of reduction in CO_2 emission for all the considered sectors is given in Table 12.

Table 12: Share (Value) of reduction in CO_2 emission by each sector in PAT 2 (production data of FY 2017-18)

Sr. No	Sector	Reduction in CO_2 emission ($MtCO_2$)
1	Iron & Steel	25.31
2	Thermal Power Plant	22.78
3	Aluminum	7.46
4	Cement	5.74
5	Refinery	4.07
6	Paper & Pulp	2.02
7	Railways	0.98
8	Fertilizer	1.26
9	Textile	0.93
10	Chlor Alkali	0.32
Total		**70.86 $MtCO_2$**

For the sake of overall calculations, after detailed discussion it was agreed that increase in annual production may or may not directly lead to overall energy savings. Hence, the energy savings from the production data of the base year 2014-15, i.e. calculations as per CASE 1 is considered for this report.

2.1.3 Summary

Under the PAT scheme, overall summary of energy (thermal & electrical) savings, and corresponding reduction in CO_2 emission as below:

Sr. No	Parameters	Values$_{CASE\ 1}$
1	Energy (thermal) saved at consumption side	7.821 MTOE
2	Energy (thermal) saved at supply side	1.560 MTOE
3	Energy (electrical) saved at consumption side	2.47 BU
4	Energy (electrical) saved at supply side	0.54 BU
5	Overall reduction in CO_2 emission	36.97 $MtCO_2$

2.2 Small and Medium Enterprises (SME) Sector

The PAT scheme, as discussed above, has been able to encourage large industries for implementation of energy efficiency measures. However, production practices in small and medium enterprises (SMEs), which are estimated to account for nearly 60% of the GDP, remain largely inefficient. But adoption of energy efficiency measures in SMEs requires a different approach than the one used for large industries. This is due to the following reasons:

- **Technical Barrier:** The SMEs lack the technical knowhow to undertake energy efficiency measures and to understand the energy savings achieved thereof. Due to limited technical knowledge, the SMEs are also not able to comprehend how the energy savings can result in financial benefit for them

- **Manpower Barrier:** The SMEs function with mostly unskilled manpower who rarely receive formal training on handling equipment. Any changes in the manufacturing process caused due to implementation of new technology is expected to reduce their efficiency in the short to medium term. Hence, there is a general reluctance of SME entrepreneurs in implementing new technologies.

- **Financial Barrier:** The entrepreneurs in SMEs usually function with low working capital and rarely have the financial reserves required for implementing technology change resulting in their unwillingness to undertake risks involved in the changes in technology.

- **Policy Barrier:** There is no policy level push on increasing energy efficiency or mapping of the energy related data of SMEs. This leads to a lack of reliable data at the macro and micro level energy consumption of SMEs, thereby preventing any efforts of designing energy efficiency measures that can be implemented at a large scale.

SME sectors like foundries, brass, textiles, refractories, brick, ceramics, glass, utensils, rice

mills, and khandsari manufacturing units etc. are said to have a large potential for energy savings, however, there is not enough data available to back up this assumption. There are a number of such units in clusters spread across the multiple states of India. Considering the barriers discussed above, it is useful to build their energy efficiency awareness by funding/ subsidizing need based studies in large number of units in the SMEs and giving energy conservation recommendations including technology up-gradation opportunities.

2.2.1 BEE – SME Programme

In line with the understanding, BEE initiated the SME programme with an objective of reducing energy intensity of the SME sector. As the first step towards this goal, adoption of Energy Efficiency (EE) technologies and practices in 29 selected clusters in the SME sector through knowledge sharing, capacity building and development of innovative financing mechanisms was undertaken. The 29 clusters included 25 clusters that were recommended for intervention and an additional 4 clusters recommended for intervention through focused programmes on delivery of technologies. The detailed project activities are as follows:

- **Energy Use and Technology Analysis** to develop better information base on status of SMEs in the chosen clusters and in understanding the possibility of undertaking Energy Efficiency measures, impact potential of these measures,

the current status of technology and energy use by the SMEs.

- **Capacity Building** to create capacities among local service providers/technology providers in the SME clusters for helping in the uptake of Energy Efficiency measures identified in the activity of Energy use and Technology analysis.

- **Facilitate implementation of Energy Efficiency Measures** through development of DPRs in the 29 clusters that are identified out of the 35 clusters for which baseline studies were undertaken

- **Facilitation of Innovative Financing Mechanism** to encourage Energy Efficiency uptake through innovative financing mechanism without creating market distortion.

As the 1st step to the program, a situation analysis of 35 clusters were prepared to produce a database of the total number of units in the cluster, their complete contact details, capacity, products manufactured, total energy usage by different types of fuels, profit/loss situation for the past three years and comments on preparedness of the management for taking part in this programme. The situation analysis also recommended a list of 30% (of the number of units subject to a minimum of 30) units where further activities should be undertaken. These 30% (or 30) units should be representative of the entire cluster in terms of technology used and/or products manufactured. The outcome of the activity is an assessment of total energy usage, preparedness of the cluster to undertake further action and a list of units where further action is recommended along with filled in data formats.

Based on the situation analysis, a smaller group of a few clusters were identified for Energy Use and Technology Audit. The aim of this audit was to assess the energy productivity of the specific unit through detailed assessment of total energy usage in the unit, an energy audit for the main energy consuming areas, potential for energy savings and recommendation on Energy Efficiency measures that can be undertaken (in terms of Energy Efficient technology and Best Practices). This activity also identifies the possible source of technology or expertise for the recommended measures. As an output, cluster manual for each of the SME clusters gets prepared which gives an overview of the clusters in terms of physical parameters as well as energy efficiency related parameters.

As part of the capacity building initiative, an introductory 1-day workshop as and when conducted with local energy efficient service and technology providers i.e. LSPs (identified in the previous activity) is conducted where representatives from the industry/associations and concerned State Designated Agency (SDA) is required to share the outcome of the previous activity and identifies the issues regarding avenues for implementing Energy Efficiency measures, roadblocks in terms of capacities in the cluster, financing issues and carbon market related issues.

Post the workshop, development of bankable DPRs are undertaken and also identify the match between the projects and the specific expertise of the LSPs in order to allot the project to the LSPs which they have to take forward in the clusters. The output of this activity is a bank of 15 DPRs for all the clusters and a match for experts and projects in all 29 clusters resulting in a total of 435 DPRs. The LSPs is equipped with the necessary capacity to undertake the implementation of Energy Efficiency project measures in the identified clusters through trainings identified by the energy auditors in the course of the project.

In order to encourage uptake of Energy Efficiency measures, facilitation of innovative financing mechanisms is undertaken without creating market distortion. The financing arrangement in the form of risk mitigating measures gets implemented through CGFTI, SIDBI and the lead banks in various districts. A fund for such risk mitigation is proposed by the World Bank and the project undertakes an arrangement between the Bank and SIDBI/lead banks to ensure implementation. Also, a 3-day training programme gets conducted with the officers of SIDBI/lead banks to provide requisite information and knowledge on how to evaluate an Energy Efficiency project that supplements a training manual.

A knowledge sharing platform "SAMEEKSHA" has also been developed for sharing the information on Energy Efficiency and Renewable Energy in SMEs.

The methodology of energy saved and reduction in the CO_2 emission is discussed next.

2.2.1.1 Methodology adopted to calculate the savings

Under this project, **7 units in Ludhiana cluster, 7 units in Indore cluster, 5 units in Pali cluster and 2 plant units in Varanasi cluster** have been undertaken under the Energy Efficiency measures and have undergone post implementation audit to estimate the energy savings realised. The same has been considered for this report.

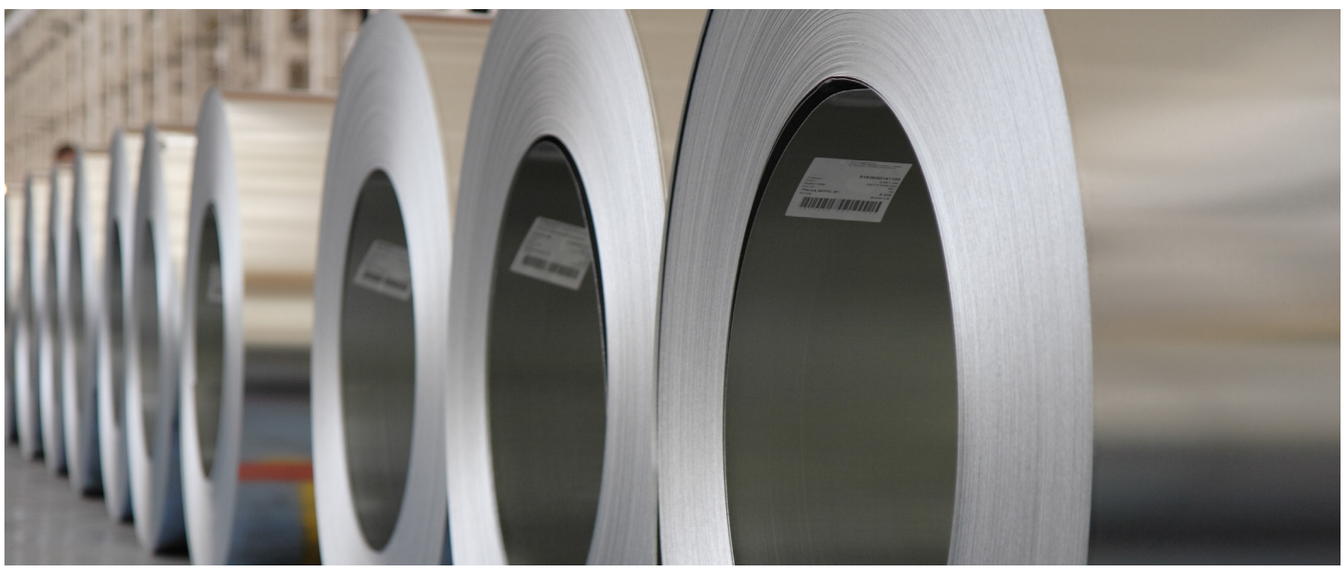
2.2.1.1.1 Estimation of energy saved

In order to calculate the energy (thermal) savings, the following methodology for each cluster is used.

- **Indore cluster -** the consolidated energy audit report of all the seven plants **(Food Sector)** were reviewed. The implementation of Energy Efficient technologies were done in the late FY 2016-17. Therefore the savings are seen in FY 17-18 only. The total energy (thermal) savings for each plant were calculated based on the difference between energy consumed before and after implementation of energy efficient technologies.

- **Ludhiana cluster -** the consolidated energy audit report of all the seven plants **(Forging Sector)** were reviewed. The implementation of Energy Efficient technologies were done in the early FY 2016-17. Therefore the savings are seen in FY 2016-17 and as no additional Energy Efficiency interventions were introduced in FY 17-18, the same amount of energy savings were observed in FY 2017-18. The total energy (thermal) savings for each plant were calculated based on the difference between energy consumed before and after implementation of energy efficient technologies.

- **Pali cluster -** the consolidated energy audit report of all the five plants **(Textile Sector)** were reviewed. The implementation of Energy Efficient technologies were done in the late FY 2016-17.



Therefore the savings are seen in FY 17-18 only. The total energy (thermal) savings for each plant were calculated based on the difference between energy consumed before and after implementation of energy efficient technologies.

- **Varanasi cluster -** the consolidated audit report of both **brick kilns** were reviewed. In one of the kilns, the adoption of zig-zag technology was done in the late FY 2016-17 and the other was done in the early FY 16-17. Therefore, for the former kiln, the savings are seen in FY 17-18 only and for the latter the savings are seen in FY 2016-17 and as no additional Energy Efficiency interventions were introduced in FY 17-18, the same savings continued in FY 2017-18. An Energy Audit was conducted in both the kilns. The total energy (thermal) savings for each kiln plant was calculated and the sample calculation is seen table 13.

Table 13: Method to calculate the energy (thermal) saved under BEE SME programme for Varanasi Cluster

Plant	Energy Savings	
	FY 2016-17	FY 2017-18
1	ES_1 = (Specific Energy Consumption before implementation – SEC post implementation of Energy Efficiency technologies) x ($Annua_{l2017-18}$ Production of number of bricks) The conversion of Million Joule to kWh and TOE is as per BEE's guidelines	Same as FY 2016-17
Total	$ES_{1\ (2016-17)}$	$ES_{1\ (2017-18)}$
$ES_1 = ES_{1\ (2016-17)} + E_{S1\ (2017-18)}$		

Plant	Energy Savings In FY 2017-18
2	ES_2 = (Specific Energy Consumption before implementation – SEC post implementation of Energy Efficiency technologies) x ($Annual_{2017-18}$ Production of number of bricks)
Total	ES_2

Total Energy Saved in FY 2017-18 = $ES_1 + ES_2$

2.2.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the kcal values, density of respective fuels and CO_2 conversion factor is considered as proposed by BEE in table 5.

Based on the results as obtained, the impact under the BEE SME programme is discussed next.

2.2.1.2 Impact of the BEE SME Programme

The total energy saved under BEE SME Programme in FY 2017-18 is **0.00117 MTOE** and total reduction in CO_2 emission is **0.00393 $MtCO_2$.**

Table 14: Energy saved and Reduction in CO_2 emission under BEE – SME Programme in FY 2017-18

Cluster	Sector Type	No. of plants	Energy Saved (TOE)	Reduction in CO_2 emission (tCO_2)
Indore	Food	7	21.99	209.80
Ludhiana	Forging	7	472.16	1296.56
Varanasi	Brick Kiln	2	362.97	899.67
Pali	Textile	5	309.07	1528.39
Total			**1166.22**	**3934.43**

Total Energy Saved (MTOE)	**0.00117**
Total Reduction in CO_2 emission ($MtCO_2$)	**0.00393**

2.2.2 GEF - UNIDO - BEE Programme: "Promoting Energy Efficiency and Renewable Energy in selected MSME clusters of India"

The project is funded by Global Environment Facility (GEF), implemented by United Nations Industrial Development Organisation (UNIDO), executed by BEE and co-financed by Ministry of Micro, Small and Medium Enterprises (MoMSME) and Ministry of New and Renewable Energy (MNRE). The project is currently being executed in 12 selected MSME clusters identified as the most energy consuming sectors. These clusters are spread across five varied sectors viz. brass, ceramic, dairy, foundry and hand tool sectors.

The aim of the project is to develop and promote a market environment for introducing energy efficiencies and enhanced use of RE technologies in process applications in 12 selected energy-intensive MSME clusters in India with expansion to more clusters later, in order to improve the productivity and competitiveness of units as well as to reduce overall carbon emissions and improve the local environment.

The project has multiple components involving cluster level interventions as well as policy level support. The project components are as follows:

- Increasing the level of end-use demand and implementation of energy efficiency, and renewable energy technologies and practices by MSMEs
- Increasing the capacity of suppliers of energy efficiency and renewable energy products, service providers and finance providers
- Scaling up the project to a national level
- Strengthening policy, institutional and decision making framework

Under the project, an analysis of current consumption level, utilization of available capacity, machine operating capacities and technologies are made. This determines the extent of expert/technical assistance and financial aid that is required to be provided in related areas.

The project involves conducting techno-economic studies at the unit and cluster level. Based upon the analysis/outcome, identification of the energy efficiency and renewable energy measures along with detailed planning of implementation is undertaken. Expert/technical assistance for the identification and planning activities is provided as part of the project. In order to develop demonstration projects, financial aid is provided to first movers as well as assistance is provided in identifying additional financial resources for the projects.

Apart from providing the technical and financial assistance, the project also includes conducting

training and awareness workshops to share experiences and knowledge on energy efficiency and renewable energy measures, providing training on best operating practices and capacity building of local service providers to provide energy efficiency and renewable energy services as well as products to the MSMEs. The project also facilitates development of 'Energy Management Cells' at the SME cluster level.

Through the activities mentioned above, the following are expected to be achieved:

- Creating a scope for energy savings, by increasing the level of end-use demand and implementation of energy efficiency and renewable energy technologies and practices by the MSMEs
- Encouraging the use of renewable energy in various industrial applications
- Improving the productivity and competitiveness of units
- Reducing overall carbon emissions and improving the local environment
- Increasing the capacity of energy efficiency and renewable energy product suppliers, service providers, finance providers
- Strengthening policy, institutional and decision-making frameworks

The methodology of energy saved and reduction in the CO_2 emission is discussed next.

2.2.2.1 Methodology adopted to calculate the savings

Under this project, 12 clusters have been considered. The list of these clusters and respective sector is given in table 15.

Table 15: List of clusters considered under GEF - UNIDO - BEE Programme

Sr. No	Sector	Clusters
1	Brass	Jamnagar, Gujarat
2	Ceramics	Khurja, Uttar Pradesh
3		Thangarh, Gujarat
4		Morbi, Gujarat
5	Dairy	Sikkim
6		Gujarat
7		Kerala
8	Foundry	Belgaum, Karnataka
9		Coimbatore, Tamil Nadu
10		Indore, Madhya Pradesh
11	Hand Tools	Nagaur, Rajasthan
12		Jalandhar, Punjab

The listed clusters have undertaken the Energy Efficiency measures and have undergone the post implementation audit to estimate the energy savings realised. The same has been considered for this report.

2.2.2.1.1 Estimation of energy saved

In order to calculate the energy (thermal) savings post implementation of energy efficient equipment, the consolidated data of annual energy savings of all the clusters were collected from the officials of UNIDO. The data obtained showcased that the annual energy (thermal) savings across all the sectors gradually grew over the years. This means that every year some energy efficiency interventions were implemented. While calculating the total energy (thermal) saved in FY 2017-18, sum of annual energy savings post installation of respective Energy Efficiency technologies was considered. For the uniformity purpose all the energy savings are converted into oil equivalent by using respective fuel calorific values.

2.2.2.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the kcal values, density of respective fuels and CO_2 conversion factor is considered as proposed in table 5.

Based on the results as obtained, the impact under the GEF - UNIDO - BEE Programme is discussed next.

2.2.2.2 Impact of the GEF - UNIDO - BEE Programme

The total energy saved under GEF - UNIDO - BEE Programme in FY 2017-18 is 0.00912 MTOE and total reduction in CO_2 emission is 0.11 $MtCO_2$

Total Energy Saved (MTOE)	**0.00912**
Total Reduction in CO_2 emission ($MtCO_2$)	**0.11**

2.2.3 GEF - World Bank - BEE Programme financing Energy Efficiency at MSMEs

This project was conceived with an objective to increase the demand for energy efficiency investments in target micro, small and medium enterprise clusters and to build their capacity to access commercial finance. The stated outcomes to the project are as follows:

- Create increased demand for Energy Efficiency investments by adopting a cluster based approach to facilitate the development of customized Energy Efficiency products and financing solutions in the five targeted industry clusters.
- Build the capacity of identified apex organizations to assist MSME units in identifying additional Energy Efficiency projects in the future, aiding in widespread replication.
- Raise the quality of Energy Efficiency investment proposals from a technical and commercial perspective
- Increase capacity of project developers, bank loan officers and branch managers thereby bridging the gap present between project identification and successful delivery of commercial finance.
- Expand the use of existing guarantee mechanisms for better risk management by banks resulting in additional commercial finance for energy efficiency.
- Establish a monitoring and evaluation system for the targeted clusters, which can be utilized to BEE's program.

Financial assistance for the project is being provided by World Bank as GEF Grant to the two implementing agencies viz. BEE and Small Industries Development Bank of India (SIDBI). A grant of USD 11.3 million is being provided by GEF and around USD 46.2 million has been raised by MSMEs in the form of private sector financing.

The project comprises of 4 components as briefly given below:

- **Component 1: Build capacity & awareness**
  This component focuses on increasing the awareness of energy efficiency at the cluster and plant level on a large scale through the implementation of outreach efforts, dissemination of information on successful projects and building capacity of various stakeholders through trainings and other related activities.

  Efforts would also be made to increase the capacity of energy auditors, financial consultants/ chartered accountants, vendors and service providers to improve project development capability, service delivery, quality & acceptability of initial and investment grade audits and loan applications.

- **Component 2: Increase investment in energy efficiency**
  This component aims to provide project development support and deployment of performance linked grants for demonstration purposes to increase investments from local commercial financing sources in developing energy efficiency of Indian MSME sector.

  The average investment envisaged in individual MSME units is expected to be in the range of INR 2 million to 4.2 million (~US$44,000 to 93,000) with a simple payback period of less than 2 years. Activities to increase use of risk mitigation instruments include expanding outreach and uptake of existing schemes such as the Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE)

  This component also witnesses participation of the local commercial finance sector, calculated to be $46 million, including MSME equity contributions.

- **Component 3: Knowledge management**
  This component essentially comprises of provision of resources and manpower for broad GEF program evaluation, analysis of cross cutting energy efficiency issues with the goal of ensuring effective implementation and replication across BEE's entire GEF funded programmatic effort.

- **Component 4: Project Management Support**
  This component aims to provide project management support to 2 PMUs within BEE and SIDBI that jointly implement the project.

2.2.3.1 Methodology adopted to calculate the savings

Under this project, 14 clusters have been considered. The list of these clusters and respective sector is showcased in table 16.

Table 16: List of clusters considered under GEF - World Bank - BEE Programme financing Energy Efficiency at MSMEs

Sr. No	Sector	Clusters
1	Forging	Pune
2	Chemical	Ankleshwar
3	Lime Kiln	Tirunelveli
4	Foundry	Kolhapur
5	Mixed Industries	Faridabad
6		Delhi NCR
7		Varanasi, Uttar Pradesh
8		Kundali, Panipat
9		Ludhiana, Jalandhar, Chandigarh
10		Mumbai Thane
11		Morbi, Rajkot
12		Dehradun, Uttarakhand
13		Coimbatore, Erode, Virudhachalam, Tirupur
14		Surat, Vapi, Valsad

The listed clusters have undertaken the Energy Efficiency measures and have undergone the post implementation audit to estimate the energy savings realised. The same has been considered for this report.

2.2.3.1.1 Estimation of energy saved

In order to calculate the energy savings post implementation of energy efficient equipment, the consolidated data of annual energy savings in FY 2017-18 were collected from the officials. The data obtained showcased that the annual energy (thermal) savings across all the sectors gradually grew over the years. This means that every year some energy efficiency interventions were implemented. While calculating the total energy (thermal) saved in FY 2017-18, sum of annual energy savings post installation of respective Energy Efficiency technologies was considered. For the uniformity purpose all the energy savings are converted into oil equivalent by using respective fuel calorific values.

2.2.3.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the kcal values, density of respective fuels and CO_2 conversion factor is considered as proposed by the BEE in table 5.

Based on the results as obtained, the impact under the GEF - World Bank - BEE Programme financing Energy Efficiency at MSMEs is discussed next.

2.2.3.2 Impact of the GEF - World Bank - BEE Programme financing Energy Efficiency at MSMEs

The total energy (thermal) saved under this Programme in FY 2017-18 is **0.021 MTOE** and total reduction in CO_2 emission is **2.12 $MtCO_2$.**

Total Energy Saved (MTOE)	**0.021**
Total Reduction in CO_2 emission ($MtCO_2$)	**2.12**

CHAPTER 3

Lighting

3.1 Unnat Jyoti by Affordable LEDs for All (UJALA)

Lighting is estimated to account for about 20% of the total electricity consumption in India. A large part of this consumption is from highly inefficient incandescent lamps or CFLs. LED lamps on the other hand, provide better light output than conventional lights and are 88% energy efficient as compared to incandescent bulbs or 50% energy efficient when compared to CFLs.

With a view to tap the immense potential of LED lamps in reducing the energy requirement, the Unnat Jyoti by Affordable LEDs for All (UJALA) programme was launched on 5th January 2015 with a target to replace 770 million incandescent bulbs with LED bulbs by March, 2019. Energy Efficiency Services Limited (EESL), was designated as the implementing agency for this programme. LED bulbs under UJALA are distributed at subsidized rates through special counters only set up at designated places in different cities across the country. For domestic lights, EESL service model enables domestic households to procure LED lights at an affordable price, with the option of paying the cost of procurement on easy installment from their electricity bill.

The key objective of the programme are as follows:

- Reduce energy consumption in lighting which helps DISCOMs to manage peak demand
- Promote use of the most efficient lighting technology at affordable rates to domestic consumers which benefits them by way of reduced energy bill
- Enhance the awareness of consumers about the efficacy of using efficient appliances which in turn could change their buying preferences from low first cost based purchases to life cycle cost.
- Increase the demand of LED lights by aggregating requirements across the country and provide an impetus to domestic lighting industry through economies of size.
- Encourage and support domestic manufacturing of LED bulbs by sustaining demand with the ‘Make in India’ policy of the Government.
- Provide a sustainable service model that obviates the need for upfront capital investment as well as additional revenue expenditure to pay for procurement of LED lights. The total cost paid by consumers is less than the total savings in electricity bills.

- Create understanding about the service model amongst all stakeholders such as industry, government agencies, financial institutions, etc. so that market based energy efficiency can happen.
- Create robust arrangements for monitoring and verification of energy savings in a simple and transparent manner
- Create an enabling environment for private sector investments in the lighting sector.

UJALA LED bulbs are 9 W and can be purchased at a price between INR 75 – INR 95 per bulb with state wise variations in prices due to difference in applicable taxes, distribution costs, etc. The consumer can purchase the LED bulb either by paying the entire amount upfront or through monthly/bi-monthly installments in the electricity bill. UJALA LED bulbs are distributed through DISCOM offices, Electricity bill cash counters, designated EESL kiosks, and weekly 'haat' markets, the location details of which are available on the UJALA web portal.

The scheme also provides assurance to the customer, in form of free replacement of LED bulbs by EESL for a period of 3 years in case of a technical defect. Customer complaints are being handled at Distribution kiosks, Customer Care Service Centre and on social media/web platform of UJALA. The total failure rate of UJALA bulbs recorded till August 2016 was only 0.3%, highest being in Delhi (0.97%). (Ministry of Power)

EESL has developed a service model where it works with electricity distribution companies (DISCOMs) through a benefit sharing approach. EESL procures the LEDs bulbs and provides to consumers at a rate of $0.154 each as against their market price of $2.3 – 3.08. The upfront investment made by EESL is paid back in two mechanisms as given below (EESL, 2017):

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

b. **On Bill Financing (OBF):** Cost recovery from consumers by deduction of easy instalments of $0.154 every month for 8-12 months. The entire cost of the LED bulbs, including the awareness, distribution and cost of capital is recovered from the consumer bills.

A dashboard has been prepared which tracks the LEDs being distributed across the country along with the annual energy savings, cost saving, avoided peak demand, CO_2 emission reduction.

The methodology of energy saved and reduction in the CO_2 emission is discussed next.

3.1.1 Methodology adopted to calculate the savings

Under this project, energy (electrical) savings from LED bulbs and LED tube lights is considered. Total 29.73 crore LED bulbs were distributed till FY 2017-18. The distributed LED bulbs replaced an average mix of 100 W incandescent bulbs & 18 W of CFLs across India. The same has been considered for this report.

For LED tube lights, total 58.28 lakh were distributed till FY 2017-18. The distributed LED tube lights replaced 40W Tubular Florescent Lamps. The same has been considered for this report.

On account of the distributed number of LED tube lights and LED bulbs, total electrical energy savings is calculated for FY 2017-18.

Also, apart from the numbers as mentioned above, there are around 63.28 crore LEDs that were distributed up to 31st March 2018 in the private market. The total impact of these LED bulbs in terms of electrical energy savings equals to 66.46 BU. This is not accounted for in this report.

3.1.1.1 Estimation of energy saved

In order to calculate the energy (electrical) savings for **UJALA scheme for LED bulbs,** following methodology is used

a. **Step 1** – Identify number of LED bulbs distributed in FY 2015-16, FY 2016-17 and FY 2017-18 as N FY $_{2015\text{-}16}$, N FY $_{2016\text{-}17}$, and N FY $_{2017\text{-}18}$ respectively.
b. **Step 2** – Average mix of 100 W of Incandescent lamps and 18 W of CFLs have been replaced, $W_{Replaced} = (W_{ICL} + W_{CFL})/2 = 59$ W of inefficient bulbs are replaced by LED.
c. **Step 3** – Identify the wattage of LED bulbs that were distributed, W_{LED}
d. **Step 4** – **Number of annual operational hours considered is 7 hrs x 300 days (hrs.)**
e. **Step 5** – As LEDs started to be distributed since early 2015, the savings are availed till date. Therefore on account of the number of LEDs distributed in the last few years, total energy savings for the FY 2017-18 has been calculated based on following formula.
$ES_{FY} = N_{FY} \times hrs. \times (W_{Replaced} - W_{LED})$

In order to calculate the energy (electrical) savings for UJALA scheme for LED tube lights, following methodology is used.

a. **Step 1** – Identify number of LED tube lights distributed in FY 2016-17 and FY 2017-18 as N $_{FY\ 2016\text{-}17}$, and N $_{FY\ 2017\text{-}18}$ respectively.
b. **Step 2** – 40W of inefficient TFLs are replaced by LED tube lights. $W_{Replaced}$
c. **Step 3** – Identify the wattage of LED tube lights bulbs that were distributed, W_{LED}
d. **Step 4** – Number of annual operational hours considered is 7 hrs x 300 days (hrs.)
e. **Step 5** – As LEDs tube lights started to be distributed in 2016, the savings are availed till date. Therefore on account of the number of LEDs tube lights distributed in the last few years, total energy savings for the FY 2017-18 has been calculated based on following formula.
$ES_{FY} = N_{FY} \times hrs. \times (W_{Replaced} - W_{LED})$

3.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the conversion factor of CO_2 for electricity is considered as proposed by BEE in table 5.

Based on the results as obtained, the impact under the UJALA programme is discussed next.

3.1.2 Impact of the UJALA programme

The total energy (electrical) saved under UJALA programme in FY 2017-18 is 31.43 BU and total reduction in CO_2 emission is 26 $MtCO_2$

Table 17: Electrical energy saved in FY 2017-18 under UJALA scheme

Financial Year	No. of bulbs distributed (in crores)	Annual operational hours (Hrs.)	Average mix of 100W ICL and 9W CFL ($W_{Replaced}$)	LED Wtage (W_{LED})	Energy Saved in BU (ES)
Energy (electrical) saved due to LED Bulbs					
2015-16	11.45	2100	59	9	12.02
2016-17	10.30	2100	59	9	22.83
2017-18	7.98	2100	59	9	31.21
Total energy (electrical) saved in FY 2017-18 by distributing 29.73 crore					**31.22**

Financial Year	No. of LED Tube lights distributed (in lakhs)	Annual operational hours (Hrs.)[3]	TFL Wattage (WReplaced)	LED Wattage (WLED)	Energy Saved in BU (ES)
2016-17	15.72	1800	40	20	0.056
2017-18	42.46	1800	40	20	0.153
Total energy (electrical) saved u in FY 2017-18 by distributing 58.28 lakhs					**0.209**

Total Energy (electrical) Saved (BU)	**31.43**
Total Reduction in CO_2 emission ($MtCO_2$)	**26**

[3]Note: No. of operational hours are considered as per the guidance of EESL

CHAPTER 4

Appliances

4.1 Standards & Labeling (S&L)

The formulation and implementation of a Standards & Labeling programme to promote appliance energy efficiency is one of the key focus areas specified in the Energy Conservation Act, 2001. The programme started in 2006 with voluntary labels for refrigerators and fluorescent tube lights and now a total of 21 appliances are under S&L notification of BEE until 31st March 2018 with 10 appliances being under mandatory regime and the remaining 11 appliances being under voluntary regime.

Mandatory Appliance	Voluntary Appliances
1. Frost Free (No-Frost) Refrigerator	1. Induction Motors
2. Tubular Fluorescent Lamps (TFL)	2. Agricultural Pump Sets
3. Room Air Conditioners	3. Ceiling Fans
4. Distribution Transformer	4. Domestic Liquefied Petroleum Gas (LPG) stoves
5. RAC (Cassette, Floor Standing Tower, Ceiling, Corner AC)	5. Washing Machine
6. Direct Cool Refrigerator	6. Computer (Notebook/laptops)
7. Electric Geysers	7. Ballast (Electronic/Magnetic)
8. Color TV	8. Office equipment (printer, copier, scanner, MFDs)
9. AC (Inverter Types)	9. Diesel driven moonset pumps
10. LED lamps	10. Solid state inverter
	11. Diesel generator

The objectives of Standards & Labeling Program is to provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the marketed household and other equipment.

There are 2 components to this program as described below:

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

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

   There are 2 types of labels i.e. **endorsement label** (provides certification by BEE which informs prospective consumers of the level of efficiency of the product) and **comparative label** (labels allowing consumers to compare energy consumption of similar products, thereby factoring in lifetime running costs to purchase decisions) The terms & conditions (T&C) for manner of display are notified in the regulation and schedule for the mandatory products and respective product schedule for voluntary products. According to the regulation, the label should be affixed in such a manner that it is not possible to easily remove the label from the product. It also states the approved methods of applying label viz. printed self-adhesive label, adhesive tapes, transfix labels, etc. or printing on an anodized name-plate or printing on products, like tubular fluorescent lamps, LED lamps.

L→ R: Comparative Label and Endorsement Label

In order to ensure that the S&L program is effectively implemented, a robust M&V framework has been adopted by BEE to ensure compliance with EC Act 2001 and other relevant legislation and regulations relating to the energy labeling of appliances and equipment. The framework has been developed towards appliance and equipment manufacturers, importers, traders, and retailers who have obligations under relevant legislation and regulations. There are majorly 2 means of assessing compliance:

a. **Check Testing:** Check testing assesses whether the claim made for the energy performance of individual products by the permittee are accurate under the conditions stipulated in the relevant product regulation/schedule. The Bureau or its designated agency (IAME or SDA or any other agency) can undertake a check testing on its own. A sample based approach is undertaken to select products for check testing. Once samples are selected, they shall be procured by the (Independent Agency for Monitoring and Evaluation (IAME) from the market and check tested in 3rd party NABL accredited laboratories. The test lab submits the test report which gets evaluated by the Bureau or its designated agency to ascertain whether the test results conform to relevant schedules/standards/regulations as well as with the information given on the label.

b. **Challenge Testing:** It is carried out as and when written complaint is received regarding wrong or fraudulent declaration of information on the star label and/or requirement given in the respective product schedule of the Bureau. In such cases, Bureau shall carry out challenge testing of the product/model in an independent laboratory and issue a notice to the permittee for conducting the testing.

4.1.1 Methodology adopted to calculate the savings

In order to calculate the electrical energy savings under the S&L scheme, 14 appliances out of 21 appliances and their data up to 31st March 2018 have been considered. The other appliances had shown negligible savings owning to lesser of registration under rest of the category in the voluntary phase; hence were not considered for this report. The list of considered appliances is in table 18.

Table 18: List of appliances considered for calculations under S&L Scheme

Sr. No	Products
1	Direct Cool Refrigerator
2	Room Air Conditioner (Fixed Speed[4])
3	Color Television
4	Frost Free Refrigerator
5	Submersible Pump Set
6	Tubular Florescent Lamps
7	Room Air Conditioner (Variable Speed)
8	Stationary Type Water Heater
9	Open well Submersible Pump Set
10	Distribution Transformer
11	Ceiling Fan
12	LED Lamps
13	Mono set Pump
14	Computers

4.1.1.1 Estimation of energy savings

In order to estimate the total energy (electrical) saved in 2017-18, the production data of last four financial years of all the 14 appliances is considered.

Following methodology is used for S&L scheme:

a. **Step 1:** Identify production of each appliances for FY 2014-15, FY 2015-16, FY 2016-17. This production is the sum of each Quarter (Q1 to Q4)
b. **Step 2:** For FY 2017-18, the production data of all the four quarters are obtained. Now, in order to calculate energy savings, for all appliances production in Q1 with annual hours, production in Q2 with operating hours equivalent to 9 months period, Q3 production with operating hours equivalent to 6 months period and Q4 with operating hours equivalent to 3 months period have been considered. Also, in case of few appliances with assumed annual hours (in case of AC with 1200 hours) the operating hours were equally distributed in 4-quarters as 1200, 900, 600 & 300 respectively)..

4.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in total CO_2 emission, the conversion factor of CO_2 for electricity is considered as proposed by the BEE in table 5.

Based on the results as obtained, the impact under the S&L programme is discussed next.

[4]Note: Including Window, Cassette, Split, and Floor Standing

4.1.2 Impact of the S&L programme

This section discusses the energy savings and reduction in CO_2 emissions under S&L programme.

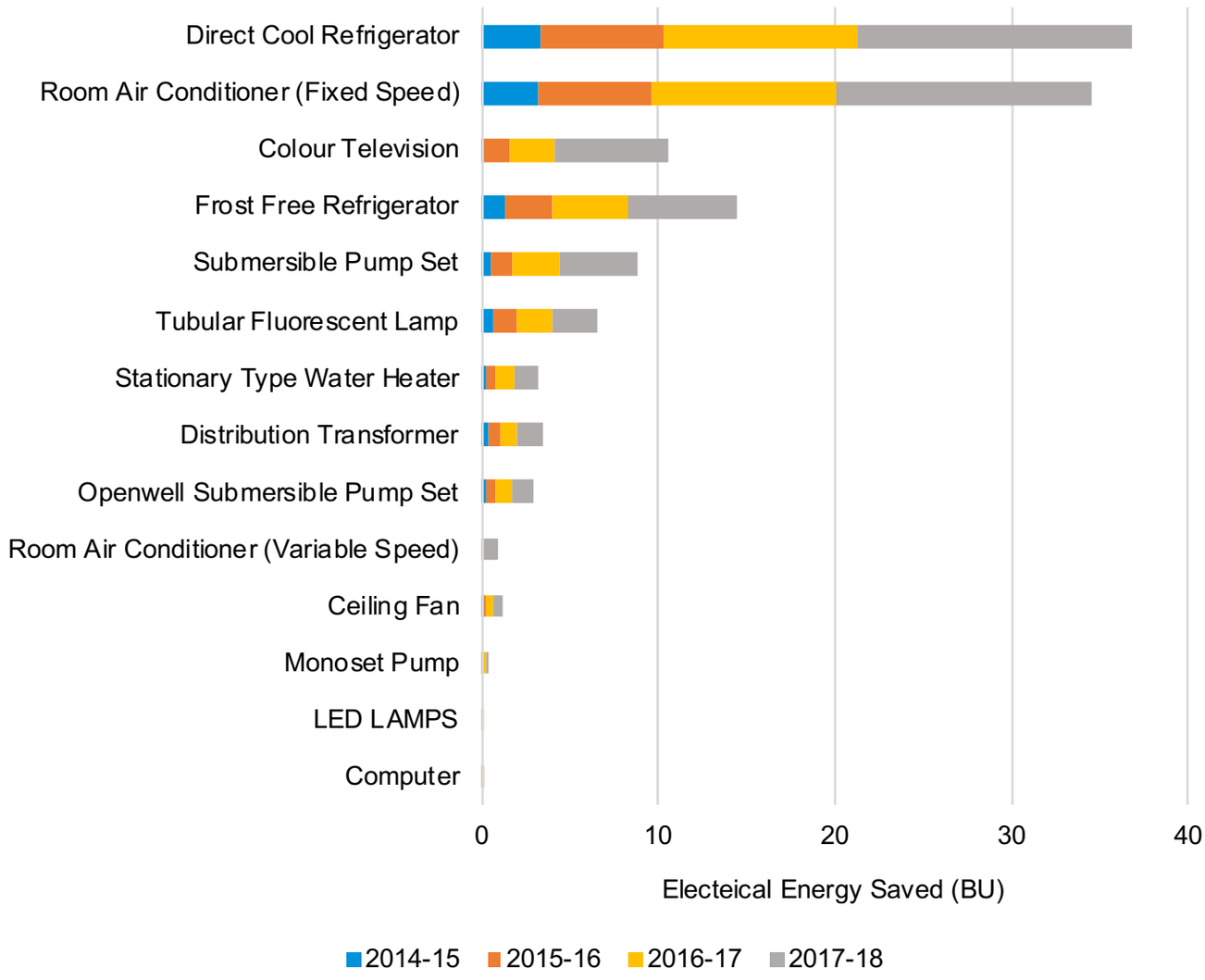
Table 19: Methodology to calculate energy (electrical) savings of S&L programme

Step 1					
Sr. No	Products	Production data of appliances			
		FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18
1	Direct Cool Refrigerator	87,46,562	87,61,774	95,06,713	1,00,14,626
2	Room Air Conditioner (Fixed Speed)	46,39,361	46,76,022	57,41,229	53,44,732
3	Color Television	1,69,912	45,50,837	26,17,893	94,79,658
4	Frost Free Refrigerator	18,36,151	19,71,685	19,55,699	25,58,369
5	Submersible Pump Set	1,32,417	2,38,172	5,33,170	8,63,401
6	Tubular Florescent Lamps	13,55,71,506	10,65,40,118	9,73,95,586	8,12,19,925
7	Room Air Conditioner (Variable Speed)	0	25,006	7,02,652	22,55,408
8	Stationary Type Water Heater	16,84,099	17,89,877	24,06,708	27,51,979
9	Open well Submersible Pump Set	88,065	1,02,771	1,35,201	1,67,855
10	Distribution Transformer	3,71,454	2,99,331	2,89,019	3,47,259
11	Ceiling Fan	14,29,442	17,97,692	27,47,053	33,86,441
12	LED LAMPS	0	0	1,17,54,592	23,934,280
13	Mono set Pump	20,924	20,909	37,187	53,860
14	Computers	1,45,823	1,16,875	2,592	0

On account of the production data, the total energy savings for the year 2017-18 is calculated.

Step 2					
Sr. No	Products	Energy savings (MU)			
		FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18
1	Direct Cool Refrigerator	3376.28	6945.04	11003.7	13893.89
2	Room Air Conditioner (Fixed Speed)	3150.17	6443.41	10480.1	13161.42
3	Color Television	63.05	1526.22	2557.88	5150.30
4	Frost Free Refrigerator	1304.24	2732.99	4205.74	5496.75
5	Submersible Pump Set	522.49	1261.54	2563.5	3702.50
6	Tubular Florescent Lamps	642.57	1367.5	2003.91	2353.58
7	Stationary Type Water Heater	263.59	562.73	973	1269.65
8	Distribution Transformer	381.17	696.55	977.65	1224.39
9	Open well Submersible Pump Set	237.64	524.66	898.6	1155.16
10	Room Air Conditioner (Variable Speed)	0	7.31	167.56	439.01
11	Ceiling Fan	83.73	188.09	350.38	472.88
12	Monoset Pump	33.41	64.11	106.66	133.49
13	LED Lamps	0	0	28.07	66.81
14	Computer	2.86	6.35	6.42	6.42
Total Energy (electrical) Saved in MU					**48,526.27**

Figure 10: Energy (electrical) saved by the appliances under S&L programme



The above graph shows that among all the appliances, Refrigerators and Room ACs have contributed to the maximum energy savings. Also the total energy saved by LED Lamps that equals to 66.81 MU has been subtracted from the total energy savings as calculated in table 19. The reason is to avoid duplication as the same has been considered in the UJALA scheme. Therefore, the total energy (electrical) saved under S&L programme in FY 2017-18 is 48.46 BU and total reduction in CO_2 emission is 40.03 $MtCO_2$

Total Energy (electrical) Saved (BU)	**48.46**
Total Reduction in CO_2 emission ($MtCO_2$)	**40.03**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CHAPTER 5

Buildings

5.1 Commercial Establishments (New Construction)

5.1.1 Energy Conservation Building Code (2017)

The building sector in India, especially in the commercial sector, provides substantial potential in energy savings to the tune of 30-40% of existing energy consumption. With a view of achieving this energy saving potential, the Energy Conservation Building Code (ECBC) was launched by BEE. The main objective of ECBC is establishing minimum requirements for energy efficient design and construction of commercial buildings by setting minimum energy efficiency levels for commercial buildings thereby leveraging in energy savings for future while retaining occupant comfort and combating climate change. In June 2017, ECBC 2017 was launched which provides 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. Adoption of ECBC 2017 for new commercial building construction in India is estimated to lead to a 50% reduction in energy use by 2030 which would translate to energy savings of about 300 Billion Units and 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 reduction.

ECBC is applicable to all buildings or building complexes (both Government and private buildings) that have a connected load of 100 kW or greater, or a contract demand of 120 kVA or greater and are used for commercial purposes. There are 6 types of buildings classified under ECBC viz. hospitality (i.e. star and no-star rated hotels, resorts), assembly (i.e. theater, transport service facilities, multiplexes), healthcare (i.e. hospitals, out-patient healthcare), businesses (i.e. small, medium and large offices based on area of building), education (i.e. schools, colleges, universities, training institutions), shopping facility (shopping malls, stand-alone retails, open gallery malls, super markets) The provisions of this

code apply to specific components of the building systems viz. building envelope; mechanical systems and equipment, including heating, ventilating and air conditioning, service hot water heating; interior and exterior lighting, electrical power & motors, and renewable energy systems.

In order 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).

For compliance the EPI shall be calculated based on either of 3 approaches:

a. **Prescriptive Method:** ECBC Buildings that demonstrate compliance through Prescriptive Method shall be deemed to have an EPI equal to the Standard Building EPI i.e. EPI ratio is 1. This includes mandatory requirements along with the prescribed (or minimum) values for envelope components, comfort systems and lighting controls.
b. **Building Envelope trade-off method:** This method can be used in place of the prescriptive method, wherein envelope performance factor (EPF) of proposed building is less than or equal to the EPF of the standard building calculated as per the stipulation provided in the code, in addition to meeting the prescriptive requirements for comfort systems and lighting & controls along with other mandatory requirements.
c. **Whole building performance method:** In this case, compliance to ECBC is considered 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. However, the mandatory requirements of the code need to be complied.

There are 3 levels of energy efficiency performance prescribed by the code:

a. **Energy Conservation Building Code Compliant Building (ECBC Building):** ECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC Compliant Building requirements in the code for all components of building systems, or by following the provisions of the Whole Building Performance (WBP) Method. Such a building is 20% more efficient than conventional building.

b. **Energy Conservation Building Code Plus Building (ECBC+ Building):** ECBC+ Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC+ Compliant Building requirements in the code for all components of building systems, or by following the provisions of the Whole Building Performance (WBP) Method. An ECBC+ building is 30-35% more efficient than conventional building.

c. **Super Energy Conservation Building Code Building (SuperECBC Building):** SuperECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under SuperECBC Compliant Building in the code for all components of the building system, or by following the provisions of the Whole Building Performance (WBP) Method. A SuperECBC building is 40-45% more efficient than conventional building.

In order to exhibit compliance to the code, mandated compliance documents are provided to appropriate authorities. Compliance documents include construction drawings and specifications that show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the authority having jurisdiction to verify whether the building complies with the requirements of this code. Details shall include, but are not limited to:

a. **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;

b. **Heating, Ventilation, and Air Conditioning:** system and equipment types, sizes, efficiencies, and controls; economizers; variable speed drives; piping insulation; duct sealing, insulation and location; solar water heating system; requirement for balance report;
c. **Lighting:** lighting schedule showing type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls; lamp efficacy for exterior lamps;
d. **Electrical Power:** electric schedule showing transformer losses, motor efficiencies, and power factor correction devices; electric check metering and monitoring system.
e. **Renewable energy systems:** system peak generation capacity, technical specifications, solar zone area

5.1.1.1 Methodology adopted to calculate the savings

This scheme is still under the voluntary stage. However, there are a few states and Union Territories (UT) that have amended and notified the code.

There are total 68 buildings across India that are either in the discussion stage, design stage, construction stage or have completed their construction as per ECBC guidelines. Total 9 buildings of 68 buildings have completed their construction FY 2017-18 and are now operational. The same has been considered for this study.

5.1.1.1.1 Estimation of energy savings

In order to calculate the energy (electrical) savings, the difference between the baseline EPI and proposed EPI of the respective buildings are considered, which is then multiplied by the total conditioned built up area in square meters (sqm). The EPI benchmarks are as per the approved guidelines under ECBC programme.

5.1.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the conversion factor of CO_2 for electricity is considered as proposed by BEE in Table 5.

Based on the results as obtained, the impact under the ECBC programme is discussed next.

5.1.1.2 Impact of the ECBC programme

The total energy (electrical) saved under ECBC programme in FY 2017-18 is 0.0056 BU and total reduction in CO_2 emission is 0.0046 $MtCO_2$

Table 20: Energy (electrical) Savings under ECBC Programme in FY 2017-18

S. No	Building Type	Building use type	City	Climatic zone	Area, sqm	Baseline EPI, kWh/ sqm/yr	Pro-posed EPI, kWh/ sqm/yr	Annual Energy Saving, kWh (ECBC Baseline)
1	Institution-al and IT	Daytime use	Jaipur	Hot and Dry	13,975	105	97	5,79,586
2	Hotel	24 hour use	Banga-lore	Moderate	19,875	116.5	97	7,00,000
3	Hospital	24 hour use	Jaipur	Hot and Dry	12,660	456	294	21,63,769
4	Office	Daytime use	Raipur	Compos-ite	10,541	137.8	47	9,57,122.8
5	Office	Daytime use	Lucknow	Compos-ite	5,288	123.2	87	3,99,230
6	Office	Daytime use	Hyder-abad	Compos-ite	6,286	94.31	88.72	1,77,600
7	Institution-al and IT	Daytime use	Haveri	Warm and Hu-mid	30,000	275	275	-
8	Office	Daytime use	Thiruva-nantha-puram	Warm and Hu-mid	4,000	182	182	-
9	Institution-al and IT	Daytime use	Hubli	Warm and Hu-mid	24,525	105	97	5,79,586
Total energy (electrical) saved in FY 2017-18 in MU								**5,556.90**

Total Energy (electrical) Saved (BU)	**0.0056**
Total Reduction in CO_2 emission ($MtCO_2$)	**0.0046**

5.1.2 Commercial Establishments (Existing Construction)

5.1.2.1 BEE Star rating programme for buildings

While the development of mandatory ECBC creates a 'supply push' by stimulating an ecosystem for energy efficiency, measures were required for creating the 'demand pull' which will enable rapid transformation towards energy efficiency in buildings. In this regard, BEE developed a Star Rating programme for buildings with an aim to create this 'demand pull' by providing a public recognition to energy efficient buildings and stimulating interests of building developers in energy efficiency.

The star rating programme is based on the actual performance of a building in terms of its specific energy usage in kWh/sqm/year. This programme rates office buildings on a 1-5 Star scale, with 5 Star labelled buildings being the most efficient. **The scheme is propagated on a voluntary basis and the label provided under it is applicable for a period of 5 years from the date of issue. Under this programme, there are 5 categories of buildings that have been identified viz. office buildings (day use and business process outsourcing (BPOs)), shopping malls, hotels, hospitals and IT parks in the 5 climatic zones of the country.**

For the purpose of buildings, Energy Performance Index (EPI) in kWh/sqm/year is considered. EPI is defined as the ratio of the annual purchased & generated electricity of the building (in KWh/yr) and the built up area (in sqm). However the total electricity does not include electricity generated from on-site renewable sources such as solar photovoltaic etc. The following table indicates the EPI with the corresponding Star Label under the various climatic zones.

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

The rating is normalized to account for the operational characteristics that define the building use, hours of operation, climatic zone and conditioned space. This 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.

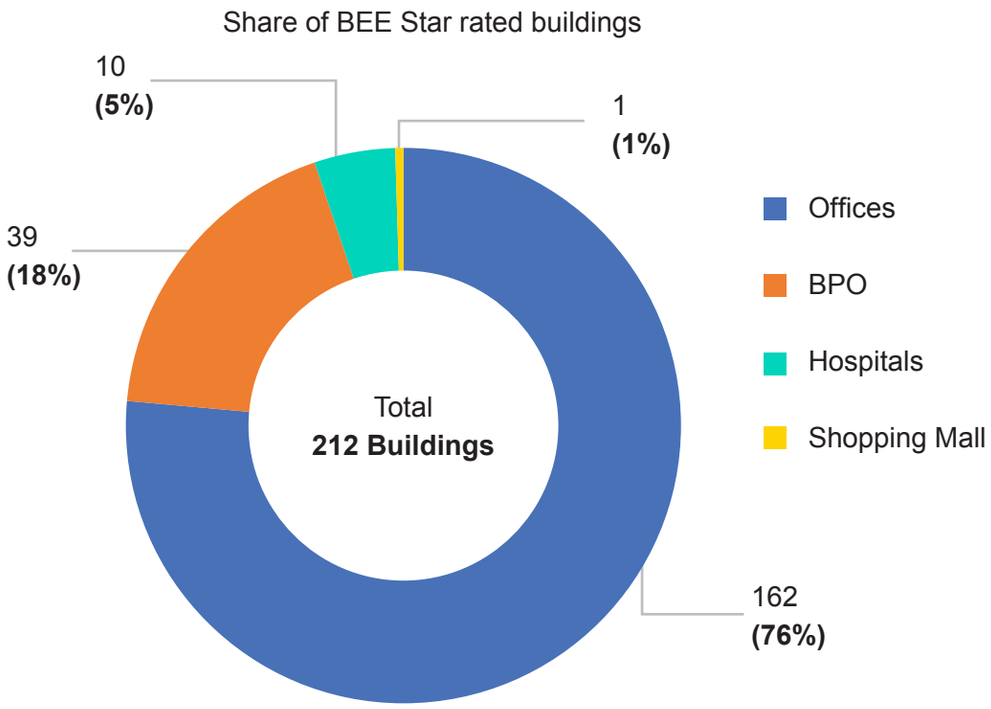
Under this programme, the user affixes the building rating label as per the label design and specification (both in terms of size and material), manner of display, and the rating plan as prescribed by the Bureau for the particular building type. The manner of display of the label is such that it is at a place of prominence at the entrance of the building and at a height of 5 feet as measured from the bottom of the label with respect to the floor.

BEE is continuously reviewing its 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 comparative assessment and target setting in existing buildings.

5.1.2.1.1 Methodology to calculate the savings

There are total four types of commercial establishments that are part of this report, viz. Offices, Hospitals, BPOs and Shopping Malls. The share of each building type is as below:

Figure 11: Share (value, %) of star rated buildings (number, percentage)



As the star rating is valid for only 5 years and there are 148 number of buildings that had received star rating in or before FY 2012-13; so it has been assumed that post completion of the 1st cycle, all these buildings have reinstated their ratings.

5.1.2.1.1.1 Estimation of energy savings

The energy (electrical) savings of star rated buildings is based on the difference between the reported EPI value and max EPI for star 1 rated building, multiplied by the conditioned area.

The bandwidths considered for **building energy star rating programme more than 50 % air conditioned built up area** is given below:

Table 21: EPI bandwidth for >50% air conditioned built up area

Climatic Zone- Composite	
EPI (kWh/sqm/year)	**Star Label**
190-165	1 Star
165-140	2 Star
140-115	3 Star
115-90	4 Star
Below 90	5 Star
Climatic Zone - Warm and Humid	
EPI (kWh/sqm/year)	**Star Label**
200-175	1 Star
175-150	2 Star
150-125	3 Star
125-100	4 Star
Below 100	5 Star
Climatic Zone - Hot and Dry	
EPI (kWh/sqm/year)	**Star Label**
180-155	1 Star
155-130	2 Star
130-105	3 Star
105-80	4 Star
Below 80	5 Star

The bandwidths considered for **building energy star rating programme less than 50 % air conditioned built up area** is given below:

Table 22: EPI bandwidth for <50% air conditioned built up area

Climatic Zone- Composite	
EPI (kWh/sqm/year)	**STAR LABEL**
80-70	1 Star
70-60	2 Star
60-50	3 Star
50-40	4 Star
Below 40	5 Star
Climatic Zone - Warm and Humid	
EPI (kWh/sqm/year)	**Star Label**
85-75	1 Star
75-65	2 Star
65-55	3 Star
55-45	4 Star
Below 45	5 Star
Climatic Zone - Hot and Dry	
EPI (kWh/sqm/year)	**Star Label**
75-65	1 Star
65-55	2 Star
55-45	3 Star
45-35	4 Star
Below 35	5 Star

5.1.2.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the conversion factor of CO_2 for electricity is considered as proposed by BEE in Table 5.

Based on the results as obtained, the impact under the BEE Star Rating programme is discussed next.

5.1.2.2 Impact of the BEE star rating programme

There are total 212 commercial buildings that have adopted BEE star rating programme. Out of these buildings, total 26 commercial establishments have received BEE star ratings in FY 2017-18. On account of total number of star rated buildings in India, the total energy (electrical) saved by these commercial establishments in the year 2017-18 0.20 BU. This has led to reduction of 0.1756 Million Tonne of CO_2.

As the electrical energy savings obtained under this scheme was due to the replacement of inefficient electrical & mechanical appliances with BEE star rated electrical & mechanical appliances, therefore in order to avoid any duplication, the energy savings of BEE Star Rating programme for buildings has been already included under S&L programme.

5.1.3 Building Energy Efficiency Programme

Amidst rapid economic growth and urbanization, India's buildings sector is anticipated to record the world's fastest surge in energy consumption through 2040. The sector consumes over a third of India's electrical energy, to meet the growing demand for lighting, space heating and cooling.

While there is a clear need for bringing the benefits of energy efficiency to the buildings sector and reduce its financial and carbon costs, this goal faces both technical and financial barriers. In response, Energy Efficiency Services Limited (EESL) has introduced Buildings Energy Efficiency Programme which offers a uniquely designed solution for buildings of the government, industry, and institutions to implement and retrofit energy efficient appliances and systems at affordable prices.

Bringing affordable energy savings to India's buildings: EESL has applied its proven model of demand aggregation as a means of ensuring affordability for the energy efficient appliances, implementation, and systems maintenance to the buildings sector. Till date, EESL has signed agreements to unlock the dormant energy efficiency potential of over 15,000 buildings including railway stations across India. Not only is the programme unlocking their energy efficiency potential at a significant scale, but also ensuring economies of scale for the appliances, systems, and services it offers. The cost effectiveness, and high rates of returns in the form of savings on electricity has created a market momentum in the commercial buildings space.

A business model that suits diverse building efficiency needs: Its approach offers two attractive pathways to clients: Energy Service Company (ESCO) Mode and Project Management Consultancy (PMC) model. Under the ESCO model, the entire up-front cost is borne by EESL and this cost is paid back by the building owner from the energy saving resulted by the intervention. In the PMC model, EESL is fully paid for its strategic input, implementation, and equipment maintenance.

Building Management System: As part of their Buildings Energy Efficient Programme offering, EESL gives building facility managers access to a Building Management System to track power consumption in real-time and identify how they can cut down power wastage from lighting, audio-visual and information technology equipment, and other appliances left on when not in use. The system can also give facility managers a snapshot of energy use comparison, energy cost comparison, and an overall energy sustainability report.

20,000 energy efficient buildings by 2020: EESL aims to bring energy efficiency solutions to 20,000 large Government and Private buildings by 2020. With an investment of around INR 2,000 crore (equivalent to USD 30.8 crore), EESL will retrofit around 2 crore LED lights, 25 lakh energy efficient ceiling fans, and 2 lakh energy-efficient ACs. EESL's programme will be expanded to include centralized air conditioning, Energy Audits, and New Generation Energy Management System.

5.1.3.1 Methodology to calculate the savings

There are a total 2901 commercial buildings under this programme. The type of commercial building includes, Central Govt. Buildings, District Courts, PWD Buildings and Railway Station buildings. The share of buildings under this programme in FY 2017-18 is as below.

Figure 12: Share of commercial buildings under BEEP in FY 2017-18

Share of Commercial Buildings under BEEP

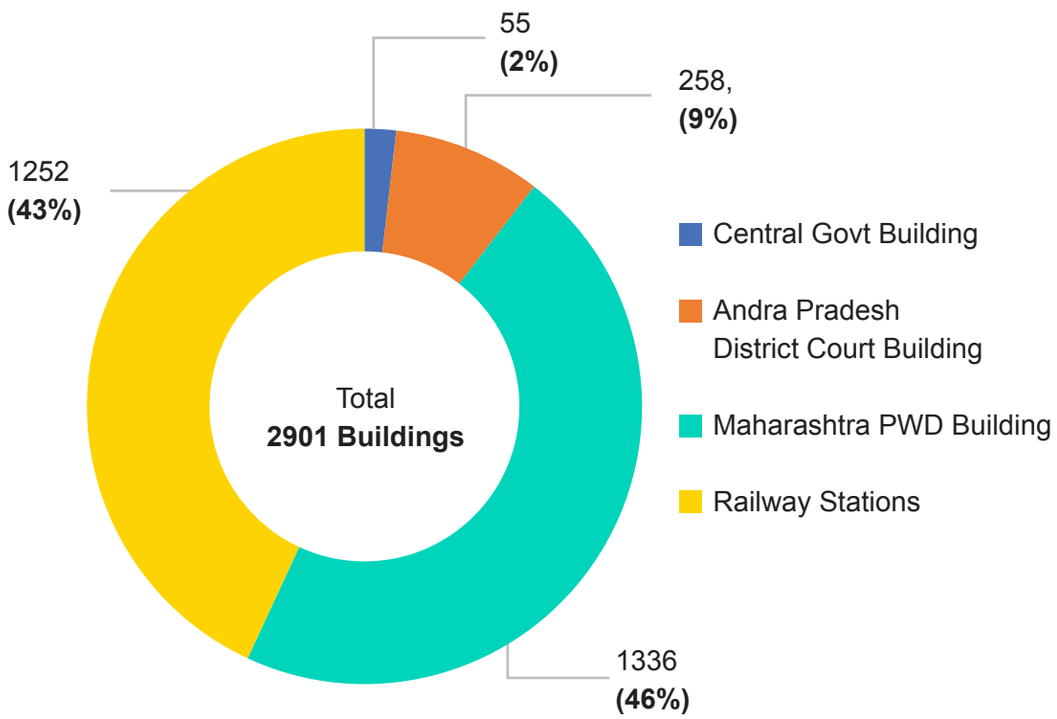


Table 23: Method to calculate Energy savings (sample)

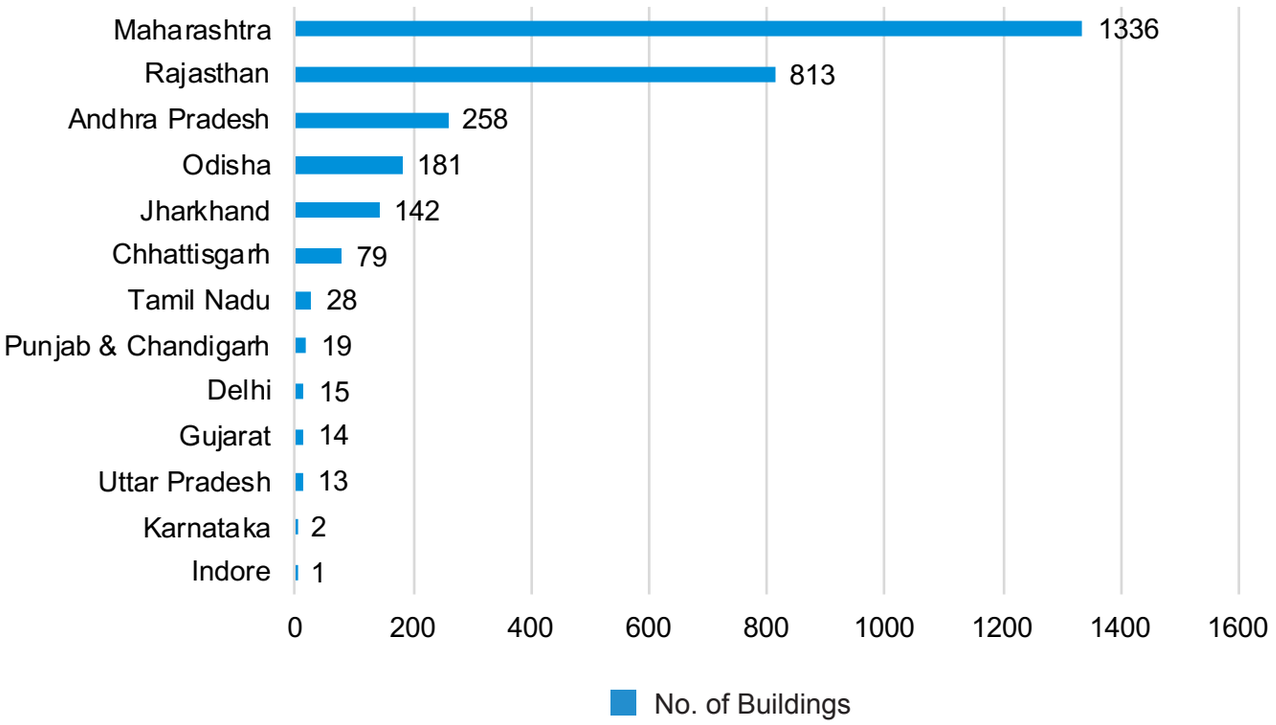
Building Information				Work Done under BEEP scheme until 31 March 2018					
				Lighting					
Name	Type	Location	Year in which work was completed	Existing fixture			Energy efficient fixture		
				Type	No	Watt	Type	Watt	

[5]Note: No. of operational hours for indoor lighting & ceiling fans = 8 hrs and 300 days. No. of operating hours for outside lighting = 12 hrs and 365 days. No of operating hours for ACs = 1200hrs.

Prior to FY 2017-18, very few buildings were a part of this programme. All the 2901 buildings became a part of this programme in FY 2017-18 only. These building are spread across several states of India as seen below.

Figure 13: Share (numbers) of commercial buildings under BEEP across India

Share of commercial buildings under BEEP scheme (in FY 2017-18)



5.1.3.1.1 Estimation of energy savings

In order to calculate the energy (electrical) savings under the BEEP, following information is collected and then energy savings for Lighting and HVAC systems is calculated.

						Savings Achieved from Lighting (kWh)[5]	Savings Achieved from HVAC (kWh)
	HVAC (Heating/Ventilation/AC)						
	Existing fixture			EE fixture			
	Type	No	Watt	Type	Wattage		
						=No. of fixtures x (Conventional Wattage minus Energy efficiency Wattage) x Annual no. of hrs.	=No. of fixtures x (Conventional Wattage minus Energy efficiency Wattage) x Annual no. of hrs.

5.1.3.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in the total CO_2 emission, the conversion factor of CO_2 for electricity is considered as proposed by BEE in table 5.

Based on the results as obtained, the impact under the BEEP is discussed next.

5.1.3.2 Impact of the Building Energy Efficiency Programme

The impact of the BEEP in terms of energy (electrical) saved across India upin FY 2017-18 is seen in table below.

Table 24: Energy (electrical) saving in MU under BEEP scheme in FY 2017-18

State	No of Building	Energy Savings (MU)
Maharashtra	1336	16.12
Rajasthan	813	3.75
Andhra Pradesh	258	2.80
Odisha	181	3.32
Jharkhand	142	1.49
Chhattisgarh	79	2.06
Tamil Nadu	28	1.61
Punjab & Chandigarh	19	3.53
Delhi	15	7.15
Gujarat	14	1.99
Uttar Pradesh	13	7.21
Karnataka	2	1.78
Indore	1	0.05
Total	**2901**	**52.85**

The total energy (electrical) saved under the BEEP scheme in the last FY 2017-18 is 0.053 BU and total reduction in CO_2 emission equals to 0.044 Million Tonne of CO_2.

As the electrical energy savings obtained under this scheme was due to replacement of inefficient electrical & mechanical appliances with BEE star rated electrical & mechanical appliances, therefore in order to avoid any duplication, the energy savings of BEEP has been already considered under S&L programme.

5.1.4 Residential & Commercial Buildings (New & Existing)

5.1.4.1 Green Building programmes

All Green Buildings are energy efficient but not all energy efficient buildings are green. This is true because a major portion of total Green building rating points are allocated toward Energy Efficiency.

5.1.4.1.1 Indian Green Building Council (IGBC)

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) was formed in the year 2001 with a vision to enable a sustainable

built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025.

The council offers a wide array of services which include developing new green building rating programmes, certification services and green building training programmes. All stakeholders of the construction industry comprising of architects, developers, product manufacturers, corporate, Government, academia and nodal agencies participate in the council activities through local chapters.

Green building rating brings together a host of sustainable practices and solutions to reduce the environmental impacts while providing an integrated approach considering life cycle impacts of the resources used. The IGBC Green Building Rating Systems are present for new buildings, existing buildings, schools, factory buildings, data center, healthcare, cities, villages' townships etc.

All the IGBC rating systems are voluntary, consensus based, market-driven building programmes. The rating systems are based on the five elements of the nature (Panchabhutas) and are a perfect blend of ancient architectural practices and modern technological innovations. The ratings systems are applicable to all five climatic zones of the country. Green projects rated by IGBC fall under one of the following levels (in ascending order): Certified, Silver, Gold and Platinum. IGBC certifies the green projects which are conceptualized, designed, constructed and operated as per IGBC Ratings.

5.1.4.1.1.1 Major highlights (CII, 2018)

Rating System	No. of Projects/ Stations	Total Energy Saving Over Conventional Building (MWh/ Annum)	Total Built Up Area (Million Sq.Ft.)	Total Reduction In CO_2 (Million Tonne Of CO_2 Equivalent Per Annum)
IGBC Green New Buildings, New Construction and Core and Shell	611	33,43,849	244.13	0.2741956
IGBC Green Existing Buildings	78	2,37,065	28.234	0.0194393
IGBC Green Metro Stations	179	50,780	18.46	0.0041640
IGBC Green Homes	209	23,381	14.3	0.0019173
IGBC Green Factory	186	12,91,627	95.2	0.1059134
Total	**1185**	**49,46,702**	**400.32**	**0.41**

5.1.4.1.2 Leadership in Energy and Environmental Design (LEED)

Leadership in Energy and Environmental Design (LEED) is one of the most popular green building certification programs used worldwide. Developed by the non-profit U.S. Green Building Council (USGBC) it includes a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods that aims to help building owners and operators be environmentally responsible and use resources efficiently.

LEED-INDIA is the Indian chapter of LEED-International which provides a green rating to a structure, whether an apartment, independent home or office, based on the stipulations provided under the LEED rating system. IT Parks, Offices, Banks, Airports, Convention centers, Educational institutions, Hotels and Residential complexes are the major structures that register for a LEED rating.

Under the LEED rating system, the following certification levels are present (Godrej Interio):

Rating	Points Required
LEED Certified	26-32
LEED Certified Silver Level	33-38
LEED Certified Gold Level	39-51
LEED Certified Platinum Level	52-69

The point are provided based on certain criterion which are given as follows:

S. No.	Rating criterion	Points Required
0.	Prerequisites	8
1.	Sustainable Sites	13
2.	Water Efficiency	6
3.	Energy & atmosphere	17
4.	Minerals & resources	13
5.	Indoor environment quality	15
6.	Innovations and accredited professional points	5
Total		69

A brief on the rating criterion mentioned above are given as follows:

- **Sustainable Sites:** Outlines various "green" opportunities available for reducing the negative impact the building has on the environment. The opportunities range from preventing erosion of top soil, water contamination & creation of heat islands, effective use of a barren or waste lands etc.
- **Water Efficiency:** It is defined as the accomplishment of a function, task, process, or result with the minimal amount of water feasible. It provides an indicator of the relationship between the amount of water required for a particular purpose and the amount of water used or delivered.

- **Energy and atmosphere:** In this point, use of energy efficient methods and appliances are considered which reduce the energy requirement of the building as well as reduce its carbon footprint. Use of renewable energy is also considered under this criterion.
- **Materials and resources:** This criterion looks at the extent to which refuse building materials and products have been reused to conserve materials, use of locally sourced products, and use of rapidly renewable building materials etc.
- **Indoor environment quality:** It takes in to account the comfort level that the building provides for human habitation viz. ample air circulation, maintenance of clean air, comfortable temperature etc.
- **Innovation and design process:** This criterion provides additional points for implementing innovative ideas to reduce the overall environmental impact or direct reduction in energy consumption.

The idea of green building certification is picking up in India and currently there are more than 752 LEED-certified projects with total space of 20.28 million square meters.

5.1.4.1.2.1 Major highlights

- India ranks 3rd on USGBC annual ranking of top 10 countries in LEED certified buildings (Hindu Business Line Article, 2018)
- According to USGBC, India has over 752 LEED certified projects with over 20.28 million square meters of space. (Hindu Business Line Article, 2018)

5.1.4.1.3 Green Rating Integrated Habitat Assessment (GRIHA)

GRIHA is India's National Rating System for Green buildings and is a tool that helps people assesses the performance of their building against certain nationally acceptable benchmarks. It has been developed by TERI (The Energy and Resources Institute) and is endorsed by the MNRE (Ministry of New and Renewable Energy). It is based on nationally accepted energy and environmental principles, and seeks to strike a balance between established practices and emerging concepts, both national and international. GRIHA attempts to minimize a building's resource consumption, waste generation, and overall ecological/environmental impact by comparing them to certain nationally acceptable limits/benchmarks.

GRIHA rating system quantifies the following aspects for deriving the ratings score:

- Energy/power consumption (in terms of electricity consumed in kWh per square meter per year)
- Water consumption (in terms of litres per person per day)
- Waste generation (in terms of kilograms per day, or litres per day)
- Renewable energy integration (in terms of kW of connected load)

These 4 aspects are further broken to 34 areas and awarded points on a scale of 100. In order to qualify for GRIHA certification, a project must achieve at least 50 points.

Project scoring is done in the following manner with 100 being the best possible score:

- 50-60 points is certified as a 1 star GRIHA rated building,
- 61-70 is a 2 star GRIHA rated building,
- 71-80 is a 3 star GRIHA rating building,
- 81-90 is a 4 star GRIHA rated building and
- 91-100 is a 5 star GRIHA rated building

Except for industrial complexes, all buildings – offices, retail malls, institutions, hotels, hospitals, health-care facilities, residences, and multi-family high-rise buildings – in the pre-design/design stage are eligible for certification under GRIHA.

5.1.4.1.3.1 Major highlights of the scheme

- More than 1200 projects are registered for GRIHA ratings
- Total energy savings is 654679 MWh and CO_2 emission reduction is 536837 tonnes (GRIHA India, 2019)

CHAPTER 6

Agriculture

6.1 Agriculture Demand Side Management (AgDSM) Programme

Agriculture constitutes around 18.5% of India's total energy consumption, and its power consumption is expected to rise by an estimated 54% between 2015 and 2022. An estimated 2.1 crore agricultural pump sets are connected to the power grid in India, to meet the irrigation needs of Indian farmers with an addition of 2.5 lakh pump sets every year. Being a largely informal sector and employing the largest amount of unskilled labour force having little to no technical knowledge and limited availability of capital, locally made inefficient pump sets are widely used that contribute to both energy and water wastage. Access to heavily subsidized water and electricity, farmers have no incentive to adopt more energy efficient practices. This has resulted in increased annual subsidy burden on the State governments which has grown to more than Rs. 65,000 crore per annum. Studies reveal that about 30%-40% energy savings is possible in agriculture sector by adoption of Energy efficient Star Labelled Pump Sets.

It is estimated that the replacement of India's 2.1 crore pumps with star rated efficient pumps will result in the following:

- Total energy savings of 4.30 billion units of electricity
- Total savings of INR 22,750 crore of subsidies
- Net reduction in CO_2 emission by 34.8 million tonnes

Additionally, the production of star rated 'Made in India' pumps can be promoted, which can promote indigenous manufacturing, leading to direct and indirect job creation. DISCOMs can benefit through the reduced peak demand, enabling them to avoid procuring marginal power for meeting agriculture demand, reducing their costs.

Agricultural Demand Side Management (AgDSM) programme was initiated in 11 DISCOMs of selected 8 states viz. Maharashtra, Haryana, Punjab, Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh and Karnataka). The economy of these states were agriculturally intensive and accounted for more than 70% of the national electricity consumption in this sector.

Under the programme, inefficient agricultural pump sets is being replaced with BEE 5 star-rated energy efficient pump sets. Farmers are being offered a zero-cost energy efficient pump set (EEPS), and a long-term partnership with EESL under the ESCO model. EESL facilitates the entire upfront investments, and recover the EEPS cost over a mutually agreed period of time by monetizing energy savings. EESL also offers free repair & maintenance service during the 5-year project duration, further incentivizing farmers to adopt newer, and more efficient models. The EEPS are accompanied with Smart Control Panels, enabling farmers to remotely monitor and control them, and thereby achieve reduction in water and energy wastage.

The 1st pilot AgDSM project was launched in Solapur district of Maharashtra where BEE consulted with Maharashtra State Electricity Distribution Company Limited (MSEDCL) identified 4 feeders (covering approximately 2000 pumps) in Mangalvedha sub-division Solapur district. The detailed project report (DPR) was prepared and an implementer agency/ ESCO also engaged for implementation. A total of 2209 pumpsets were replaced (free of cost to farmers) with energy efficient star rated pumpsets reflecting annual energy savings of 6.1 million units.

Next, EESL successfully completed its first AgDSM project for 590 pump sets in Byadgi and Nippani circles under the Hubli Electricity Supply Company Limited (HESCOM), Karnataka. Further, EESL have replaced 1,337 pump sets in Mandya district under the Chamundeshwari Electricity Supply Corporation Limited (CESC), Karnataka.

EESL have been able to achieve over 30% energy savings. This not only resulted in the reduction in State subsidy but also increased the overall efficiency of the power sector.

6.1.1 Methodology adopted to calculate the savings

There are total 23,127 BEE 5 star rated 5 HP pumps which were distributed till FY 2017-18 to replace inefficient pumps. The same has been considered for this report.

6.1.1.1 Estimation of energy savings

The energy savings were calculated on account of total number of inefficient pumps that were replaced by the energy efficient pumps in the past few years.In order to calculate the energy savings, following steps were used:

- **Step 1:** Divide the existing savings in MU by the total number of pumps replaced as per the AgDSM dashboard(www.agdsm.in)
- **Step 2:** Multiply the output of Step 1 with 18,018 (no. of 5HP pumps replaced in the FY 2017-18).

While calculating total energy (electrical) savings, the savings from previous financial years have also been taken into consideration as the energy efficient pumps installed during that time continues to save energy during operational hours.

6.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in total CO_2 emission, conversion factor of CO_2 for electricity is considered as proposed by the BEE in table 5.

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

6.1.2 Impact of the scheme

Prior to the FY 2017-18 total 5,109 BEE five star rated 5 HP pumps were installed in several regions across India. In the financial year 2017-18, there were total 18,018 number of inefficient 5 HP pumps that were replaced by 5HP BEE five star rated pumps under AgDSM program.

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 2017-18 is 0.070 BU and reduction in emission of CO_2 is 0.056 Million Tonne.

As the electrical energy savings obtained under this scheme was due to replacement of inefficient pumps with BEE star rated pumps, therefore in order to avoid any duplication, the energy savings of AgDSM has been already included under S&L programme.

CHAPTER 7

Municipality

7.1 Municipal Demand Side Management (MuDSM) programme

Public lighting and public water works account for nearly 3.75% of India's net power consumption which stands at nearly 27.5 billion units and is expected to rise to approximately 51.23 billion units by 2021-22. As per BEE/NPC study, there is a savings potential of nearly 23% in municipalities by adopting demand side management initiatives.

In order to tap the energy savings potential of municipalities, BEE initiated nation-wide Municipal DSM (MuDSM) programs to address energy efficiency in water pumping, sewage pumping, street lighting and public buildings across Urban Local Bodies (ULBs) in the country. A situation analysis was carried out in the Municipal sector across 171 cities spread in 23 states/UTs.

The MuDSM programme has evolved in to a 2 pronged approach, wherein energy efficiency in municipal pumping systems is undertaken in Municipal Energy efficient Programme (MEEP) and energy efficiency in public lighting system is addressed by Street Light National Programme (SLNP). Both of these programs are implemented by EESL.

Launched in 2015, EESL's SLNP has been instrumental in replacing over 50 lakh street lights in over 500 cities in India, leading to 135 crore kWh of energy savings and cost saving of INR 742 crore every year. To bring in mass-scale transformation, EESL has adopted a unique strategy by joining hands with states, municipal bodies and ULBs. Furthermore, EESL has also undertaken multiple sensitization programs to stimulate this transformation.

Under the programme, EESL replaces the conventional street lights with LEDs at its own costs, with no upfront investment by the municipalities, thereby making their adoption even more attractive. Over a period, EESL is repaid through the consequent reduction in energy and maintenance cost of the municipality. A seven-year contract with local bodies guarantees a minimum energy saving of typically 50% and provides free replacements and maintenance of lights at no additional cost to the civic partners. Also, EESL's LED lamps have a Central Control Monitoring System (CCMS), which allows remote monitoring and operation of the installed street lights. This ensures that street lights are automatically switched on once the sun sets, and switched off after dawn. The system also sends alerts for each light that needs attention, to reduce failure and the need for sudden repair.

MEEP is being implemented in conjunction with Atal Mission for Rejuvenation and Urban Transformation (AMRUT) to unlock India's immense potential savings in energy, cost and water by retrofitting energy efficient pumps across 500 smart cities. Under this scheme, investment grade energy audit (IGEA) will be conducted in the ULBs to ascertain the extent to which replacement of energy efficient pumps can be undertaken. Post IGEA, EESL will replace inefficient pumps in public water works and sewerage systems 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. It is estimated that through this project, annual savings of INR 3200 crore and reduction in 3.9 million tonnes of CO_2 emission can be achieved.

7.1.1 Methodology adopted to calculate the savings

Total of 54.77 Lakh inefficient street light bulbs were replaced by LED street lighting bulbs till FY 2017-18. The same has been considered for this report.

7.1.1.1 Estimation of energy savings

Energy savings were calculated due to number of inefficient street lights that have been replaced by LED street lights in the past few years. In order to calculate the energy (electrical) savings, following steps were used:

a. **Step 1:** Divide the existing savings in MU by the total number of street lights bulbs replaced as per the SLNP dashboard
b. **Step 2:** Multiply the output of Step 1 with 35.10 Lakhs (no. of inefficient street light bulbs replaced in the FY 2017-18).

While calculating the total energy (electrical) savings, savings from previous financial years have also been taken into consideration as LED bulbs installed in streetlights during that time continues to save energy during operational hours.

7.1.1.2 Estimation of reduction in CO_2 emission

In order to calculate the reduction in total CO2 emission, the conversion factor of CO_2 for electricity is considered as proposed by BEE in table 5. Based on the results obtained, the impact under the MuDSM programme is discussed.

7.1.2 Impact of the scheme

Prior to the FY 2017-18, a total of 19.67 Lakhs LED street lighting bulbs were installed in several regions across India. In the financial year 2017-18, there were total 35.10 lakhs number of inefficient street lighting bulbs were replaced by LED street lighting bulbs under MuDSM program. On account of these replacements, the impact of MuDSM scheme in terms of energy saved across India in FY 2017-18 is **3.7 BU** and reduction in emission of CO_2 is **3.05 Million Tonne.**

CHAPTER 8

State Designated Agency

State Designated Agencies (SDAs) are statutory bodies set up under clause (d) of section 15 of the Energy Conservation Act (EC Act), 2001. The purpose of these bodies are to coordinate, regulate and enforce the provisions of the Act in their respective States and work in close coordination with BEE. Although SDAs gave no direct energy saving target for the central scheme for building capacity of SDAs, they have been encouraged to take up energy efficiency projects with due monitoring and verification. Across the states, different agencies' have been nominated to be SDAs such as Renewable Energy Development Agency, Electrical Inspectorate, Distribution Companies or Power Departments.

The SDAs are expected to prepare and implement a 5 year Energy Conservation Action Plan (ECAP). SDAs are also expected to enhance capacity to undertake regulatory duties, as mandated by the Act. BEE supports the capacity building of SDAs by providing technical and financial assistance to undertake specific activities. Financial support is provided for the following activities:

1. Creation of database for Energy Managers / Energy Auditors and Designated Consumers and other stakeholders.
2. Organizing workshops/training program, develop communication through electronic/print media to increase awareness of stakeholders in the field of energy efficiency
3. Conduct investment grade energy audit and preparation of Detailed Project Reports of Government Buildings
4. Development of adequate IT infrastructure for database management and communicating with stakeholders.
5. Implementation of Energy efficiency Demonstration Projects in the area of energy efficient street lighting, revamping of drinking water pumping system and energy efficiency in SMEs clusters as well as rural and urban households

Based on the aforementioned mandate, the following works were reported by the state SDAs in 2017-18:

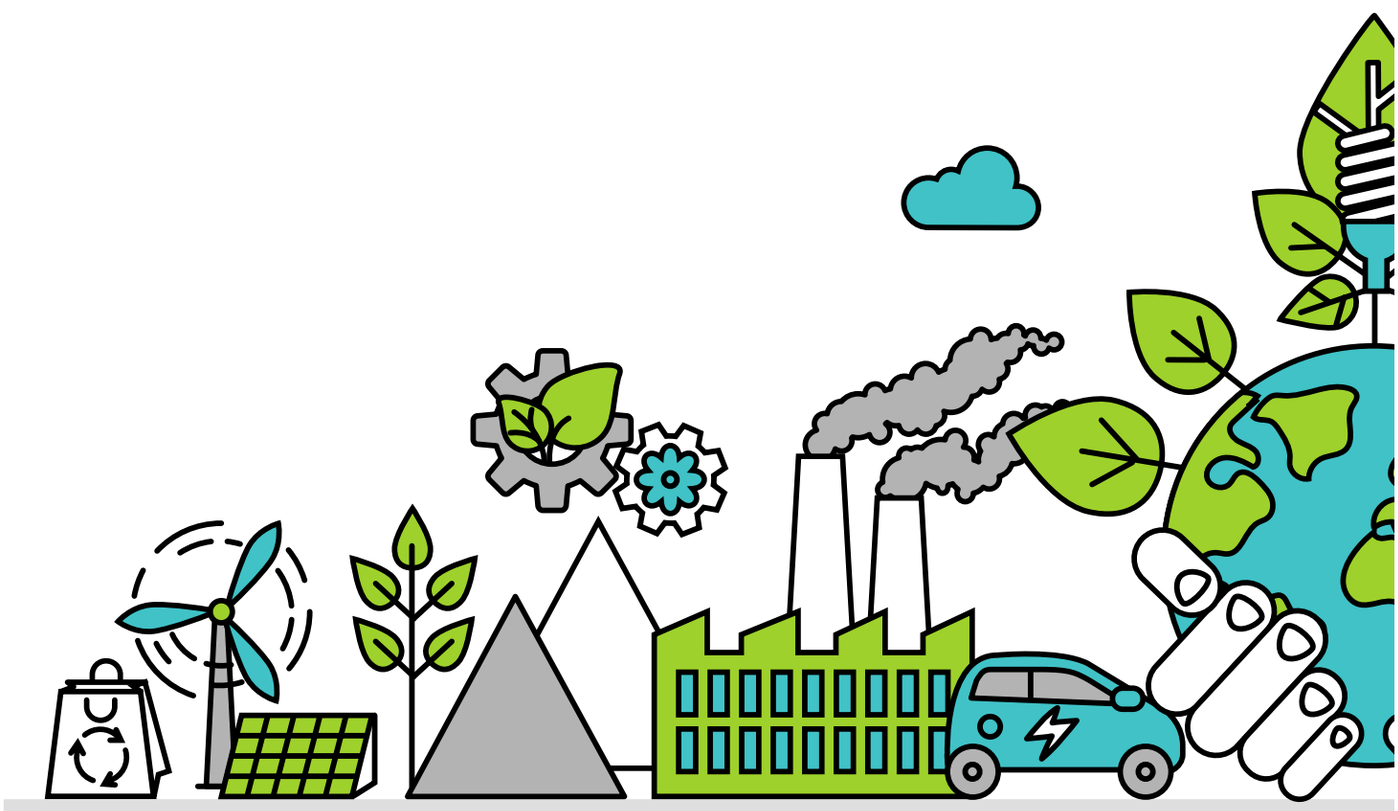
1. **Arunachal Pradesh:** SDA has replaced 5 nos. agricultural water pumpsets with energy efficient variants as well as replaced inefficient electrical appliances with energy efficient variants in 52 Government schools and selling energy efficient appliances to consumers. SDA has also successfully implemented Model Energy Efficient Village Campaign in Darlong village. With these initiatives, SDA has reported total energy savings of 230.1 MU.

2. **Assam:** SDA has completed implementation of energy efficiency activities in 12 schools of state, energy audit in 4 teas estates and energy audit of street lighting system in Rangapara Town Committeee and Nagaon Municipalities. 2 workshops – 1 for PAT and 1 for SME cluster completed by SDA in 2017-18.

3. **Bihar:** SDA has undertaken demo projects of retrofitting conventional appliances with energy efficient variants at Mangal Talab Auditorium and 18 government schools was undertaken along with distribution of LED bulbs, installation of street lights and installation of energy efficient drinking water systems. With these initiatives, SDA has reported total energy savings of 0.25 MU and cost savings of INR 0.13 crore. 3 capacity building programmes – 2 for ECBC and 1 for brick kiln SME cluster has been organized in 2017-18 by SDA.

4. **Chandigarh:** SDA has installed 346 LED tubelights in Government hospital and 3000 LED streetlights in the city apart from undertaking various awareness programs.

5. **Chhattisgarh:** SDA has undertaken replacement of 500 conventional lights and 500 fans with energy efficient variant in 100 Government schools. SDA has also conducted 3 capacity building workshops for PAT DCs, 1 workshop on best practices/innovative technology adoption on energy efficiency, 35 workshops on ECBC and 1 workshop for financial institutions apart from training of farmers.



6. **Daman & Diu:** A number of initiatives were undertaken utilizing BEE fund which primarily included installation of LED street light at various areas. Cumulatively, with these initiatives, SDA has reported total energy saving of 0.93 MU and cost savings of INR 0.35 crore. Also, 3 conferences on ECBC as well as in-house conferences and external expert lectures for energy professionals organized by SDA.

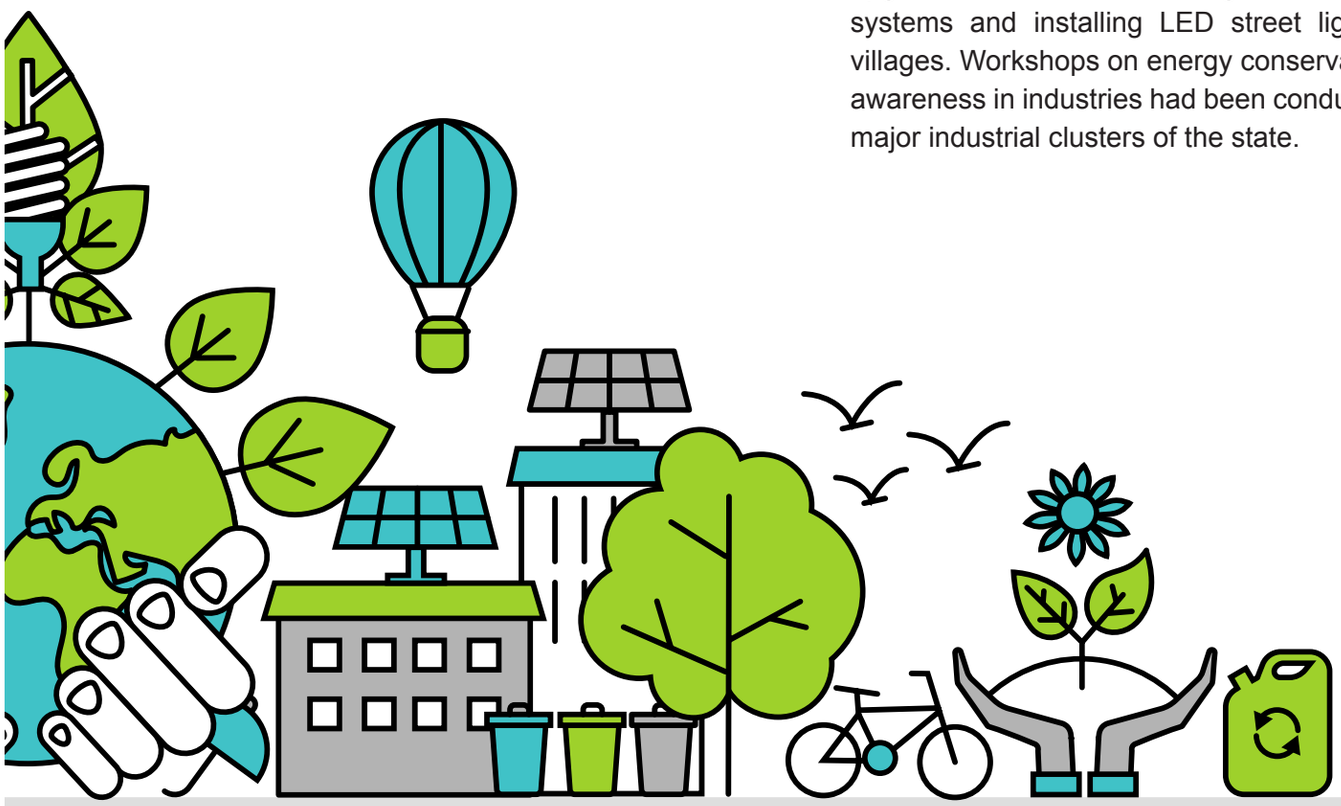
7. **Delhi:** SDA has planned to implement energy efficiency measures in Delhi Secretariat building and replace conventional light and fans with energy efficient variants in Government schools in rural outskirts. SDA has also organized 1 state level PAT workshop, 1 training workshop for financial institutions and awareness programme for ESCOs.

8. **Goa:** SDA has assisted in distributing 8.2 lakh LED bulbs under UJALA program and replacement of 2 lakh conventional lighting under National street lighting program. Funds from SECF utilized in replacement of about 5500 sodium vapour street light.

9. **Gujarat:** SDA has completed installation of 4800 LED street lights in municipal region along with installation of 2828 LED tube lights, 2418 five star rated fans in 133 Government schools. Also, 45 villages have been electrified with LED street lights, 5000 LED bulbs distributed in households of 2 villages. An incentive upto Rs.10000 is being provided to farmers for replacement. SDAs have undertaken multiple workshops with financial institutions, energy auditors and managers and DCs notified under PAT program.

10. **Haryana:** SDA has completed energy efficient measures in 55 Government schools and work is underway in another 165 schools. Other activities of SDA include installation of agricultural solar pumps sets, organizing energy conservation awards and performing energy audit. SDA has also organized 12 workshops – 11 for ECBC and 1 for PAT Scheme.

11. **Himachal Pradesh:** SDA has replaced 500 inefficient street light and 5000 conventional luminaries with energy efficient variant in HP University, Shimla. SDA is also working on upgradation of rural drinking water pumping systems and installing LED street lights in 2 villages. Workshops on energy conservation and awareness in industries had been conducted in 4 major industrial clusters of the state.



12. **Jharkhand:** Replacement of existing lighting fixtures with 362 energy efficient lighting systems undertaken by SDA along with supply and installation of 2484 LED bulbs and 50 LED Street light. With these initiatives, SDA has reported total energy saving of 0.502 MU and cost savings of INR 0.164 crore.

13. **Kerala:** Energy efficiency study conducted for 15 distribution transformers and retrofitting of conventional appliance with energy efficient variant undertaken in 100 Govt. schools, 2 Model Energy Efficient Villages and demonstration projects in rural water pumping system of Kerala Water Authority implemented by SDA. SCEF utilized in preparing DPRs for Waste Heat Recovery for large industries, conducting energy audit in 4 textile unit and developing an energy smart school. SDA has also conducted 30 hands-on training program on ECBC compliance involving total of 1400 participants along with other capacity building programs involving DISCOMs, DCs, MSMEs and CEA/CEMs of the state.

14. **Karnataka:** Energy efficient lighting installed in 21 Government schools and replacement of existing street lights with LED undertaken in Tumkur, Bengaluru and 5 other towns. The state government funds have been utilized to bring energy efficiency in street lights under state ESCOMs viz. GESCOM & MESCOM. With these initiatives, SDA has reported total energy saving of 3.89 MU and cost savings of INR 1.95 crore. Also, awareness programs undertaken in 6 villages in Raichur & Yadgir districts under Gram Swaraj Abhiyan.

15. **Madhya Pradesh:** SDA has completed retrofitting of luminaries in 200 schools across 5 districts of the state, developed 2 model energy efficient villages. SDA has also completed 20 workshops – 14 on ECBC and 6 on energy efficiency and energy conservation awareness in the state. Energy efficient appliances have been distributed in 8 districts (100 villages in each district) by the SDA under the Gram Swaraj Abhiyan (GSA)

16. **Maharashtra:** SDA has undertaken multiple projects utilizing funds from SCEF viz. installation of energy efficient street lighting to zilla parishad and government/semi-govenrment buidings. SDA has also conducted 29 workshops across the state for developing awareness and capacity building of relevant stakdeholders.

17. **Meghalaya:** SDA implemented demonstration projects at Meghalaya Legislative Assembly and Office building of Deputy Commissioner by replacing existing lights with LED lights, along with other awareness building activities. As a result of these initiatives, SDA has reported total energy savings of 0.055 BU and cost savings of INR 0.033 crore.

18. **Mizoram:** SDA has undertaken demonstration project on energy efficient street lighting in 7 districts, development of 3 model energy efficient villages, replacement of conventional lighting with LEDs in 100 Government schools and has undertaken 24 awareness campaigns. With these initiatives, SDA has reported total energy savings of 1.91 MU and cost savings of INR 0.705 crore

19. **Nagaland:** SDA has successfully implemented EE demonstration projects in 50 Government schools and created 11 model energy efficient villages. SDA has also undertaken 8 awareness campaigns in colleges and higher secondary schools and 3 seminars on S&L with local stakeholders. SDA has completed implementation of energy efficient measures in its building. With these initiatives, SDA has reported total energy savings of 0.0018 MU and cost savings of INR 0.65 crore.

20. **Odisha:** LED street light demonstration project completed in hydro-electric projects at Upper Kolab, Chipilima, Rengali and Mukhiguda. SDA has undertaken activities to improve efficiency in drinking water pumping and lift irrigation under MuDSM and AgDSM respectively. Around 1.17 Lakhs Street lights have been replaced with LEDs covering 107 Urban Local Bodies (ULBs). Capacity building exercises viz. workshop on capacity building of financial institutions, PAT workshop with DCs were organized in the state. With these initiatives, SDA has reported total energy savings of 12.34 MU, CO2 emission reduction of 8639 MT and monetary savings of INR 7.74 crore.

21. **Punjab:** SDA has replaced 390 street lights with energy efficient variants and retrofitted drinking water supply system of Mohali town with energy efficient variants. Apart from these activities, SDA has implemented energy efficiency activities in 50 schools and distributed 6900 LED lamps of 7W and 7000 LED lamps of 9W under Energy Efficient Village Scheme. SDA has also conducted multiple workshops and awareness campaigns involving CEAs, AEAs, CEMs and participants in 260 schools.

22. **Rajasthan:** SDA has implemented energy conservation measures in Government buildings through PWD, installation of LED street lights at multiple locations across the state, installation of energy efficient pumps in PHED water supply station as well as organizing Rajasthan Energy Conservation Awards.

23. **Sikkim:** SDA has completed replacement of existing luminaries and fans with energy efficient variants in 50 Government schools and distributed 660 LED tube lights and LED bulbs in 330 households of 4 villages. Funds from SECF utilized to replace conventional lights with LED lights at District Hospital in East Sikkim and to conduct energy audit in Government Fruit Preservation Factory.

24. **Telangana:** SDA has developed 2 model energy efficient villages and implemented demonstration project of retrofitting energy efficient appliances in 27 SC/ST/BC/Social Welfare Government Hostels covering 6 districts of the state. SDA has also conducted multiple workshops with SMEs, DCs for PAT cycle and other officials of the state to generate awareness about energy efficiency.

25. **Tamil Nadu:** Energy conservation measures implemented in 2 government buildings by SDA. Preparation of Waste Heat Recovery Policy and Sector Specific Energy Savings Plan is underway.

26. **Uttarakhand:** SDA has completed demonstration project in 3 Government buildings in the state as well Rajya Bhawan in Dehradun, implementation of energy efficiency programs in 40 Government schools and developed 3 model energy efficient villages. SDA has also completed replacement of existing drinking water systems with energy efficient variants in 3 areas, energy audit and implementation of energy efficient measures in select SMEs in the state. SDA has also 2 5-day training program for 100 women in designing and producing LED equipment.

27. **Uttar Pradesh:** SDA is implementing energy efficient measures in Secretariat Building to make in Model Energy Efficient Building. It has also replaced 9 rural drinking water pumps, 9000 agricultural pumpsets and organized 72 workshops with educational institutions of the state.

28. **West Bengal:** SDA implemented demonstration project on retrofitting energy efficient appliances in Alipurduar division and replacement of existing pumping system of 6 establishments under RK Mission and 8 buildings under WBSEDCL. Allocation from SECF (INR 69.25 lakh) utilized in preparation of sector specific annual energy savings plan and replacement of conventional lighting with LED lights in SDA building. Workshop on PAT e-certs Trading Mechanism for DCs of PAT Cycle-I was conducted in December 2017.

CHAPTER 9

Conclusion

There are 13 energy efficiency programmes/schemes that are currently active and supporting the country to achieve India's Nationally Determined Contribution (NDC) targets. The overall summary of all the considered programmes is mentioned in Table 25.

9.1 Summary of impact of energy efficiency programmes/schemes

The table below summarizes the impact of all the energy efficiency programmes/ schemes in India for FY 2017-18.

Table 25: Summary of impact of Energy efficiency programmes/schemes in India in FY 2017-18

Name of the scheme / programme		Energy Saved		Reduction in CO_2 emission ($MtCO_2$)	Monetary Savings (INR in Crore)
		Thermal (MTOE)	Electrical (BU)		
PAT Scheme	Energy Consumption side (all sectors excluding TPP)	7.821	2.47	30.66	9,813.07
	Energy supply side (TPP)	1.56	0.54	6.31	1,981.00
BEE – SME Programme		0.00117	0	0.00393	1.28
GEF – UNIDO – BEE Programme		0.00912	0	0.11	10.00
GEF – World Bank Programme – BEE		0.021	0	2.12	23.03
UJALA Programme		0	31.43	26	15,715.00
Standards & Labeling Programme		0	48.46	40.03	24,231.60
ECBC – Commercial Buildings Programme		0	0.0056	0.0046	2.80
BEE Star rated buildings*		0	0.2	0.18	100.00
Building Energy Efficien Energy efficiency Programme*		0	0.053	0.044	26.50
AgDSM Programme*		0	0.07	0.056	35.00
MuDSM Programme		0	3.7	3.05	1,850.00
TOTAL		**9.41**	**86.60**	**108.29**	**53,627.78**

*- Electrical energy savings (BU), reduction in CO_2 emission ($MtCO_2$) and Monetary Saving (INR in Crores) are already included under S&L programme. Hence in the TOTAL savings (energy, emission and monetary) the respective values of BEE Star rated building scheme, BEEP and AgDSM programme are not considered.

As most of these schemes are cross-sectoral in nature, their overall impact on total electrical energy saved as compared to total electrical energy consumed in FY 2017-18 across all the sectors equals to 86.60 BU. This is approximately 7.19% of the net electricity consumption (1204.7 BU) in 2017-18 (CEA, 2018).

Similarly, total energy saved as compared to total energy consumed in FY 2017-18 across all the sectors is in the order of 15.06 MTOE. This is approximately 2.69% of the net energy consumption (559 MTOE[6]).

Similarly, total energy saved as compared to total energy supplied in FY 2017-18 across all the sectors equals to 16.62 MTOE. This is approximately 1.97% of the net energy supply (843.8 MTOE).

Overall impact of Energy efficiency schemes/ programmes in India has helped India to save around INR 53,627.78 crores for the year 2017-18. Such schemes / programmes have not only helped India financially but has also supported the nation move a step closer to meet its target of Paris agreement by reducing emission of 108.29 $MtCO_2$.

[6] Source: BEE UNNATTEE Dynamic Excel Tool, 2018 (Extrapolated number)

9.2 Impact of energy efficiency schemes in FY 2017-18 across the sectors

The net electrical energy consumption and thermal energy consumption of India in FY 2017-18 was 1204.70 Billion Units (BU) (CEA, 2018)and 559 Million Tonne of Oil Equivalent (MTOE) respectively.

The share of energy (Thermal & Electrical) consumed across all the sectors, viz. Industry, building (domestic and commercial), municipal, agriculture, transport (railways) and others (municipality and miscellaneous open access users) is seen in table 26 & 27 and figure 14 & 15.

Table 26: Share of electrical energy consumption (BU) in FY 2017-18

Sector	Share of electrical energy consumption (value in BU)
Industry	481.88
Domestic	289.13
Agriculture	216.85
Commercial building	108.42
Others (Municipal)	84.33
Transport	24.09
Total (BU)	**1204.7**

Table 27: Share of total (thermal + electrical) energy consumption (MTOE) in FY 2017-18

Sectors	Share of total energy consumption (value in MTOE)
Industry	347
Transport	128.4
Domestic building	52.3
Agriculture	19.4
Commercial building	9.1
Others (Municipal)	2.8
Total (MTOE)	**559**

Figure 14: Sector wise electrical energy consumption share of India (2017-18)

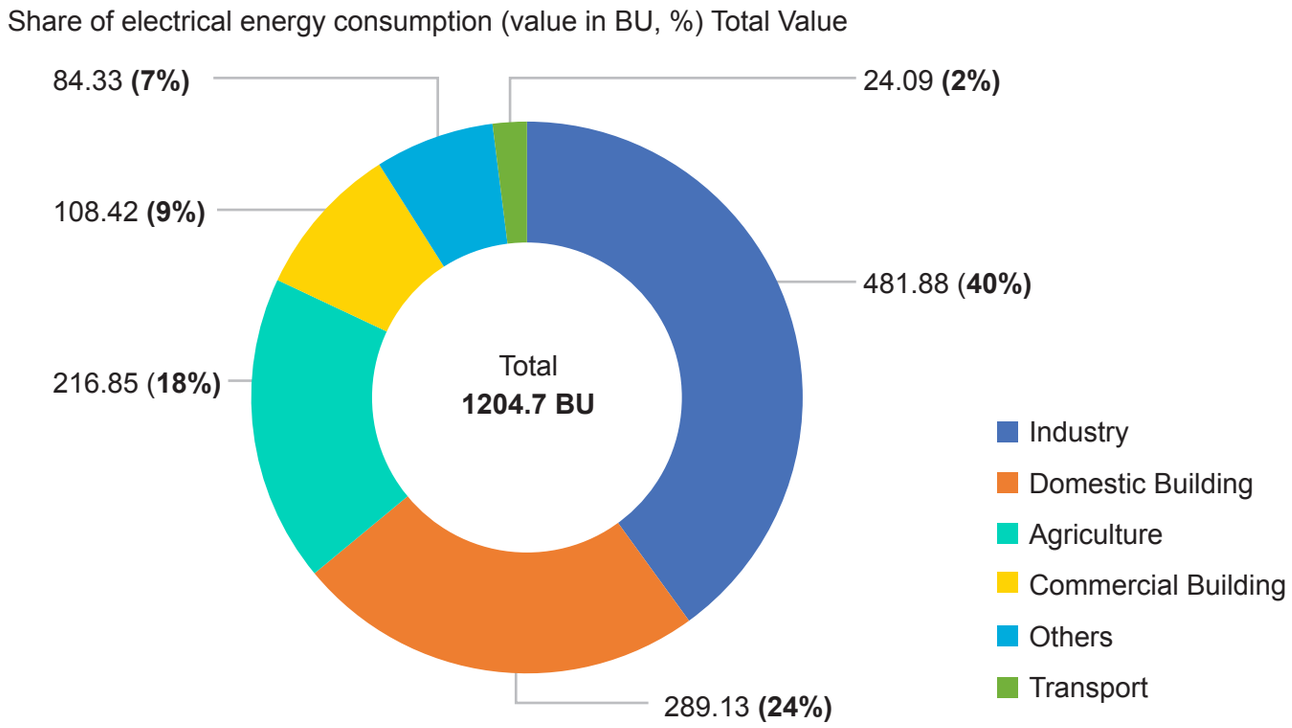
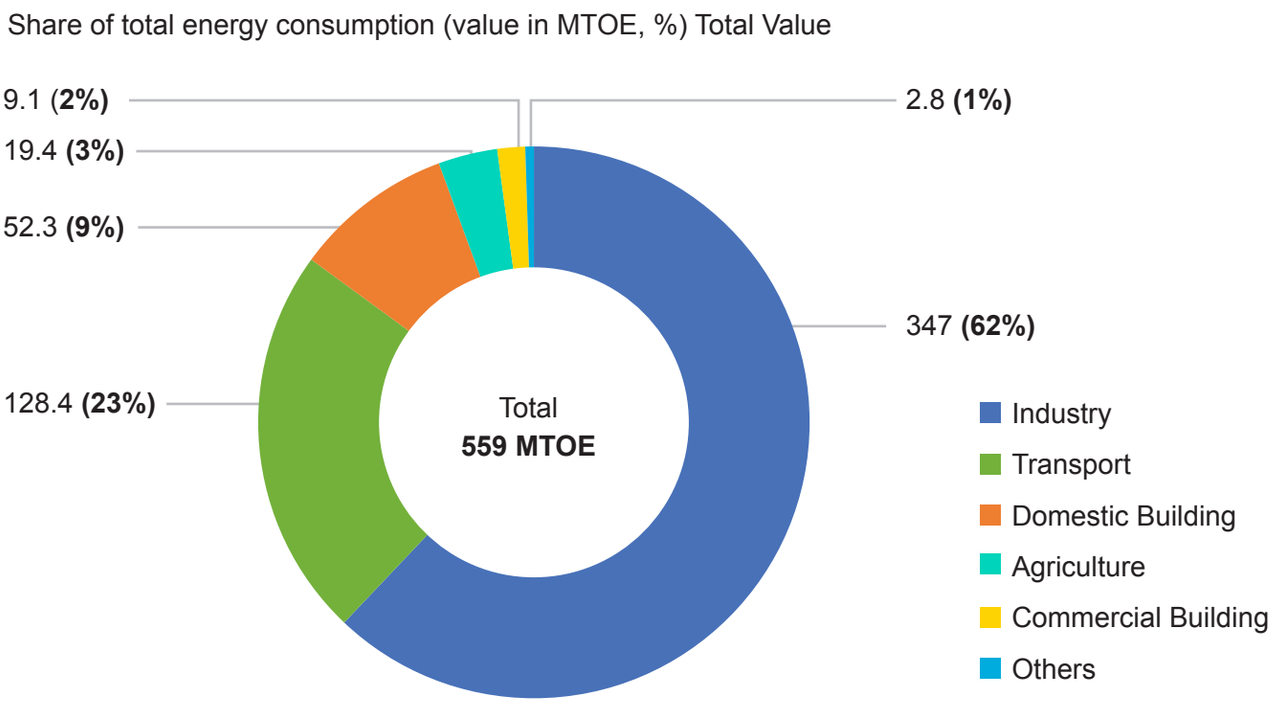


Figure 15: Sector wise total energy consumption share of India (2017-18)



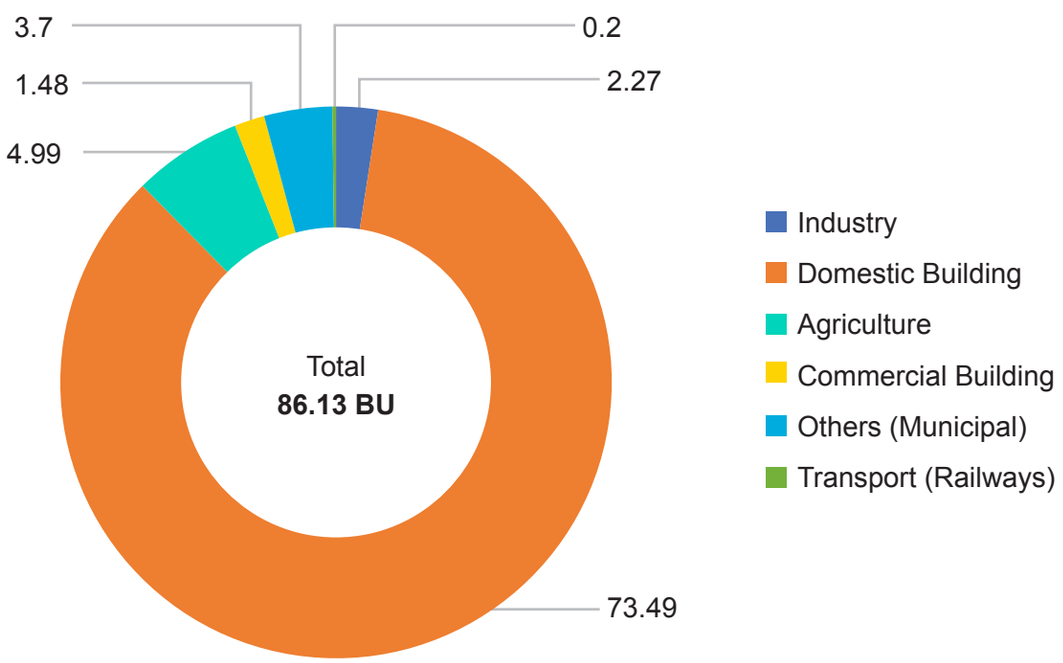
As most of these schemes/programmes are cross-sectoral in nature, they have successfully managed to save electrical energy across all the sectors. The share of same is seen in Table 28 and Figure 16.

Table 28: Impact of electrical energy saved across all the sectors as compared to total electrical energy consumed by them in FY 2017-18

	Electrical energy savings 2017-18 (in BU)	
Sector	**Consumption**	**Savings**
Industry	481.88	2.27
Commercial	108.42	1.48
Domestic	289.13	73.49
Agriculture	216.85	4.99
Others (Municipal)	84.33	3.70
Transport (Railways)	24.09	0.20
Total	**1204.7**	**86.13**

Figure 16: Impact of energy efficiency schemes and programmes in saving electrical energy across the sectors in 2017-18

Share of electrical energy saved (value in BU) Total Value



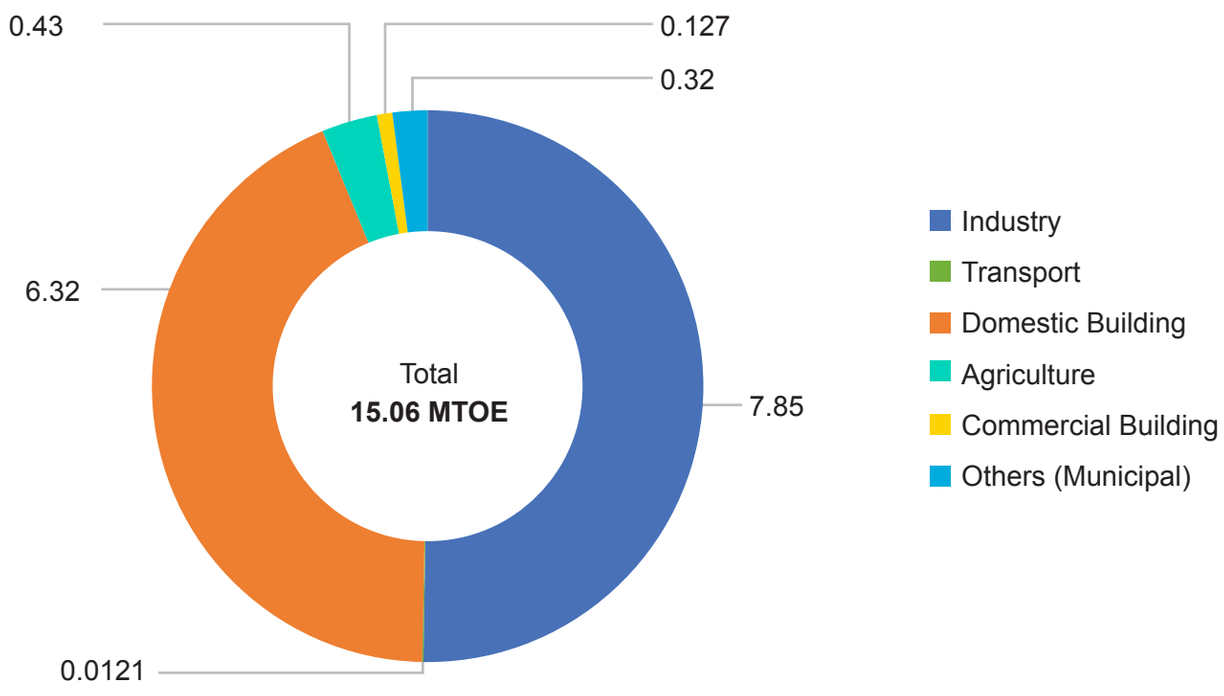
Similarly, total energy saved across all the sectors in FY 2017-18 is 2.79% of the net total energy consumption (559 MTOE). The share of same is seen in Table 29 and Figure 17.

Table 29: Impact of total energy saved across all the sectors as compared to total energy consumed by them in FY 2017-18

	Total energy savings 2017-18 (in MTOE)	
Sector	**Consumption**	**Savings**
Industry	347	7.85
Commercial	19.4	0.127
Domestic	128.4	6.32
Agriculture	52.3	0.43
Others (Municipal)	9.1	0.32
Transport (Railways)	2.8	0.0121
Total	**559**	**15.06**

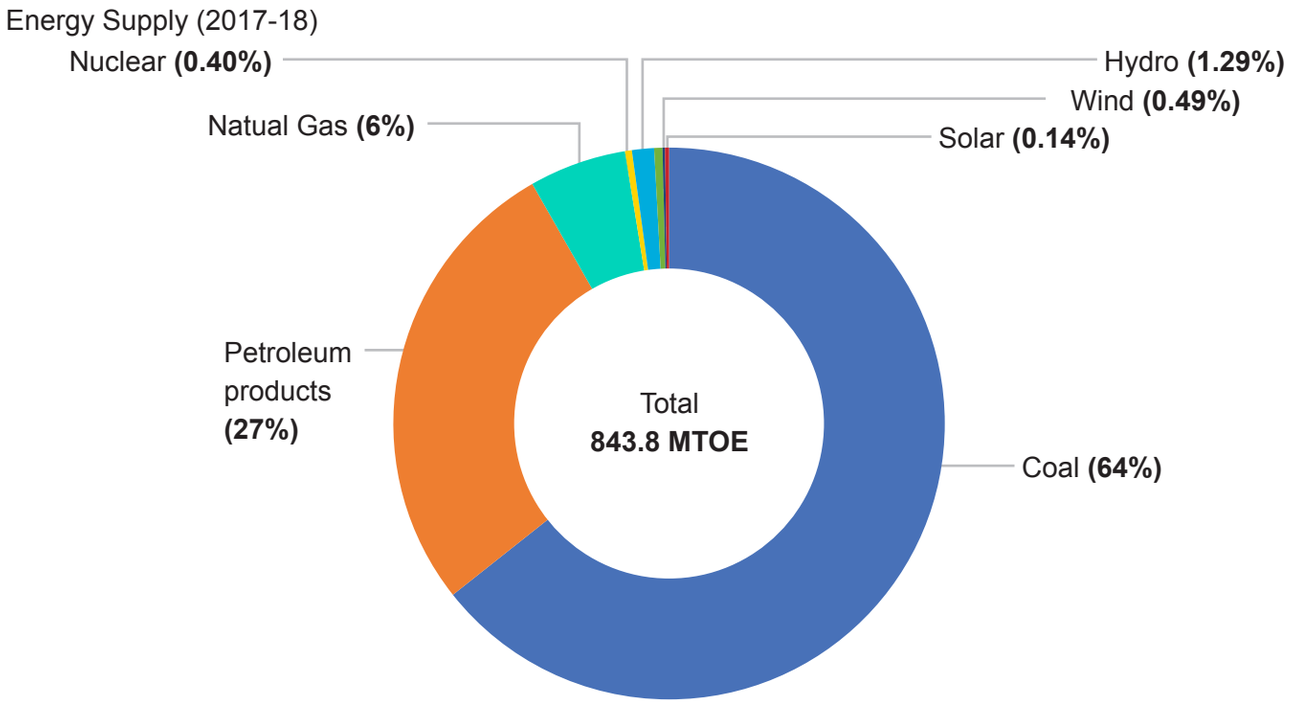
Figure 17: Impact of energy efficiency schemes and programmes in saving total energy across the sectors in 2017-18

Share of total energy saved (value in MTOE)



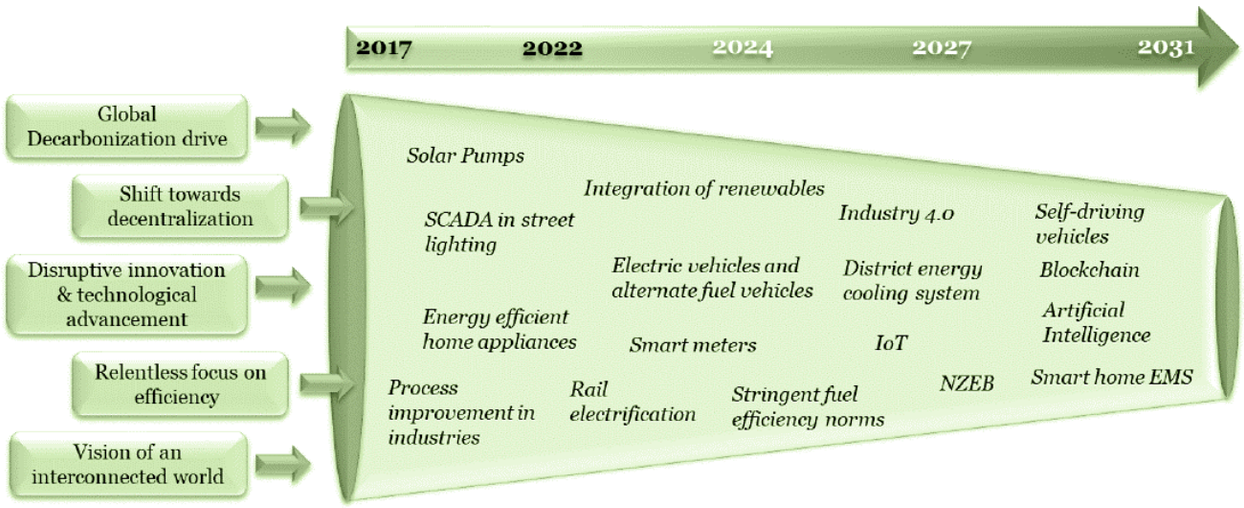
Also, along with the consumption side, total 1.97% of the net energy supply (843.8 MTOE) has been saved in FY 2017-18. The share of same is seen in Figure 18.

Figure 18: Share of energy supply in 2017-18



9.3 Way forward

Based on the data provided in the document, it can be understood that all these schemes/programme, were largely successful in creating institutional readiness and strong public awareness of energy efficiency in India. However, it is understood that the future landscape (as seen in figure below), driven by disruptive technologies and economic mega-trends (such as smart cities, e-mobility etc.) is fast changing the dynamics of energy sector.



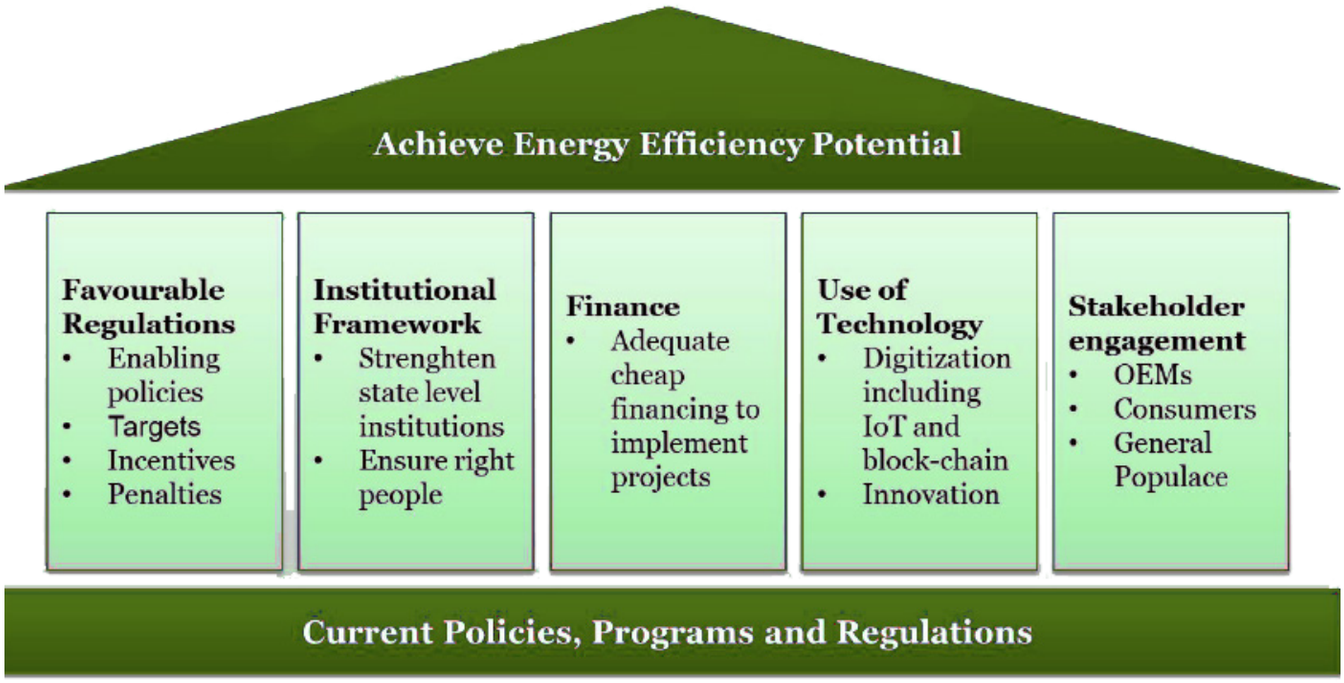
With the Gross Domestic Product (GDP) expected to grow at around 8%, if energy consumption (primary energy and electricity) in India were to continue along current lines, it could lead to a growing imbalance between supply and demand. The gap between supply and demand can be fulfilled by either increasing generation or by enhancing the efficiency of energy usage. Supply options often require huge investments and have a high gestation period. Enhancing energy efficiency (primary energy and electricity) provides an attractive solution for meeting the ever rising demand without sacrificing the greater goal of high growth. This should help to avoid, or at least limit, the perpetual headlong rush towards new production capacities which, even when based on the use of alternative energy forms to fossil fuels, still require heavy investment and significant financing. Apart from the demand and supply imbalance, the emissions intensity of the country is mounting with India contributing to 6% of global emissions. With the country submitting the Intended Nationally Determined Contributions (INDC) targets to United Nations Framework Convention on Climate Change (UNFCCC), intending to reduce emission intensity of its GDP, the role of energy efficiency would be crucial in complying by those targets.

With this understanding, the Bureau of Energy efficiency has developed a National Strategic Plan to **Unlock National Energy efficiency potential (UNNATEE)**. The plan lays a plain framework and implementation strategy, in the short, medium term and long term, in order to conceptualize a comprehensive roadmap to address India's environmental and climate change commitments. The roadmap is based on three scenarios, viz Scenario 1 - When Least Effort is put in, Scenario 2 - When Moderate Effort is put in and Scenario 3 - When High Effort is put in to adopt all the proposed sector specfic energy efficiency measures

The national target for energy efficiency savings and implementable roadmap to be achieved in the next fourteen years is established. The energy saving potential for each sector under moderate scenario is presented in the table below. The total energy saving potential of the country is estimated to be 86.9 MTOE by year 2031 with the highest saving potential in Industrial sector.

Sectors	**Energy Consumption (MTOE)** 2031	**Energy Saving (MTOE)** 2031	**Energy Saving (%)** 2031
Agriculture	58.7	5.7	9%
Commercial	24.5	4.9	17%
Domestic	86.5	12.1	12%
Municipal	7	0.9	12%
Industrial	396	47.5	11%
Transport	217.2	15.8	7%
Total	**789.9**	**86.9**	**10%**

In order to achieve the desired energy efficiency savings as mentioned above, following five key pillars have been considered.



In order to achieve the potential energy efficiency saving target, the total investment potential of the country is estimated to be **840,852 INR Cr. by the year 2030** with Transport sector constituting highest energy saving investment potential.

This plan also aims to align the country's international commitment of **Intended Nationally Determined Contributions (INDCs) targets** and United Nations Sustainable Development Goals (UN-SDG). By adoption of energy efficiency measures, India holds a potential to reduce 438 $MtCO_2$ by 2030.

List of Figures

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