MINISTRY OF POWER
GOVERNMENT OF INDIA

STATE ENERGY EFFICIENCY ACTION PLAN (SEEAP)

PUNJAB - ACTION PLAN

JANUARY 2025

State Energy Efficiency Action Plan (SEEAP) for Punjab

Report Prepared For:

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Azadi Ka Amrit Mahotsav

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BUREAU OF ENERGY EFFICIENCY
(Ministry of Power, Government of India)

Foreword

The Bureau of Energy Efficiency (BEE), under the Ministry of Power, Government of India, has been actively working to promote energy efficiency across various sectors of the Indian economy through initiatives like the National Strategic Plan for Energy Efficiency and the National Mission ROSHANEE. These efforts align with India's commitment to doubling its energy efficiency improvement rate by 2030, as declared at the G20 summit.

To harness the vast potential for energy efficiency in sectors such as industry, buildings, agriculture, and transport, the State Energy Efficiency Action Plan (SEEAP) has been developed. SEEAP aims to establish clear state-wise focus areas and develop actionable strategies to mainstream energy efficiency interventions.

This report provides valuable insights for policymakers, government agencies, and other stakeholders to implement effective programs and achieve India's climate goals. It also serves as a platform for knowledge sharing and scaling up energy efficiency activities nationwide.

I am pleased to announce that most States/UTs have formed State Level Steering Committees (SLSCs) under the leadership of Chief Secretaries. These committees will play a crucial role in developing mechanisms to implement the identified action plans.

I encourage all stakeholders to review this document and contribute their valuable feedback to further enhance its effectiveness in promoting energy efficiency at the state level.

October, 2024

(Dr. Srikant Nagulapalli)

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The development of "State Energy Efficiency Action Plan (SEEAP)" is an important step towards the Central-State collaboration for mainstreaming energy efficiency at the state level to achieve India's climate commitments. This strategic document has been prepared based on collaboration of Bureau of Energy Efficiency, Ministry of Power, Government of India along with State Designated Agencies and different stakeholder and ministries in the state level.

The ASSOCHAM team extends its profound thanks to Shri Pankaj Agarwal, Secretary, Ministry of Power, Government of India and Shri Srikant Nagulpalli, Director General, Bureau of Energy Efficiency (BEE), for their leadership and guidance during the execution of the assignment. The ASSOCHAM team recognizes and extends its sincere gratitude to Shri Milind Deore, Secretary, BEE, for his invaluable inputs provided during the execution of the assignment. The team acknowledges the co-operation and the support extended by Shri Abhishek Sharma, Director, BEE for supervising the assignment throughout the execution phase. The team appreciates Shri Vikash Kumar Jha, Project Engineer, BEE for his continuous support in coordination with various stakeholders.

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Associated Chambers of Commerce and Industry of India (ASSOCHAM)

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ABBREVIATIONS

AAGR - Average Annual Growth Rate
ASSOCHAM - The Associated Chambers of Commerce and Industry of India
AgDSM - Agriculture Demand Side Management
BEE - Bureau of Energy Efficiency
BLDC - Brushless Direct Current
CAGR - Compound Annual Growth Rate
CEA- Central Electricity Authority of India
DISCOM - Distribution Company
DSM - Demand Side Management
ECBC - Energy Conservation Building Code
ECSBC – Energy Conservation & Sustainable Building Code
EE - Energy Efficiency
EESL - Energy Efficiency Services Limited
EIA - Energy Information Agency
ENS – Eco Niwas Samhita
ESCO- Energy Service Companies
FY - Financial Year
GSDP - Gross State Domestic Product
KUSUM - Kisan Urja Suraksha Evam Utthaan Mahabhiyan
LED - Light Emitting Diode
MEEP – Municipal Energy Efficiency Programme
MNRE - Ministry of New and Renewable Energy
MOSPI - Ministry of Statistics and Programme Implementation
Mtoe - Million Tonne of Oil Equivalent
MU - Million Unit of Electricity (in kWh)
MuDSM - Municipal Demand Side Management
NEMMP - National Electric Mobility Mission Plan
NHPC - National Hydroelectric Power Corporation
NMEEE - National Mission on Enhanced Energy Efficiency
PEDA - Punjab Energy Development Agency
PMKSY - Pradhan Mantri Krishi Sinchai Yojana
PSERC- Punjab State Electricity Regulatory Commission Board
PSPCL - Punjab State Power Corporation Ltd.
PSTCL - Punjab State Transmission Corporation Limited
RBI – Reserve Bank of India
SLNP – Street Light National Programme
SEEAP - State Energy Efficiency Action Plan
SEEI - State Energy Efficiency Index
TFEC – Total Final Energy Consumption
UNNATEE - Unlocking National Energy Efficiency Potential

Executive Summary

The country faces rising energy demand and environmental impacts, necessitating a decoupling of economic growth and energy demand. India's commitment to energy conservation aligns with its Intended Nationally Determined Contribution for the Paris Climate Conference. At COP26 in 2021, India unveiled its climate action plan, targeting net-zero emissions by 2070 and 50% renewable energy by 2030.

The State Energy Efficiency Action Plan (SEEAP) for a particular State/UT developed by identifying focus sectors of the State and estimating the potential of energy conservation in sectors which are predominant in the region. The State Energy Efficiency Action Plan is developed for a short term-plan for a tenure of 5 years and a long-term plan targeting high-impact energy efficiency by the year 2030.

For the state of Punjab, SEEAP was developed under the guidelines of Bureau of Energy Efficiency, Ministry of Power, GOI and Punjab Energy Development Agency (PEDA) and inputs & suggestions from various government departments and sector experts were considered. The objective of the State Energy Efficiency Action Plan is to arrive at sector-specific approaches for energy efficiency for the state of Punjab.

In FY-2020, Punjab's total final energy consumption (TFEC) reached 15.48 Mtoe, with oil accounting for 44.73%, electricity 27.32%, and captive coal plants 24.36%. Non-power coal and coal in captive plants constituted 2.73% and 1.18%, respectively.

Based on TFEC and economic growth projections, Punjab's TFEC is estimated to reach 41.30 Mtoe by FY 2031. On the basis of the projected GSDP of the state and projected energy consumption Buildings, Industry, Transport and Agriculture sectors were identified as focus sectors and sector specific strategies were analyzed.

Proposed strategies:

Industry Sector: Expand PAT Scheme and implement energy efficiency measures, targeting 0.219 Mtoe for moderate scenario and 0.576 Mtoe for ambitious scenario energy savings by FY-2031, as well as 0.685 $MtCO_2e$ (moderate scenario) and 1.802 $MtCO_2e$ (ambitious scenario) emissions reduction by FY-2031.

Buildings Sector: Implement ECSBC, replace inefficient appliances, and mandate ratings, aiming for 0.076 Mtoe for moderate scenario and 0.100 Mtoe for ambitious scenario energy savings by FY 2031, along with 0.238 $MtCO_2e$ (moderate scenario) and 0.312 $MtCO_2e$ (ambitious scenario) emissions reduction by FY-2031.

Transport Sector: Develop EV infrastructure and provide incentives, can achieve saving potential 0.849 Mtoe for moderate scenario and 1.177 Mtoe for ambitious scenario energy savings by FY-2031, as well as 2.656 MtCO2e (moderate scenario) and 3.683 MtCO2e (ambitious scenario) emissions reduction by FY-2031.

Agriculture Sector: Transition to solar pumps and BEE 5-star electric pumps, targeting 0.064 Mtoe for moderate scenario and 0.087 Mtoe for ambitious scenario energy savings by FY-2031, as well as 0.200 $MtCO_2e$ (moderate scenario) and 0.273 MtCO2e (ambitious scenario) emissions reduction by FY-2031.

Overall, these efforts aim to reduce energy consumption by 1.207 Mtoe for moderate scenario and 1.940 Mtoe for ambitious scenario by FY 2031, create a ₹3,569 Crore market in energy efficiency, and reduce emissions by 3.779 $MtCO_2e$ (moderate scenario) and 6.071 $MtCO_2e$ (ambitious scenario) by FY-2031.

Action Plan	Scenarios		Estimated Energy Saving Potential (Mtoe) by 2026		Estimated Energy Saving Potential (Mtoe) by 2031	
	Moderate	Ambitious	Moderate	Ambitious	Moderate	Ambitious
Industry						
Deeping and Widening of Perform, Achieve and Trade Scheme	50% energy intensive industries can be covered	70% energy intensive industries can be covered	0.0761	0.1995	0.1020	0.2651
Energy efficiency in MSME clusters	60% energy intensive MSMEs can be covered	80% energy intensive MSMEs can be covered	0.0939	0.2496	0.1169	0.3107
Buildings						
Effective Implementation of ECSBC	5% of the Commercial Buildings above 100kW (25% Savings) 4% of the Residential Buildings (20% Savings)	5% of the Commercial Building above 100kW (35% Savings) 4% of the Residential Buildings (20% Savings)	0.0009	0.0012	0.0025	0.0033
Replacement program for inefficient appliances	Awareness of 48% of the consumer	Awareness of 63% of the consumer	0.0264	0.0352	0.0727	0.0954
BEE Star Rating or Shunya Rating of Buildings	5% of the Commercial Buildings above 100kW with 35% savings	5% of the Commercial Buildings above 100kW with 50% savings	0.0003	0.0004	0.0007	0.0010
Transport						
EV Transition and Charging Infrastructure	80% 2W & 4W, 40% 3W and 30% Buses will be covered	100% 2W & 4W, 50% 3W and 50% Buses will be covered	0.1527	0.2056	0.8485	1.1767
Agriculture						
Transition of conventional diesel pumps to Solar powered pumps	Transition of 75% diesel-powered pumps to solar pumps	Transition of 100% diesel-powered pumps to solar pumps	0.0107	0.0215	0.0322	0.0430
Replacement of inefficient pumps (non-star rated) with BEE 5-Star rated electric pumps along with smart control panel	Transition of 50% inefficient electric pumps to BEE 5 Star rated electric pumps	Transition of 70% inefficient electric pumps to BEE 5 Star rated electric pumps	0.0095	0.0190	0.0317	0.0443
TOTAL			**0.371**	**0.732**	**1.207**	**1.940**

1. Introduction

1.1. Background

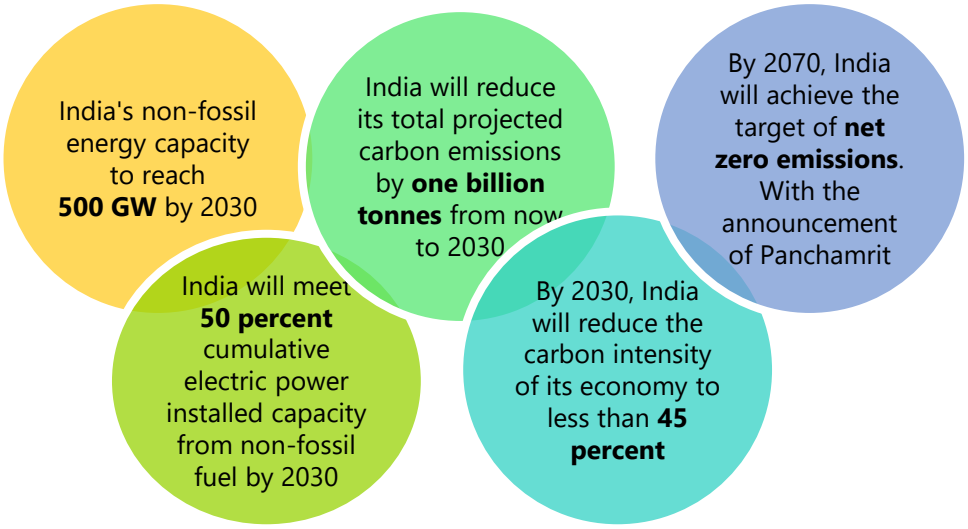
India's economy is characterized by an emerging and developing market. In 2019, India became the fifth-largest economy in the world in nominal terms, surpassing United Kingdom and behind the United States, China, Japan and Germany[1]. The size of the Indian economy in Fiscal Year (FY) 2020 was estimated to be INR 145 Lakh Crores at constant prices of 2011-12[2]. With the growth of the Indian economy, the demand for energy has increased significantly, resulting in high energy levels in some sectors and increase in the country's emissions.

As per International Energy Agency's (IEA) World Energy Outlook 2021 report, India currently has a share of 6.1% in the global primary energy consumption, which is projected to increase to 9.8% by the year 2050. India's Final Energy Consumption in FY 2020 was recorded at 533.44 MTOE (as per Domestic Conversion Factors) with coal and crude oil being the largest contributors to the total energy consumption. India's per capita energy consumption and per capita emissions are well below the global average per capita emissions. However, India continuously taking steps to reduce the energy consumption and emissions and ensure sustainable growth of nation.

India has set ambitious economic goals for the future and achieving these goals is expected to result in significant increase in the country's energy demand and emissions. In view of this, India has also set ambitious goals for energy and climate performance. The country has also emphasized the importance of energy transition towards decarbonization of the economy and has recently emerged as one of the world leaders in Energy Transition. States and Union Territories of the country have a key role to play in the fulfilment of these goals. The key strategy adopted by the Government of India is the efficient use of energy resources and their conservation. This is essential since the efficient use of energy and its conservation is the least-cost option to meet the increasing energy demand, reduce wasteful consumption and in leading the country's economic growth in sustainable manner.

1.2. India's Nationally Determined Contributions (NDCs)

In the 2016 Paris Climate Conference, India in its Nationally Determined Contributions (NDCs) had committed that it will reduce the emission intensity of its GDP by 33% to 35% by 2030 from 2005 level. In the recent Conference of Parties (COP -26) at Glasgow, UK, India announced the Panchamrit, which lists down five ambitions:



India's earlier target of 33% to 35% reduction in emission intensity from 2005 level by 2030 has been revised to approximately 45%. In view of the enhanced target under Panchamrit, India's energy efficiency efforts need to be increased and States have a vital role in India's energy efficiency policy implementation and in meeting state-specific goals on sustainable development in the most energy-efficient way. It is imperative that the States actively participate in the schemes to facilitate the achievement of the overall goal of reducing the energy intensity of the country.

On 1st November 2021, during the 26th United Nations Climate Change Conference of the Parties (COP26) in Glasgow, Prime Minister Narendra Modi introduced the idea of 'Lifestyle for the Environment (LiFE)'. He urged individuals and institutions across the world to support LiFE as a global movement, aimed at promoting mindful and deliberate utilization instead of mindless and destructive consumption to safeguard the environment. This means making choices that are better for the environment, such as using renewable energy sources, reducing

waste, and conserving resources. The program aims to teach people about the impact their daily actions have on the environment and provide them with the tools and resources they need to adopt eco-friendlier practices.

In line with the national targets, Punjab aims to achieve energy security and sustainability by promoting energy efficiency and renewable energy.

As per the Punjab Vision Document 2047[1], the state of Punjab has set a number of targets in this regard, including:

- Reducing T&D losses to 13.6% by 2030 and 12.75% by 2047.
- Increasing the share of renewable energy in the state's electricity mix to 30% by 2030 and 55% by 2047.
- Solarizing rural water supply systems to 10% by 2030 and 50% by 2047.
- Solarizing agriculture pumping systems to 30% by 2030 and 100% by 2047.
- Promoting EV adoption and building EV infrastructure by providing tax and subsidy to EV buyers and mandatory charging stations in paid parking by 2030, and 60% of all fleet to be run on non-emitting fuel by 2047.

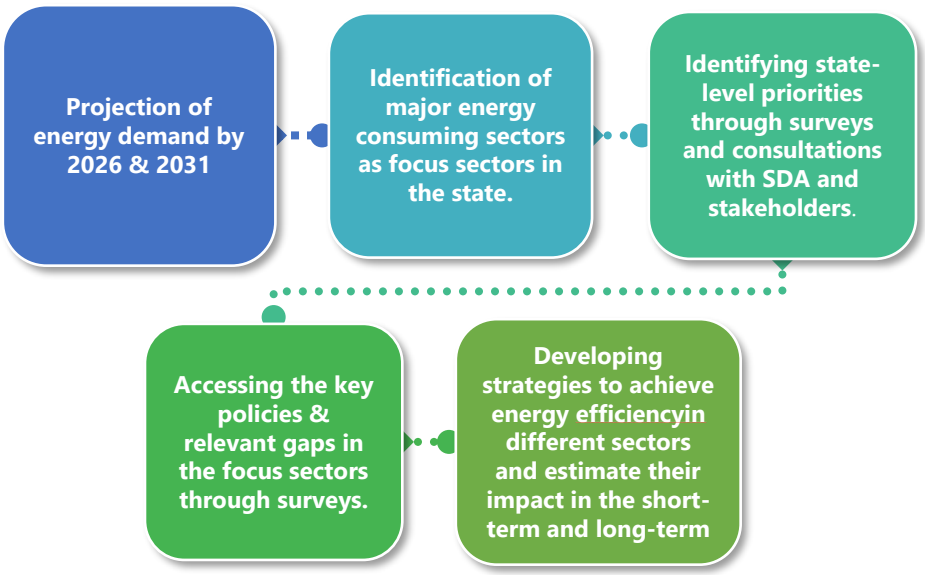
1.3. About SEEAP

The State Energy Efficiency Action Plan for Punjab is being developed by identification of focus sectors, to ensure that the allocation of resources is as per the requirement of Punjab and estimate the potential of energy conservation in sectors that are predominant in Punjab. The State Energy Efficiency Action Plan has been developed in two parts, a short term-plan for a tenure of 5 years and a long-term plan targeting high impact energy efficiency by the FY 2031 to achieve the targets committed in COP-26. This State Energy Efficiency Action Plan has been developed under the guidance and support of stakeholder

1 www.pbplanning.punjab.gov.in/sites/default/files/documents/Punjab_Vision_Document_2047.pdf (Pg. 303)

departments/agencies of Punjab and will be implemented by them in the state after its adoption.

Expected Outcomes of State Energy Efficiency Action Plan (SEEAP)



1.4. State Profile

Punjab is located in the northern part of the Indian sub-continent. Punjab shares borders on the west with Pakistan, on North by Jammu & Kashmir & on North-East by Himachal Pradesh, and on the South by Haryana and Rajasthan.

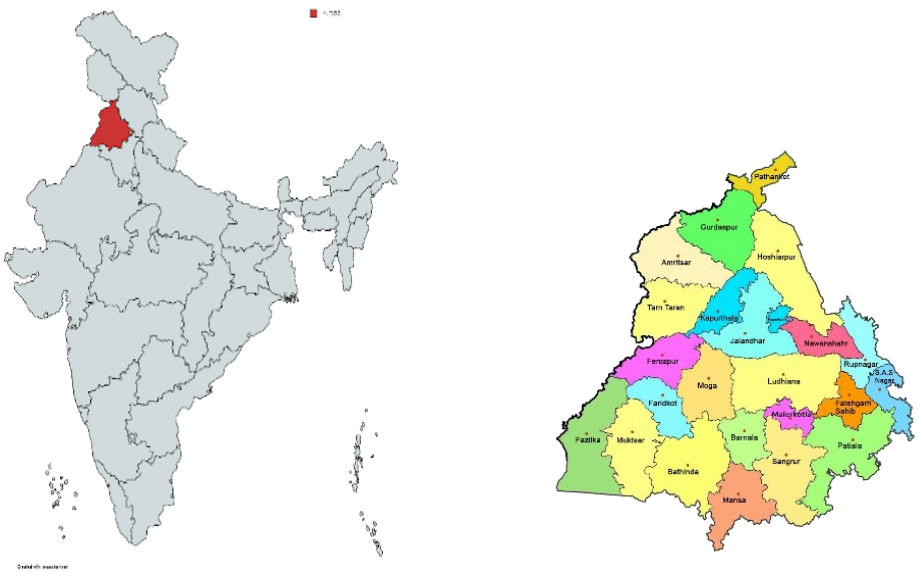


Figure 1: Location of Punjab on Map if India and Punjab Administrative divisions map

According to the Census of India 2011, the population of Punjab is 277.43 Lakhs. The state's population increased by 13.9 percent compared to the 2001 census and was projected to reach 303.39 Lakhs in 2021.

Table 1: Basic Statistics of Punjab[2]

Particulars	Unit	Number
Area	Sq. Km	50,362
(i) Rural Area		48,265
(ii) Urban Area		2,097
(Population 2011)		
Total Population	Lakh	277.43
Rural Population		173.44
Urban Population		103.99
% Of Rural to Total Population	%	62.52
% Of urban to Total Population		37.48
Gross State Domestic Product GSDP	₹ 5.37 Lakh Crores	
Contribution in National GDP (FY2020)	3.69% (*INR 145.16 Lakh Crore)*	

Expanding over an area of 50,362 km^2, the state has a bolstering agriculture sector and is known as the 'the breadbasket' of the nation. Punjab fosters per capita electricity consumption of 1,564 kWh in year 2020-2021, which was 1450 kWh in the year 2016-2017, indicating a growth of 7.86 percent.[3] To cater to this increased growth, the state has invested credible funds to develop its energy infrastructure bracing the current energy demand.

1.5. State Energy Scenario

Punjab has seen strong growth in power demand in the past decade. Punjab has several renewable & non-renewable energy generation resources. As per the statistical data from Punjab State Power Corporation Ltd, annual generation of the state including thermal, hydro, hydel, IPPS, cogeneration was about 56,542.11 GWh for the FY-2020. The state has recorded a total consumption of 47,598 GWh in FY-2020. The electricity requirement has escalated from 39,374 GWh in FY 2015

[2] Source: Punjab Statistical Abstract 2020 – Table 1.1 page 3 onwards
[3] Source: https://docs.pspcl.in/docs/cearrtp20211213153036455.pdf (page no. 10)

to 47,598 GWh in FY 2020, showing a total growth of 19.76%.[4] The total energy generation for the same is from various sources including state based thermal and hydro plants, Renewable Energy Sources (RES) etc.

Table 2: Electricity Generation for FY 2020[5]

Electricity Generation Table for FY 2020	Value (GWh)
Thermal (State Owned)	1,738.50
Thermal (IPPs)	17,717.00
Large Hydro	4,933.49
Renewable Sources (Solar, Biomass, Mini/Micro Hydro, etc.)	2,089.65
Royality/open access + wheeling + export	- 444.16
Share from BBMB	4,363.26
Share from Central Sector	26,174.40
Total Generation (excluding BBMB & central sector share)	**26,034.48**
Total Generation (including BBMB & central sector share)	**56,542.11**

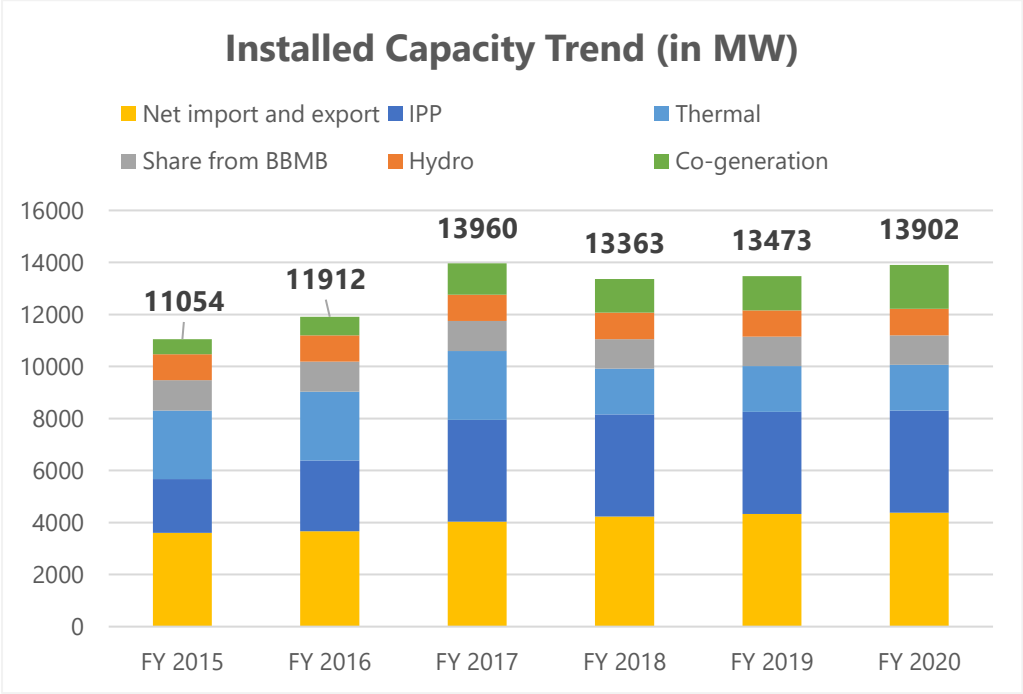


Figure 2: Installed Capacity Trend in state of Punjab[6]

The graph above represents the total installed capacity of electricity generation across the state of Punjab. The state has recorded a growth of additional 2,848

[4] PSERC- Tariff Orders 2015-2019
[5] Source: https://pspcl.in/1Statistics
[6] Source: Punjab State Power Corporation Limited (PSPCL) (https://pspcl.in/1Statistics)

MW from FY 2015 to FY 2020. Punjab generates its electricity from various sources such as thermal power plants, hydro power plants, importing from the central power plants, IPPs, co-generation, renewable resources. On the present condition, the state of Punjab depends upon the non-renewable generation as far its energy generation is concerned. Punjab State Electricity Regulatory Commission Board (PSERC) and Punjab State Power Corporation Ltd. (PSPCL) together have targeted to move towards energy generation from renewable sources.

The below mentioned figure represents the various sources of the electricity generation in the state of Punjab, the state has major share of 31.54% (4385 MW) for import and export followed by IPPs holding a share of 28.20% (3920MW), thermal holds a capacity of 1760 MW comprising of 12.66% of the total installed capacity, followed by the co-generation having a capacity of 1688 MW, share of MMBM holds a share of 8.15% (1133 MW) and rest of 7.31% (1016 MW) comes under the Hydro power plants.

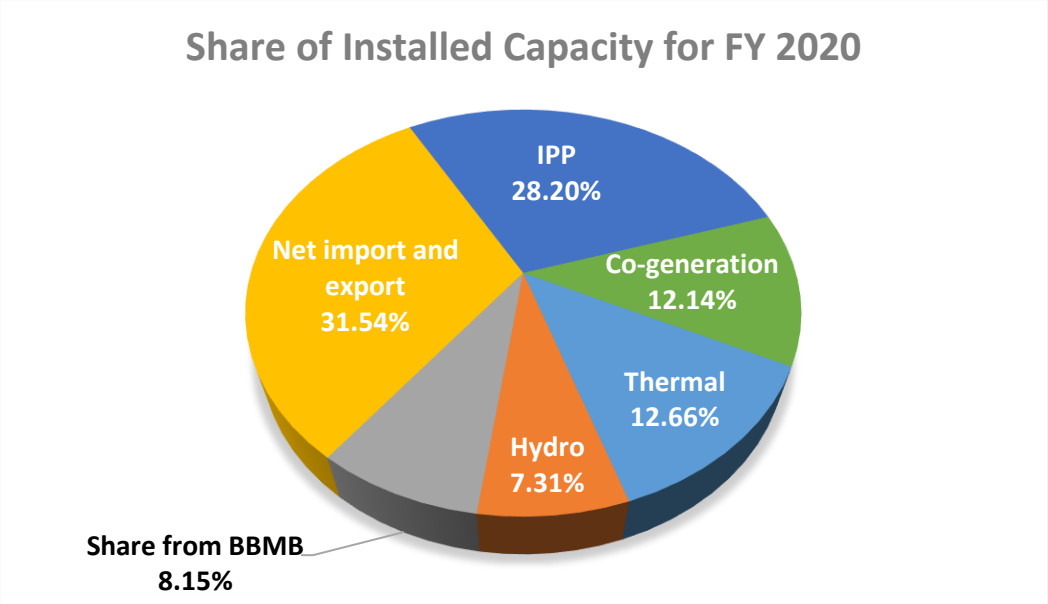


Figure 3: Share of Installed Capacity for FY 2020[7]

As per the data from Ministry of New and Renewable Energy (MNRE); the state of Punjab has a total installed renewable energy capacity of 1,449 MW in FY2020, out of which 65% (948 MW) of the installed capacity is solar and 22% (317 MW)

[7] Source: https://pspcl.in/1Statistics

is Bioenergy, and rest 13% comprises of Hydel and Waste to energy. Punjab government striving to increase the Renewable Energy capacity from the 3220 MW (14%) in year 2023 to at least 30% of the state installed power capacity and also decrease the carbon intensity by year 2030.

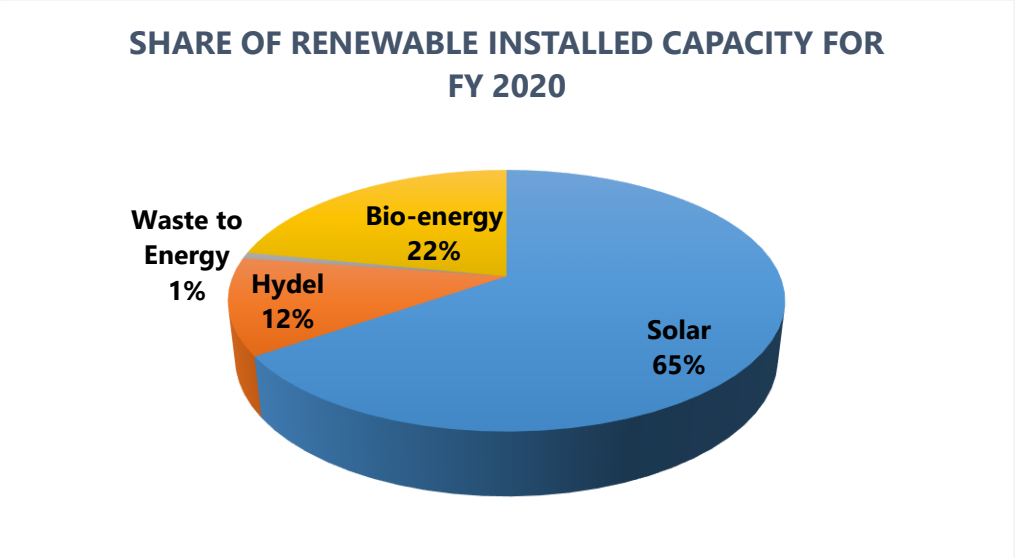


Figure 4: Share of Renewable Energy installed capacity FY 2020[8]

The Punjab Energy Development Agency is making continuous efforts for increasing the share of the energy mix. Under the prerogative of the sustainable development goals (SDGs) in the state, efforts are being made to increase the share of renewable energy to 30% of the total energy matrix by the year 2030. The agency and the state aim to bring it up to 40% by the year 2047. To achieve the said targets, the Punjab has defined the targets for the different program and projects based on the assumptions for the NRSE projects, and others such as providing incentives on entry tax, fee, and stamp fee in the upcoming projects for the attracting the private sectors, usage of decentralized renewable energy across different energy guzzling sectors. Installation of solar parks on unproductive lands with providing incentives to the company owners. The agency and the government of the state has stated some targets against some indicators which are enlisted below:

[8] Source: https://www.mnre.gov.in/solar/current-status/

1.6. Overview of Institutional framework and stakeholder mapping

The government of India enacted the Energy Conservation act-2001, which provides legal framework, institutional arrangement and a regulatory mechanism at the center and the state level to enhance energy efficiency in the nation. The Bureau of Energy Efficiency was established on 1st March 2002, under the provisions of the Energy Conservation Act, 2001. It is responsible for the implementation of policies and programs related to energy conservation and energy efficiency.

Punjab Energy Development Agency: Punjab Energy Development Agency has been designated as the State Designated Agency, by the government of Punjab under the guidelines of Bureau of Energy Efficiency. PEDA coordinates, regulates and enforces the Energy Conservation Act-2001 within the State of Punjab. PSERC has a statutory function under the Electricity Act, 2003 to guide the Distribution Licensee to become an efficient, commercially viable entity and to function at a high level of efficiency. The Commission issues directives to achieve the objectives through its Tariff Order every year to enable the Licensees to achieve higher performance and efficiency. Vide Notification No 1/9/08-EB(PR)196, dated-16.04.2010 Govt. of Punjab unbundled Punjab State Electricity Board into two companies PSPCL and PSTCL.

Table 3: Institutional Framework for Electricity in Punjab

Process	Utilities/ Governing Institution
Generation and Distribution	Punjab State Power Corporation Limited (PSPCL)
Transmission	Punjab State Transmission Corporation Limited (PSTCL)
Regulatory Body	Punjab State Electricity Regulatory Commission (PSERC)

2. Identification of Focus Sectors

The economic sectors of the state of Punjab can be broadly classified into sectors namely Industry, Building, Transport, Agriculture, Municipalities and DISCOMs, and Cross Sectors. These sectors can be further divided into sub-categories, as shown in the figure below.

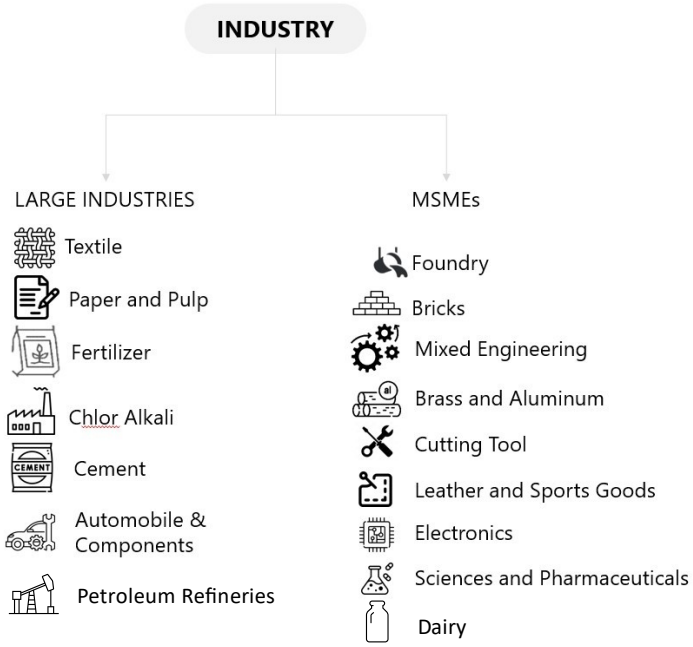


Figure 5: Sub-Categorization of Punjab Industry Sector[9]

Identification of focus sectors or focus areas is important because it is a general characteristic of a state that a major portion of energy is being consumed by few energy-guzzling sectors. Focusing efforts towards these sectors is necessary to ensure that the allocation of resources is as per the state's priorities and towards sectors that have the highest potential for energy savings and emissions reductions.

The focus sectors of the state have been identified based on the share of energy consumption and emissions in the respective sectors, gap analysis of the

[9] Source: http://investpunjab.gov.in/

respective sectors, inputs from stakeholder consultation, and priority areas of the state.

2.1. Methodology of Focus Sector Identification

In order to arrive at the focus sectors, the various factors were analyzed namely the energy consumption, emissions, Gross State Value Addition (GSVA). Adding to that, gap analysis in respective sectors, potential for energy efficiency and emissions reduction, state has planned efforts in prioritized sectors, and SDA and stakeholder inputs have been considered to arrive at the focus sectors.

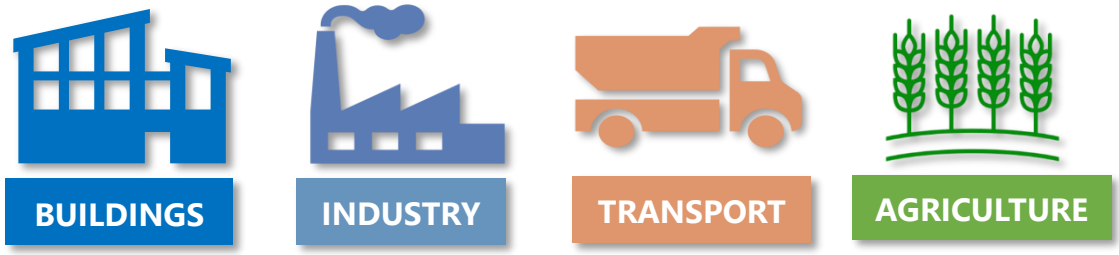
Gross State Value Addition (GSVA)

The Gross State Value Added (GSVA) of different economic categories was sourced from National Accounts Data, prepared by MoSPI. The GSVA sectors are not the same as the end use sectors used for the purpose of this report. However, these sectors have been used to deduce end use sectors for calculating imported coal and the same has been detailed in relevant sections. The GSVA sectors may also oftentimes not be representative of sectoral growth in terms of energy as the link between economic activity and energy use in several sectors is dependent on several factors.

2.2. Identified Focus Sectors

Based on the total final energy consumption in the state and its sectoral distribution, focus sectors have been identified for the state. The focus sectors represent the share of energy consumption through available data in Primary and Secondary Energy sources. It also reflects the views and recommendations of the stakeholders, existing and proposed policy infrastructure, and vision of the state Government for different sectors.

Based on the above parameters and other important considerations, the following have been identified as the focus sectors for devising energy efficiency strategies in Punjab.



3. Projections and Forecasting

Economic and energy projections for the state up to the target year FY 2031 are performed in order to predict the future growth patterns of the respective sectors and to assess the impact of possible energy efficiency interventions in these sectors. The Gross State Domestic Product (GSDP) projections and the sectoral energy consumption projections form the basis of the expected emissions and emissions intensity of the state in the target year FY 2031, which is important in developing the emissions reduction targets for the state and in aligning the state with the national goals.

Fiscal Year (FY 2020), implying the period from April 2019-March 2020 has been selected as the base year for projections in this study keeping in view the years FY 2021 and FY 2022 being pandemic years.

The Gross State Domestic Product (GSDP) of the State of Punjab was recorded at INR 5.37 Lakh Crore[10] in FY 2020 and is projected to reach INR 12.56 Lakh Crore in FY 2031, at constant prices of 2011-12. The GSDP for the period FY 2023-FY 2031 is forecasted by taking weightage of the GSDP growth rate recorded in the years FY 2015-FY 2020 and the projection of GSDP growth rate by Punjab Economic Survey[11]. The historic and forecasted GSDP for the State of Punjab is shown in the figure given below.

The Total Final Energy Consumption (TFEC) has been projected for all sectors up to FY 2031 taking into account the historic energy consumption trend from FY 2015 to FY 2020 along with the historic and projected GSDP growth for Punjab.

Using the above-mentioned factors, the Business-as-Usual (BAU) growth rate factors are calculated for all the sectors in order to project the future energy demand by FY2031. The Total Final Energy Consumption of the state in the

[10] https://www.mospi.gov.in/web/mospi/download-tables-data/-/reports/view/templateFour/21201?q=TBDCAT

[11] Source: https://ifms.punjab.gov.in/docs/eBgtBooks/2022-23/Economic_Survey.pdf

Business-as-Usual (BAU) scenario is projected to reach 41.30 Mtoe in FY 2031 from 15.48 Mtoe in FY 2020, with a projected CAGR of 9.33%.

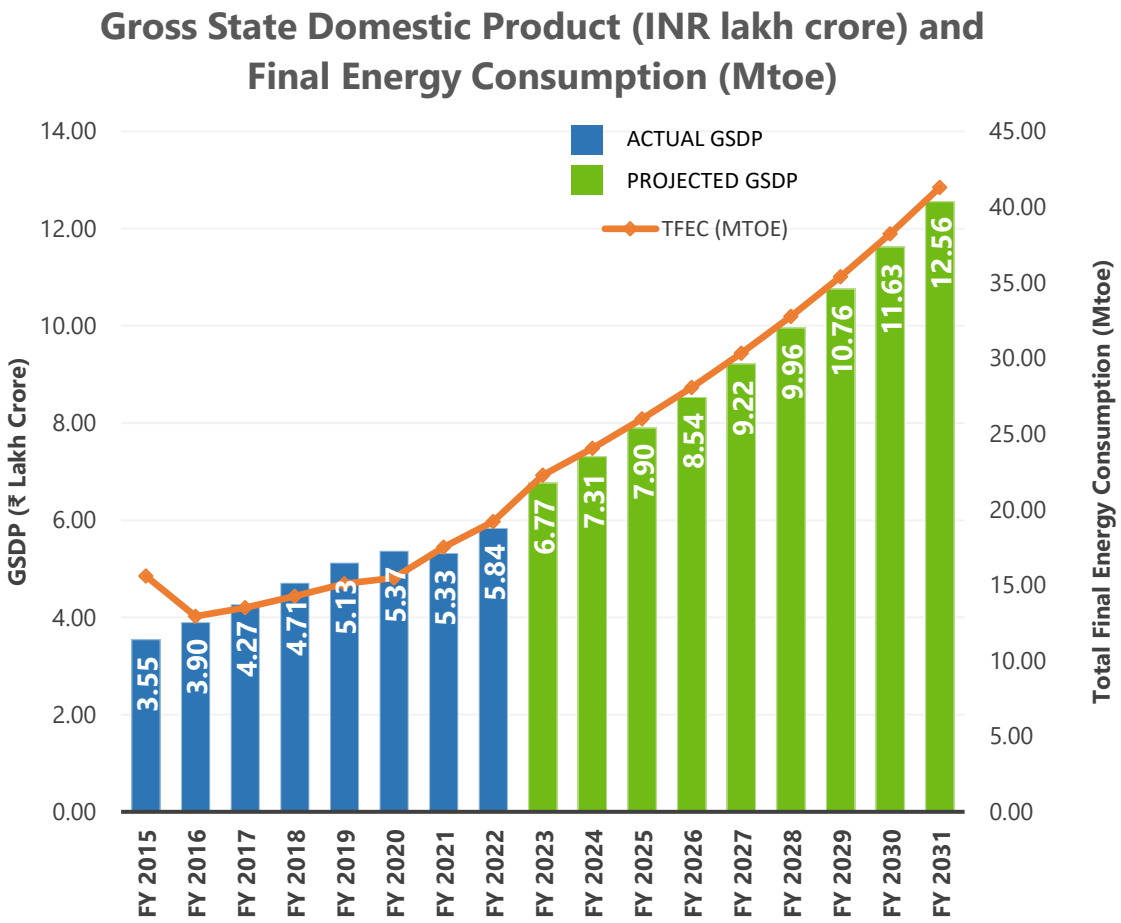


Figure 6: GSDP and TFEC Trend[12]

[12] https://www.mospi.gov.in/web/mospi/download-tables-data/-/reports/view/templateFour/21201?q=TBDCAT

BUILDINGS SECTOR

4. Focus Sector 1: Buildings

4.1. Current Scenario

In Punjab, as per census 2011 around 37.50% of the population resides in urban areas and 62.5% of the population resides in the rural area. The energy consumption of the state shows that the building sector is the second highest in total final energy consumption (TEFC). Punjab state has 22 districts and 12581 villages. Several cities such as S.A.S Nagar/Mohali, Patiala, Jalandhar, Amritsar, Bathinda are growing rapidly. Service Sector and Industrial development in Punjab has led the population to migrate to the urban areas. The growth in the commercial establishments has also led to growth in the residential buildings, vertical growth in residential occupancy in several cities of Punjab has been observed. The domestic and commercial building sectors are expected to increase at a very rapid rate.

In Punjab, PEDA has prepared and notified the Energy Conservation Building Code for the state. Furthermore, Bureau of Energy Efficiency, GoI has launched Eco-Niwas Samhita (ENS) for residential buildings and residential part of mixed land used projects build on plot area ≥ 500 square meters in 2018. In the first phase minimum standards for the building envelope were launched to limit heat gain or heat loss of the residential building comprising adequate day lighting potential and ventilation. BEE, GoI developed Eco-Niwas Samhita part–II for setting up minimum standards for the Electromechanical Equipment for efficient use of energy in residential buildings. The provisions of ENS must be incorporated in Unified Building Byelaws (UBBL).

In Recent, the Energy Conservation (Amendment) Act, 2022. A unified code for buildings sector "Energy Conservation and Sustainable Building Code (ECSBC)" has been introduced. The ECSBC code will be applicable for both commercial and residential buildings. The buildings sector is one of the energy-guzzling sectors in the state of Punjab. As per the graph below it can be witnessed that the energy consumption in the buildings sector has been continuously increasing since FY

2015. The increase in urbanization is very rapid and the demand in the domestic sector is major in terms of buildings and electricity requirement.

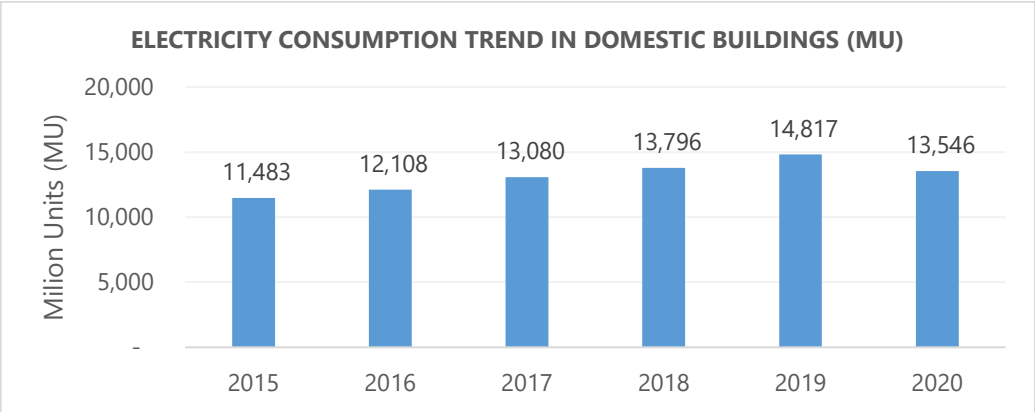


Figure 7: Electricity Consumption Trend in Domestic Buildings (MU)

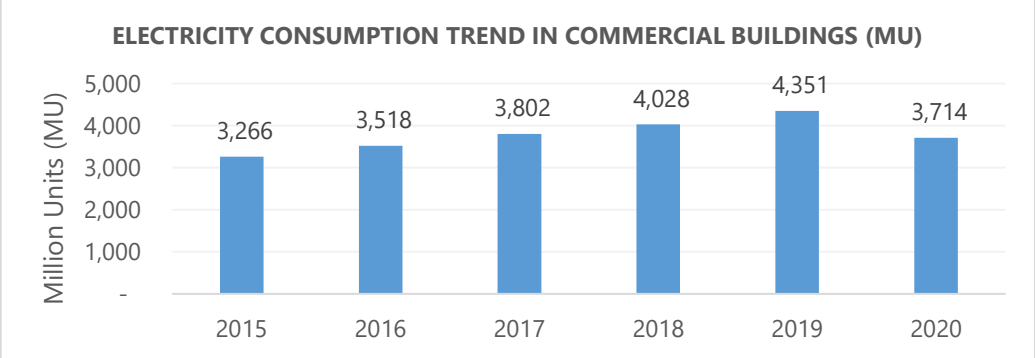


Figure 8: Electricity Consumption Trend in Commercial Buildings (MU) [13]

The commercial sector plays a vital role in the urbanization of Punjab, but it contributes only 21.52% to the total electricity consumption of the building sector. Meanwhile, the domestic sector accounts for 78.48% of the total electricity consumption, highlighting the need for a policy to promote energy efficiency in households. Implementing energy efficiency plans in even a small fraction of the domestic sector could significantly reduce electricity consumption. The figure below illustrates the distribution of electricity consumption between the commercial and domestic sectors for the fiscal year 2020. [14]

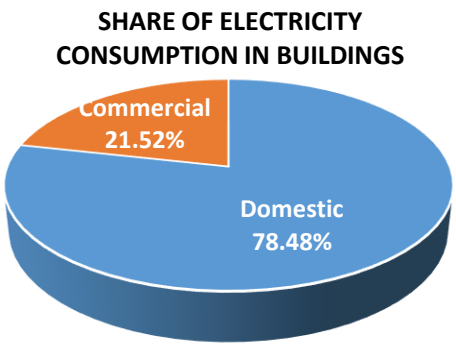


Figure 9: Share of Electricity Consumption

[13] Source: Tariff Orders from FY 2015 to FY 2020
[14] Source: Tariff Orders from FY 2015 to FY 2020

4.2. Energy Efficiency Strategies in Buildings Sector:

This section presents the proposed strategies in the domestic buildings and commercial buildings sector along with their impact in terms of energy saving potential. The following strategies are proposed in the building sector, as part of the State Energy Efficiency Action Plan:

1. Effective Implementation of ESCBC.
2. Replacement Programme for inefficient appliances.
3. Mandatory BEE Star Rating or Shunya Rating of Buildings.

Although programs like Standards & Labelling and ECBC are prevalent in the state, the proposed strategies focus on enhancing the extent of their implementation by increasing the penetration of technology into the population and rate of implementation of these strategies.

Strategy #1 Effective Implementation of ECSBC (previously known as ECBC & ENS)

The State of Punjab has already notified the Energy Conservation Building Code (ECBC) for commercial buildings in the year 2016 and amended in 2021. The state is in the process of adopting Eco-Niwas Samhita (ENS) for residential buildings.

However, in a recent EC Act Amendment 2022, unified code "Energy Conservation and Sustainable Building Code" (ECSBC) was introduced which will cover both commercial and residential buildings. Till the implementation of ECSBC in state, ECBC and ENS will work in place of ECSBC.

Effective implementation of Energy Conservation and Sustainable Building Code (ECSBC) by increasing the penetration of ECBC and ENS compliant buildings in the state is proposed for upcoming commercial and domestic buildings in the state as a strategy for energy savings in the buildings sector.

Savings Methodology for ECBC and ENS:

In order to calculate the energy savings from ECBC and ENS respectively, the electricity consumptions data of both domestic and commercial buildings has been considered from the PSPCL tariff order[15]. In terms of electricity consumption growth, the domestic buildings sector experiences a CAGR of 2.79%, while the commercial buildings sector shows a CAGR of 2.17%.

To calculate potential savings through ECBC, the electricity usage within the commercial buildings sector was forecasted up to FY 2031 using the formula presented below:

Electricity Consumption (Commercial) in FY2031 = x(1+CAGR%)^(b-a)

where:

x = Base year consumption

CAGR% = Growth rate of Commercial buildings consumption (FY2015 to FY2020)

a = Base year (i.e., FY2020), and

b = Projected year (i.e., FY2031)

Electricity Consumption (Commercial) in FY2031 = 3714 GWh (1+2.17%)^(2031-2020)

Electricity Consumption (Commercial) in FY2031 = 4701 GWh.

After forecasting the energy demand in the commercial building sector from FY 2023 to FY 2031, the annual increment in the electricity consumption in the commercial buildings sector was projected.

The total incremental electricity consumption in the commercial sector of the state is projected to be a total of 824.15 GWh between FY 2023 to FY 2031. This increment in electricity consumption accounts for all the categories of commercial buildings of varying loads. The Energy Conservation Building Code (ECBC) sets minimum energy standards for commercial buildings having a connected load of 100 kW or more.

[15] PSPCL Tariff Orders (https://docs.pspcl.in/vieworders.html?ofc=sesalesto)

It has been taken into consideration that around 5% of the buildings in the state have connected load of 100 kW or more. This percentage is an assumption to estimate the potential savings. Considering this percentage, the total Incremental electricity consumption contributing to buildings having load >100kW is estimated to be 41.21 GWh by FY2031.

Based on the energy savings percentage from ECBC (25% savings) and ECBC+ (35% savings), the moderate and ambitious savings by FY2031 in the commercial buildings sector are found to be **10.30 GWh (0.00089 Mtoe)** and **14.42 GWh (0.0012 Mtoe)** respectively.

An effective approach to reduce long-term unnecessary electricity usage in residential buildings is by making them more energy efficient. Implementing Energy-saving measures as per Eco Niwas Samhita (ENS) can be helpful in achieving this goal in the residential sector.

To calculate potential savings through ENS, the electricity usage within the domestic buildings sector was forecasted up to FY 2031 using the formula presented below:

Electricity Consumption (Domestic) FY2031 = x(1+CAGR%) ^(b-a)

where:

x = Base year consumption
CAGR% = Growth rate of domestic buildings consumption (FY2015 to FY2020)
a = Base year (i.e., FY2020), and
b = Projected year (i.e., FY2031)

Electricity Consumption (Domestic) in FY2031 = 13546 GWh (1+2.17%)^(2031-2020)

Electricity Consumption (Domestic) in FY2031 = 18339 GWh.

In the residential sector, by FY 2031, the electricity consumption is projected to be around 18,339.24 GWh. The overall incremental electrical consumption is estimated to be 4,025.99 GWh based on the anticipated household electricity demand by FY2031. In order to assess the savings that can be achieved from successful implementation of ENS, it is assumed that 4% of all the residential building stock would be ENS compliant by 2031. The strategy is expected to result in electricity savings of 19.32 GWh in the moderate scenario and that of

24.15 GWh in the ambitious scenario. The cumulative energy savings expected from the enhanced implementation of ECBC and ENS in the state is shown below:

Table 4: Energy Savings for the Buildings Sector[16]

Particulars	Moderate Scenario	Ambitious Scenario
Energy Saving Potential (Mtoe) in ECBC	0.00089	0.00124
Energy Saving Potential (Mtoe) in ENS	0.00166	0.00208
Total Energy Saving Potential (Mtoe)	**0.00255**	**0.00332**
Total Emission Reduction Potential ($MtCO_2$)	**0.0079**	**0.0103**

Actionable Items:

1. **Setting-up of effective enforcement plan with ULBs and SDA as monitoring agencies-** Effective implementation of ECBC and ENS depends on the effectiveness of rules & regulation adopted by the state. To ensure the same role & responsibility of all concerned departments, checkpoints, monitoring mechanism and penalties must be properly defined in ECSBC rules & regulations. SDA being an extended arm of Bureau of Energy Efficiency shall monitor the process of ESCBC compliance and record the data of total energy savings achieved through the implementation of ECSBC.
2. **Development and maintenance of ECSBC compliance portal, directory of energy efficient materials/technologies** – For effective and aggressive implementation, it is proposed that the state shall has its own ECSBC online portal to aid in quick ECBC & ENS approval and monitoring process online. The portal would ensure a faster process of compliance application, third party verification and certification. The portal may also contain educational resources, directory of materials and vendors and user-friendly guides for enhanced awareness and capacity building of developers and professionals.

[16] Source: For calculating the energy savings, the electricity data was referred from tariff orders

Investment would be needed in the development and annual maintenance of the ECSBC portal for which PEDA will be the regulatory agency.

3. **Capacity Building Workshops for ECSBC** – Capacity building of these stakeholders including architects, engineers, builders, policymakers, and local communities, is key to promoting construction practices necessary to comply with ECBC and ENS guidelines. State Government shall organize workshops at various levels to encourage people for behavioral change and run mass campaigns to reach out maximum people to increase awareness about the importance of Energy Conservation and Sustainable buildings. Workshops and campaigns shall be carried out to target maximum building professionals to aware them about the code and compliance procedures.
4. **Pilot projects for Super ECBC buildings as case studies (initial 20 Buildings)** – It is proposed that the state government also undertake the development of Super-ECBC buildings in the state and publish its case studies for the understanding of stakeholders. Initially upcoming government building can be taken as a pilot project and the best energy efficient technologies can be implemented to achieve the Super ECBC level. Case Study can be published in social media to encourage developers and other stakeholders to make Super ECBC compliant buildings.
5. **Home Energy Auditor Training, compliance structure and incentive on energy savings for first few residential projects** – BEE has developed a Home Energy Auditing tool. SDA may run awareness and capacity development programs in the state of Punjab to train building professionals about the benefit of auditing and implementation of Energy Conservation Measures (ECMs) in residential houses. SDA may encourage RWAs by providing some incentive based on energy savings on implementation of ECMs in their societies. These action items will help in the promotion of ENS in the state and create technical capacity of the professionals.
6. **Periodic upgradation of PWD Schedule of Rates (SoR) to incorporate latest energy efficient materials and technologies**

   Regular upgradation of PWD Schedule of Rates (SoR) to incorporate the latest energy efficient materials and technologies is required as technologies

in the field of energy efficiency are developing on some very regular intervals. Adoption of new innovative technologies becomes easier if it is mentioned in PWD Schedule of Rates (SoR) document.

Strategy #2 Replacement program for inefficient (below than 3 Star Rated) appliances.

Implementation Timeline: Long Term (Till FY 2031)

The Standards & Labelling (S&L) Programme of Bureau of Energy Efficiency (BEE) has seen a successful implementation across the country, leading to significant savings in energy through mandatory and voluntary use of energy efficient electrical appliances by consumers in a wide range of applications. The S&L Programme encompasses appliances and equipment that have applications in multiple sectors, however the buildings sector is the most widely covered sector in terms of types and number of appliances. Currently, the S&L Programme encompasses a total of 38 appliances, of which 16 are subject to mandatory regulation while the other 22 are regulated on a voluntary basis. The following table provides a detailed list of appliances that fall under mandatory and voluntary regulation.

Table 5: List of mandatory and voluntary appliances under S&L Programme

Mandatory Appliances	Voluntary Appliances
1. Room Air Conditioners	1. General Purpose Induction Motors
2. Frost-free refrigerators	2. Submersible Pump Sets
3. Tubular Florescent Lamps	3. Domestic Gas Stoves
4. Distribution Transformer	4. Office Equipment's (Printers & Copier)
5. Room Air Conditioner (Cassette, Floor Standing)	5. Ballast
6. Direct Cool Refrigerator	6. Computers (Laptop/Notebooks)
7. Color TV	7. Diesel Engine driven monoset pumps
8. Electric Geysers	8. Solid State Inverter
9. Variable Capacity Inverter Air Conditioners	9. Diesel Generator Sets
10. LED Lamps	10. Microwave Oven
11. Ceiling Fans	11. Solar Water Heater
12. Washing Machine	12. Commercial Beverage Coolers.
13. Chillers	13. High Energy Li Battery
14. Deep Freezers	

15. Light Commercial AC 16. Ultra-High Definition (UHD) TV	14. Tires 15. Pedestal Fan 16. Induction Hob 17. Grid Connected Solar Inverter 18. Air Compressors 19. Side By Side/Multidoor Refrigerator 20. Solar Photovoltaic 21. Table/Wall Fan 22. Packaged Boiler

The current strategy has been proposed for the complete buildings sector covering both Domestic and Commercial Buildings. However, a majority of the mandatory and voluntary appliances have a significantly higher penetration in the domestic buildings sector than in the commercial buildings sector. The electricity consumption pattern varies greatly between urban and rural areas. This is due to the variation in type and number of appliances being used by urban and rural residents. This entails the inclusion of the number of urban and rural households in the savings calculation. Based on the estimated population of the state as per the report "Population Projections for India and States 2011 – 2036" and Household Size as per census, the number of households were estimated out for urban and rural regions. Different categories of appliances have different penetrations among the urban and rural households, based on the usage pattern. Some appliances viz. Fans, refrigerators, washing machines, LEDs, air-conditioners, and microwaves have higher penetration as compared to other appliances. Considering the study given in the report "Impact Assessment of BEE's Standard & Labeling Program", penetration of different appliances among urban and rural areas was estimated. List of appliances considered in strategies is mentioned below:

Table 6: Appliances taken into consideration for the strategy

Window AC	Color TV CRT
Split AC	Washing Machines
Refrigerator-DC	Computer/Laptop/Notebooks
Refrigerator-Frost Free	Electric Geysers
Ceiling Fans	Cooking Stoves

Savings Methodology for Standard & Labelling Programme

According to the study conducted by CLASP (Collaborative Labeling and Appliance Standards Program) to assess consumer awareness of energy labelling, 48% of consumers are aware of the scheme and 15% have some knowledge of it. Appropriate number of 3-Star rated appliances have been taken from the calculation of total number of appliances. Saving strategies in the moderate scenario include replacement of 3-star rated equipment to 5-star rated appliances, whereas in the ambitious scenario, replacement of non-star rated to 5-star rated equipment has been considered as a saving strategy. The percentage savings achieved upon transitioning from non-Star to 5-Star Labelled equipment's (efficiency) were taken into account for calculating savings in above mentioned scenarios. The strategy is estimated to result in energy savings of 0.073 Mtoe in the moderate scenario and 0.095 Mtoe in the ambitious scenario till FY 2031.

Table 7: Moderate and ambitious scenarios for deepening of S&L Programme[17]

Particulars	Moderate Scenario	Ambitious Scenario
Energy Saving Potential (Mtoe)	0.0727	0.0954
Emission Reduction Potential ($MtCO_2$)	0.2275	0.2986

Savings Methodology for Electric Induction Stove

The widespread adoption of electric cooking has had a significant impact on various aspects of our lives and the environment. One of the most prominent impacts is the reduction of air pollution and greenhouse gas emissions. By eliminating the need for gas or other fossil fuels, electric cooking significantly decreases the release of harmful pollutants and contributes to cleaner air quality. This is particularly beneficial for indoor environments, as electric stoves eliminate the combustion byproducts that can negatively affect health and indoor air quality. Additionally, electric cooking has the potential to integrate with renewable energy sources, allowing households to utilize clean and sustainable electricity for their cooking needs. The advancements in electric cooking

[17] Source: Clasp Report (https://www.clasp.ngo/research/all/impact-assessment-of-bees-standard-labeling-program-in-india/ Page 61

technology, such as induction cooktops, have also led to improved energy efficiency and precise temperature control, further enhancing the environmental benefits. While there are considerations regarding the source of electricity generation, the overall impact of electric cooking on reducing emissions, improving air quality, and promoting energy conservation makes it a favorable choice for a sustainable and healthier future.

Moderate Scenario (FY2026)

5% of households switching to Electric Induction Stove by FY2026 = 5% x Number of households (2026) x Energy Savings from switching LPG to Electric Induction = 5% x 65,85,942 x 0.001125 TOE = 370.46 TOE = 0.00037 MTOE.

Ambitious Scenario (FY2026)

10% of households switching to Electric Induction Stove by FY2026 = 10% x Number of households (2026) x Energy Savings from switching LPG to Electric Induction = 10% x 65,85,942 x 0.001125 TOE = 740.92 TOE = 0.00074 MTOE.

Moderate Scenario (FY2031)

15% of households switching to Electric Induction Stove by FY2031 = 15% x Number of households (2031) x Energy Savings from switching LPG to Electric Induction = 15% 70,32,204 x 0.001125 TOE = 1,187 TOE = 0.00119 MTOE.

Ambitious Scenario (FY2031)

30% of households switching to Electric Induction Stove by FY2031 = 30% x Number of households (2031) x Energy Savings from switching LPG to Electric Induction = 30% 70,32,204 x 0.001125 TOE = 2,373 TOE = 0.00237 MTOE.

Table 8: Energy Saving Calculation for Electric Induction

Energy content of 14kg LPG (1 Cylinder)	0.01582	TOE
Energy content of 14kg LPG (9 Cylinders for 1 year)	0.14238	TOE
Average electricity consumption of Electric Induction Stove	1.5	kWh
On average, usage of electric induction in a household	3	Hours
Total Energy consumption of Electric Induction Stove (per Day)	4.5	kWh
	0.000387	TOE
Total Energy consumption of Electric Induction Stove (1 Year)	0.141255	TOE
Energy Savings from switching LPG to Electric Induction	0.001125	TOE
Number of Household Projection		

2011	2021	2026	2031
54,10,000	61,68,000	65,85,942.20	70,32,204.07
Source: LPG Profile (https://rb.gy/9u26p) Page 10			

The below chart depicts the energy savings from transitioning of domestic LPG cylinder to electric Induction stove. The energy savings account to 0.00037 and 0.00074 Mtoe by FY 2026 in moderate (5% of the household) and ambitious scenario (10% of the household) respectively. However, the energy savings in FY 2031 accounts for 0.00119 and 0.00237 Mtoe in moderate (15% of the household) and ambitious scenario (30% of the household) respectively.

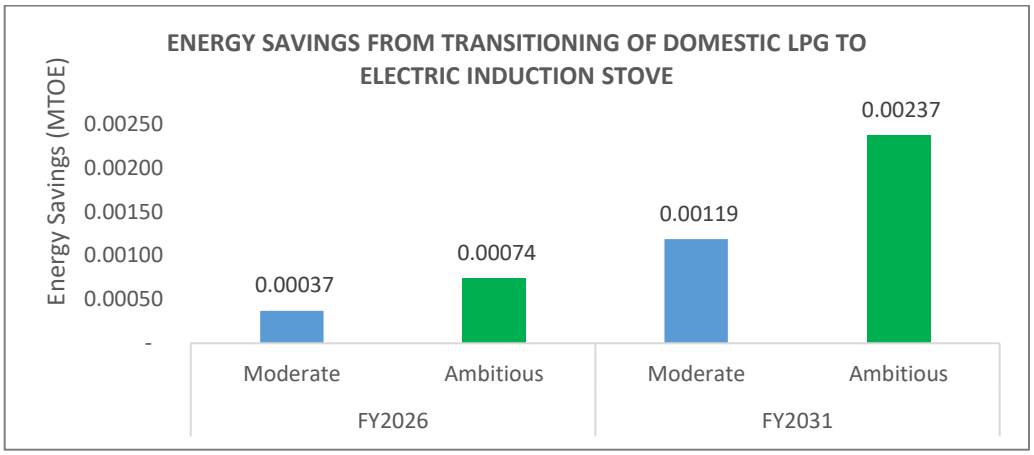


Figure 10: Energy Savings Scenario from Transitioning of Domestic LPG to Electric Induction Stove

Actionable Items:

The action items to be carried out in order to implement the strategy at ground level mainly involve dissemination of the scheme's guidelines and specification amongst stakeholders such as manufacturers, retailers and consumers in a way that can ensure meeting the implementation timeline proposed for the strategy. The following action items are suggested in order to ensure effective implementation:

1. **Development of state-specific implementation models and identification of relevant agencies-** A detailed phase-wise plan needs to layout based on consumer's priority and reachability. It is important to develop a transparent model that can reach out to every household in the state. Financial implications will play a major role in replacement schemes so ESCOs and PPA models can be analyzed in detail. UJALA scheme is a successful case study in this area, can be referred for the development of

state specific plan. Identification of implementing departments and agencies and listing of ESCOs in the state is required.

2. **Issuance of directive to government offices and buildings in the state to replace all existing inefficient appliances (lower than 3 Star Rated) with BEE 5-star rated appliances-** State Government shall issue directives to all government offices and buildings owned by state government to replace all appliances which are lower than 3-star rated or purchased/installed before 2015 with BEE 5-Star rated appliances.
3. **Phase-wise plan for replacement of existing inefficient appliances (lower than 3 Star Rated) with BEE 5-star rated appliances in all buildings, through DSM schemes** Development of phase-wise Demand Side Management (DSM) plan based on the consumer's priority and market scenario shall be developed in consultation with DISCOMs. Implementation can be done with the support of DISCOM's and various ESCOs listed with the state government.
4. **Workshops & Campaigns on behavioral change interventions for energy conservation –** Capacity building of these stakeholders is key to develop a market environment for energy efficient appliances. State Government shall organize workshops at various levels to encourage people for behavioral change and run mass campaigns to reach out maximum people to increase awareness about benefits of behavioral changes and promote Lifestyle for Environment (LiFE). Workshops and campaigns shall be carried out to target maximum people by organizing through online platforms, print media, social media, and nukkad nataks etc.

Strategy #3 Mandatory BEE Star Rating or Shunya Rating for Government Buildings

Implementation period: Long Term (Till FY 2031)]

The voluntary Star Rating and Shunya Rating system currently serves as a benchmarking tool for classifying buildings based on their energy performance. However, it is recommended to be made mandatory for all the government buildings owned by the state government to encourage its adoption. Conducting

energy performance assessments and assigning buildings a rating on a scale of 1 to 5 stars or Shunya Rating will drive the development of energy-efficient buildings in the state. Buildings that meet the required criteria will be eligible for certification with a Star Rating or Shunya Rating based on the assessment results.

Table 9: Moderate and ambitious scenarios for BEE Star Rating or Shunya Rating of Buildings

Particulars	Moderate Scenario	Ambitious Scenario
Energy Saving Potential (Mtoe)	0.0007	0.0010
Emission Reduction Potential ($MtCO_2$)	0.0022	0.0031

Actionable Items:

1. **Issuance of directives to all government departments to conduct energy audits and target to achieve BEE Star Rating for their buildings**-

   State Government shall issue directives to all government departments and buildings owned by state government to conduct energy audit and implement energy conservations measures and target to achieve BEE Star Rating or Shunya Rating for their buildings.

2. **Periodic energy audits for buildings to maintain the star rating of buildings**-

   The state government shall issue a notification requiring buildings to undergo mandatory periodic energy audits. This will help to ensure that buildings maintain their desired star rating and encourage building owners to reduce their energy performance index (EPI) and save energy. By achieving a star rating, buildings can demonstrate their commitment to energy efficiency and sustainability.

3. **Capacity Building of Architects, Technicians, Building Professionals and Developers**-

   Capacity building programs of Architects & Building Professionals and Developers will ensure to increase the technical capacity of and awareness about innovative technologies. Capacity building of these stakeholders is key to developing a market environment for energy

efficient buildings. The capacity building programs can be taken up periodically, preferably quarterly. Capacity building workshops may be carried out either district-wise or zone-wise and target maximum stakeholder to participant in these programs.

4. **Market Outreach for Star & Shunya Rating by Social Media Awareness-**

   Promotion of the Star & Shunya Rating is an important part of promoting energy efficiency in buildings. In order to increase awareness about this rating program, promotion campaigns shall be carried out to reach masses by advertising in print media, social media, conduct nukkad nataks, and plays etc.

5. **Mandatory minimum set point of 24 degrees for air conditioners in all government buildings –**

   The Bureau of Energy Efficiency has been raising awareness on the energy savings and cost benefit of lowering the operating set point of air conditioners and have advised consumers across the country to maintain set point on or above 24 degrees Celsius to ensure optimal temperature and energy consumption from the use of air conditioners. It is recommended that government departments take the lead in the implementation of this practice across the state.

6. **Transformation of iconic government buildings to Net-Zero energy buildings -** Transforming government buildings to net zero will ensure maximum energy performance of these buildings. It will further boost the market and professional environment of sustainable construction products, energy efficient appliances, and energy audit and consulting services. The SOR of government construction projects can be regularly updated with energy efficient and climate responsible materials through the help of this strategy.

Savings Methodology for BEE Star Rating or Shunya Rating of Buildings:

In order to calculate the energy savings from BEE Star Rating or Shunya Rating of Buildings, the total incremental electricity consumption of Commercial and

Domestic buildings from FY2023 to FY2031 has been considered, which amounts to 4,850 GWh (See Appendix). Out of this incremental electricity consumption, we have assumed that 5% of the buildings in the state have a connected load greater than 100kW. Therefore, the total additional electricity consumption attributed to buildings with a load >100kW is calculated as 5% of 4,850 GWh, which equals 242.51 GWh.

We have assumed that out of this 242.51 GWh, total incremental electrical consumption contributing to BEE Star Rating for Buildings is 10% i.e., 10% of 242.51 GWh, which equals to 24.3 GWh.

In the moderate scenario, we have taken into account 35% of energy savings while in the ambitious scenario we have considered 50% of energy savings by FY2031.

Moderate Scenario Savings through Building Star Rating (3 Star) = 35% x 24.3 GWh = 8 GWh = 0.0007 Mtoe

Ambitious Scenario Savings through Building Star Rating (5 Star) = 50% x 24.3 GWh = 12.1 GWh = 0.001 Mtoe

4.3. Energy Saving Targets & Monitoring Mechanism

The proposed strategies can together achieve maximum potential energy savings of 0.0760 Mtoe in moderate scenario and 0.0998 Mtoe in ambitious scenario by FY 2031. The energy saving and emissions reduction targets for the short term (till FY 2026) and long term (till FY 2031) for the buildings sector under the two scenarios are shown in the table below:

Table 10: Moderate and ambitious scenarios energy savings for buildings sector[18]

Action Plan	Energy Savings in 2031 moderate scenario (Mtoe)	Energy Savings in 2031 ambitious scenario (Mtoe)
Effective implementation of ECSBC	0.0025	0.0033

[18] Source: Electricity: Tariff Orders from FY 2015 to FY 2020

Replacement program for inefficient appliances	0.0727	0.0954
BEE Star Rating or Shunya Rating of Buildings	0.0007	0.0010
Total	**0.0760**	**0.0998**

Monitoring Mechanism:

The monitoring framework for achieving the target of the building sector can be easily set up by defining annual reduction targets of the sectoral reduction goal. Monitoring of points mentioned below through the dashboard will support in monitoring of energy efficiency initiatives in the state.

- Development of strategy-specific dashboards to monitor the impact and track progress of ECBC buildings, ENS buildings, Net Zero buildings in the state and the energy savings achieved from these strategies.
- Regular reporting and updating of dashboards can be done with the support of PEDA or ECBC/ENS cell.
- Development of dashboard to monitor the sale of different star-labelled appliances sold in a year categorized according to star rating level.

Mechanism for data collection and reporting from various clusters and various energy efficiency initiatives may be done through Setting up a Sector Specific Energy Efficiency Cell (SSEEC), Cluster Level Energy Efficiency Cell (CLEEC) and Building Level Energy Manager/Auditor.

Setting up a Sector Specific Energy Efficiency Cell (SSEEC)

- The working of this cell will be different from the operations of SDA, the SSEEC will be responsible to collect data from all the cluster energy efficiency cells in the state of Punjab and share the same with the SDA for tracking the achievement of the targeted goal.

Cluster Level Energy Efficiency Cell (CLEEC)

- The CLEEC will be responsible for gathering information from specific type of buildings, industries on their operations, energy efficiency goals and will report the same to the SSEEC at the end of each quarter.

Building Level Energy Manager/Auditor

- The building level energy auditor and energy manager will be responsible for sharing data with the cluster level cell for specific building type in the specified format.

INDUSTRY SECTOR

5. Industry Sector

5.1. Current Scenario

Punjab has emerged as a preferred investment destination for national and international investors. The state is a vibrant and fast-growing, attracting investors for profitable investments. The state provides investment opportunities in sectors such as textiles, agro-based industries, automotive and auto components, sports goods, and light engineering goods. Punjab is the source of 95% of India's woolen knitwear production, 85% of India's sewing machine production, and 75% of India's sports goods production. According to the Department for Promotion of Industry and Internal Trade, cumulative FDI inflow in the state stood at US$ 778.73 million during 2019-21. The following are the major industries in Punjab:

- Hosiery and Readymade Garments
- Textile and Yarn Industry
- Cycle and Cycle Parts
- Sewing Machine Manufacturers
- Sports Goods
- Sanitary Fittings
- Leather and Rubber Industry
- Packing Material and Machinery
- Textile Printing
- Printing Industry
- Information Technology
- Pharmaceuticals
- Diesel Engine and Parts
- Steel Rolling Mills
- Combine Harvester
- Bricks
- Foundry & Forging

Punjab has a huge investment opportunity for energy efficiency as the state has a large number of MSME units. They play an important role in the state's economy and provide employment to a large share of people. The individual power consumption of MSMEs is usually low but the collective consumption of clusters is usually high. The electricity consumption of the industrial sector for the Punjab state has risen in the last few years.

The existing PAT DCs in the state of Punjab are Cement, Chlor-Alkali, Pulp & Paper, Textile, TPP, Fertilizer, DISCOM, and Petroleum Refineries.

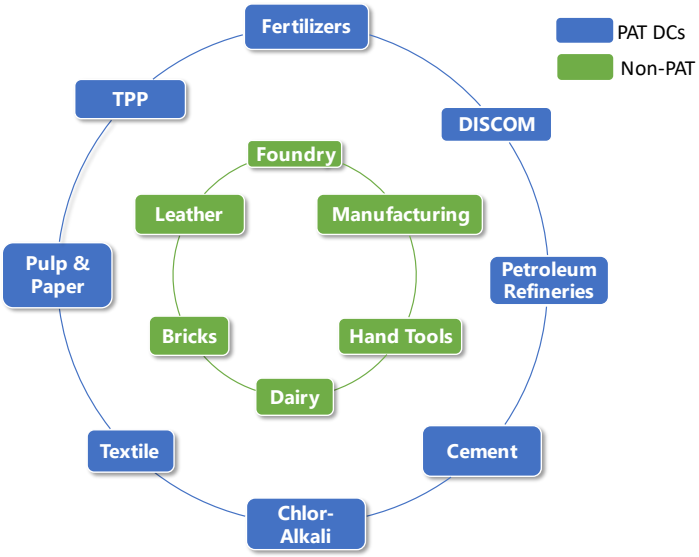


Figure 11: Prominent PAT and Non-PAT DCs in the State

5.2. Energy Efficiency Strategies in the Industry Sector:

This section presents the proposed strategies in the prominent sectors and focus areas identified in the industry sector along with their impact in terms of energy efficiency and emissions reduction. Strategies are proposed with their relevant action items.

Strategy #1: Deeping and Widening of Perform, Achieve and Trade (PAT) Scheme

Implementation Timeline: Long Term (Till FY 2031)

The analysis performed to determine the coverage of Perform, Achieve, and Trade (PAT) in Punjab revealed that as of FY 2019, the industries covered under the PAT scheme have a share of 22.82% in the total energy consumption in the industry sector.

In the proposed strategy, it is recommended that the state enhance coverage of energy consumption in PAT industries (DCs) by deepening and widening the PAT scheme in the state. Deepening and Widening of PAT scheme would imply notifying more industries as designated consumers under the current PAT sectors by lowering the threshold limit for eligibility (TOE/annum), as well as the inclusion

of new sectors under the PAT scheme. The introduction of new sectors such as Dairy, Food Processing, Sugar Mills, Cold Storage, Forging & Foundry, Steel Re-rolling etc. in the PAT scheme can be targeted for Punjab where these sectors are prominent. Lowering of threshold can be done in all PAT notified sectors in a phase-wise manner so that the coverage of scheme can be widespread.

Savings methodology for Deepening and Widening of PAT Scheme:

In order to calculate the energy savings, the Baseline Specific Energy Consumption (SEC) data from the BEE PAT Circular has been considered. The targets for achieving moderate and ambitious SEC reductions have been determined as follows: for the Sugar Industry, this entails a reduction of 22% and 33% from the baseline SEC. For Textile Industry, a reduction of 10% and 18% from the baseline SEC, while for Cement, Pulp & Paper and Fertilizer, a reduction of 10% and 20% reduction has been considered. It is assumed that the existing units of both sectors will achieve the moderate SEC target in 50% units and achieve the ambitious SEC target in 70% units. These percentages are an assumption for estimating potential industry savings.

Table 11: Energy Savings in Moderate and Ambitious Scenario[19]

Sector	Baseline SEC	Moderate SEC	Ambitious SEC	Production in 2031 ('000 tonnes)	Energy saving in moderate scenario (Mtoe)	Energy saving in ambitious scenario (Mtoe)
Sugar	28.00 kWh/tonne of cane	22.00 kWh/tonne of cane	18.70 kWh/tonne of cane	938.86	**0.00024**	**0.00053**
Textile	0.505 toe/tonne	0.45 toe/tonne	0.41 toe/tonne	2,890	**0.073**	**0.184**
Cement	0.017 toe/tonne	0.0154 toe/tonne	0.0137 toe/tonne	3,707	**0.0032**	**0.0089**
Pulp & Paper	0.293 toe/tonne	0.264 toe/tonne	0.235 toe/tonne	197.89	**0.0029**	**0.0081**
Fertilizer	0.428 toe/tonne	0.385 toe/tonne	0.342 toe/tonne	954.78	**0.0228**	**0.0638**
Total Energy Saving Potential (Mtoe)					**0.102**	**0.265**
Total Emission Reduction Potential ($MtCO_2$)					**0.319**	**0.830**

[19] Source: BEE PAT circulars; BEE and GIZ enhancing energy efficiency reports

Actionable items:

1. **Partial Risk guarantee program to encourage implementation of latest energy efficient technologies in the sectors (Over and above existing schemes with state contribution)**

   A Partial Risk Guarantee (PRG) program can be an effective tool for encouraging the implementation of the latest energy-efficient technologies in various sectors. The program involves providing a guarantee to a lender or investor, which covers a portion of the risk associated with financing the adoption of energy-efficient technologies. Under the program, the lender or investor can provide financing at a lower cost, as the risk is partially covered by the guarantee. This helps to reduce the cost of financing for the borrower, making it more affordable to implement energy-efficient technologies. BEE, under its existing PRGFEE scheme has already released guidelines for partial risk guarantee that may be adopted by the state for effective implementation.

2. **Capacity Building of Energy Managers and Energy Auditors in PAT DCs and new probable sectors for compliance with scheme and new technologies:** Though its mandatory to go through a refresher training for all energy auditors and managers, it is important to attain knowledge of changing schemes and policies that could positively impact large consumers and help them implement schemes in their respective organizations.

3. **Mandatory Standardized Energy Audits in every three years for all units that have energy consumption below PAT threshold, in all notified PAT sectors, excluding MSMEs:** Though separate guidelines are issued for PAT industries, non-PAT, non-MSME industries could also benefit from energy audits. This shall not only ensure their improved energy performance, but also, ensure that if brought under PAT scheme at a later stage, they would be accustomed and more willing to participate in it. The audits will also improve competitiveness of these industries. A monitoring mechanism may be developed to see the impact of energy audits and advise industries in a constructive way from time to time.

4. **Development of mechanisms for B2B interaction with global technology suppliers.**

   Global technologies are often beyond the reach of domestic industries due to several reasons. A platform to improve competitiveness and efficiency in energy may be provided under a structure to ensure advancement of manufacturing process and improvement in energy efficiency at the same time.

Strategy #2: Energy Efficiency Interventions in MSME Clusters

Implementation Timeline: Short Term (Till FY 2026) for lower coverage; Long Term (Till FY 2031) for higher coverage.

The strategy is proposed for the Small and Medium Enterprises (SME) sector, which consists of MSMEs in identified prominent sectors such as Bricks, Hand Tools, Cycle Manufacturing, Leathers, Steel Rerolling, Foundry & Forging etc. A PAT-like scheme is proposed under this strategy for the unorganized and small industries sectors, which would not meet the threshold energy consumption under the conventional PAT scheme. The strategy would involve the implementation of energy efficient technologies and new & innovative decarbonization technologies in the market in order to enable SMEs to meet their energy saving targets.

Savings methodology for Energy Efficiency Interventions in MSME Clusters:

In order to calculate the energy savings from energy efficiency interventions in MSME clusters, the Baseline Specific Energy Consumption (SEC) has been considered for the respective clusters from SAMEEEKSHA platform[20]. The Moderate and Ambitious SEC target has been calculated by considering 5% and 10% reduction with respect to the baseline SEC. The production of the respective cluster has been forecasted till FY2031. Using this forecasted production and the moderate & ambitious SEC target, the energy consumption in Business-as-usual

[20]www.sameeeksha.org/index.php?option=com_content&view=article&id=108&Itemid=489

(BAU), moderate and ambitious scenario by FY2031 can be calculated using the formula below:

Business-as-usual energy consumption = Baseline SEC x Production (2030)

Moderate energy consumption = 60% x Moderate SEC target x Production (2030)
+ 40% x Baseline SEC x Production (2030)

Ambitious energy consumption = 80% x Ambitious SEC target x Production (2030)
+ 20% x Baseline SEC x Production (2030)

Energy Savings in Moderate Scenario by FY2030 = BAU energy consumption – Moderate energy consumption

Energy Savings in Ambitious Scenario by FY2030 = BAU energy consumption – Ambitious energy consumption

It was assumed that 60% of industries will be able to adopt the strategy in a moderate scenario and 80% industries will be covered in the ambitious scenario. These percentages are an assumption for estimating potential industry savings. The strategy is expected to result in energy savings of 0.1169 Mtoe and 0.3107 Mtoe in the moderate and ambitious scenarios respectively.

Table 12: Energy Savings in Moderate and Ambitious Scenario in MSME Clusters[21]

Sector	Baseline SEC (toe/tonne)	Moderate SEC (toe/tonne)	Ambitious SEC (toe/tonne)	Production in 2031 ('000 tonnes)	Energy saving in moderate scenario (Mtoe)	Energy saving in ambitious scenario (Mtoe)
Bricks	0.0395	0.0375	0.0355	68,242.54	**0.081**	**0.2155**
Hand Tool	0.3966	0.3768	0.3569	72.60	**0.001**	**0.0028**
Cycle Manufacturing	1.943	1.846	1.749	209.05	**0.012**	**0.033**
Leather	0.022	0.021	0.020	177.15	**0.00012**	**0.00032**
Steel Rerolling	0.035	0.033	0.032	8,831.79	**0.00927**	**0.02473**
Forging	0.092	0.088	0.083	2,758.68	**0.00764**	**0.02037**
Foundry	0.094	0.089	0.085	1,913.71	**0.0054**	**0.01439**
Total Energy Saving Potential (Mtoe)					**0.1169**	**0.3107**
Total Emission Reduction Potential ($MtCO_2$)					**0.3658**	**0.9725**

[21] Source: Sameeksha Portal

Actionable items:

A number of action items will need to be adopted by the relevant departments and implementing agencies to achieve the energy savings estimated for this strategy. These action items include:

1. **Carrying out energy and resource-mapping studies in MSME clusters –** For the industries not covered under PAT, there is a challenge in reporting accurate energy consumption data for individual clusters or sub-sectors. Understanding of energy consumption patterns in the clusters is necessary to ensure optimized allocation of resources and assess the feasibility of technology implementation in a particular cluster. Energy and resource-mapping studies are comprehensive studies on MSME clusters and sub-sectors that can give insights into the current status of technology implementation in the cluster, set benchmark energy consumption, design threshold limits for a PAT-like scheme, and analyze the future potential of technology implementation in terms of energy and cost savings. Energy and resource-mapping studies are proposed to be carried out in the prominent MSME clusters and industry sub-sectors of the state annually to set benchmarks and track progress in the implementation of this strategy.
2. **Implementation of Demonstration Projects on energy efficient technologies in SME clusters –** Demonstration projects are proposed to be carried out every year on a periodic basis in all prominent SME clusters to promote these technologies and make stakeholders aware about the monetary and energy performance impact of these technologies.
3. **Workshops on technology interventions for energy conservations in MSMEs –** It is proposed to organize cluster wise workshops for MSMEs on technology interventions that can be implemented in respective industries. It is important to disseminate technical information about new technologies among owners and maintenance team of MSMEs so that they can implement the latest technologies in their units.
4. **Periodic standardized energy audits for MSMEs on load basis and reimbursement of energy audit cost with a maximum cap** – Government of Punjab shall develop a standard format of energy audit and issue

notification for conducting mandatory periodic (in every 3 Years) energy audits by every unit above a certain limit of connected load. The government can also provide reimbursement of energy audit cost with a maximum cap of INR 75,000. Monetary support to small industries and MSMEs can be provided to maintain the standard of conducted energy audit.

5. **Sector-specific policy development for financial assistance on implementation of ECMs suggested in energy audit-** A policy shall be developed at state level to provide the financial assistance for implementation of ECMs recommended in the energy audits. Policy development shall consider the sector specific requirements, energy saving potential of sector and its importance in state level GSDP.
6. **Phase wise plan to implement DSM scheme for replacement of existing inefficient (non-star rated) pumps & motors through DISCOMS-**
   State government department shall develop a demand side management (DSM) plan to replace all existing pumps and motors which are lower than 3-star rated or purchased/installed before 2015 with BEE 5-Star rated appliances. Phase wise plan can be executed through DISCOMs or listed ESCOs in the state.
7. **Technical assistance for transition from Bull Trench Kiln to Zig-Zag Kilns in Bricks cluster, Induction billet heater in Cycle manufacturing cluster, energy efficient furnaces etc. –** As bricks, cycle manufacturing, leather Steel Rerolling, Forging and Foundry are key industries in the MSME sector, upgradation of technology will unlock large potential of energy savings. As these industries include several small sized units, technical assistance to upgrade in key energy consumption sectors such as furnaces and motors will create a large impact.
8. **Policy on Energy Efficiency in MSME:** The state of Punjab should develop and implement a comprehensive policy on energy efficiency in the MSME sector. This policy should focus on providing incentives, subsidies, and support to encourage MSMEs to adopt and implement energy-efficient technologies with the support of Energy Service Companies (ESCOs). It

should also outline the standards and guidelines that MSMEs need to adhere to in order to improve their energy efficiency.

9. **Policy on Energy Efficiency in Motors:** As motors are widely used in various industries, Punjab should establish a specific policy that targets energy efficiency improvements in motors. This policy could involve promoting the manufacturing of energy-efficient motors, providing financial assistance for motor replacements, and encouraging industries to undertake regular maintenance and optimization of motors.
10. **MSME Budget for Skilling and Re-skilling of Technicians/Operators in the form of Certification from Technical Institution:** Punjab government should allocate a budget to run a dedicated program to skilling and re-skilling of technicians/Operators in the MSME sector. This budget should be used to collaborate with technical institutions and organizations to design certification programs that enhance the skills and knowledge of technicians/operators in energy-efficient practices.
11. **Issuance of Directives for Ban on Highly Polluting Fuels in MSME Clusters**, **especially in Industries like Leather:** To combat pollution and improve air quality, Punjab should issue strict directives banning the use of highly polluting fuels in MSME clusters, particularly in industries like leather that often rely on such fuels. This measure will encourage industries to transition to cleaner and greener energy sources, reducing their environmental footprint. The directives would prohibit the use of fuels such as furnace oil, kerosene, petcock etc. in these clusters.

5.3. Monitoring Mechanism

The proposed strategies can together achieve maximum potential energy savings of 0.219 Mtoe in moderate scenario and 0.576 Mtoe in ambitious scenario by FY 2031. The energy saving and emissions reduction targets for the short term (till FY 2026) and long term (till FY 2031) for the industry sector under the two scenarios are shown in the table below:

Table 13: Moderate and ambitious scenarios energy savings for Industry sector

Action Plan	Energy Savings by 2031 moderate scenario (Mtoe)	Energy Savings by 2031 ambitious scenario (Mtoe)
Deeping and Widening of PAT Scheme	0.102	0.265
MSME Clusters	0.1169	0.3107
Total	**0.219**	**0.576**

The monitoring framework for achieving the target of the industry sector can be easily set up by defining annual reduction targets of the sectoral reduction goal. The reduction target verification can be later done for monitoring the following for each quarter.

Setting up a Sector Specific Energy Efficiecy Cell (SSEEC) in Dept. of Industries

- The working of this cell will be different from the operations of SDA, the SSEEC will be responsible to collect data from all the cluster energy efficiency cells in the State of Punjab and share the same with the SDA for tracking the achievement of the targeted goal.

Cluster Level Energy Efficiency Cell (CLEEC)

- The CLEEC will be responsible for gathering information from specific type of industries on their operations, energy efficiency goals and will report the same to the SSEEC at the end of each quarter.

Industry Level Energy Manager/Auditor

- The industry level energy auditor and energy manager will be responsible for sharing data with the cluster level cell for specific industry in the specified format.

TRANSPORT SECTOR

6. Transport Sector:

6.1. Current Scenario

Due to emerging of Punjab state as one of the most vital business centers in India, the government of Punjab has invested a lot in recent years to provide proper transportation facilities to the people. The common modes of transportation in the state of Punjab are roadways, railways, and airways through which the state is very well connected to the other states in India. The rapidly increasing population and economic activities in the state have led to an exponential increase in demand for passenger and freight transport services.

The transport sector in Punjab is driven by road transport, followed by railways. Punjab ranks 2nd in terms of road density with 92% of its roads surfaced. The state government has notified Punjab Electric Vehicle Policy in 2022 which provides benefits such as 100% waiver on motor vehicle tax, 100% waiver on permit fee for the 4 wheelers and tolls on the state highways to be waived off. The number of registered motor vehicles has shown a persistent increase over the year. Further, there has been a steady increase in private vehicles under the four wheelers and two-wheeler category which exhibits a potential of positive electrical vehicle transition in Punjab. It may also be noted that, in commercial vehicle category like trucks and lorries, the vehicle owns 64% of the total share, however considering the market availability of EVs for this category in the whole country, this transition will require some time and can be a part of the long-term strategy towards achieving the desired target of Panchamrit.

Adding to that, the sectorial transport share of the state is led by trucks and Lorries followed by the light motor vehicles (passengers) in the total registered vehicles. Further, the two-wheeler sector also shows potential for transition when compared with market availability. The share of registered transport vehicles as of 2019 is as given below:

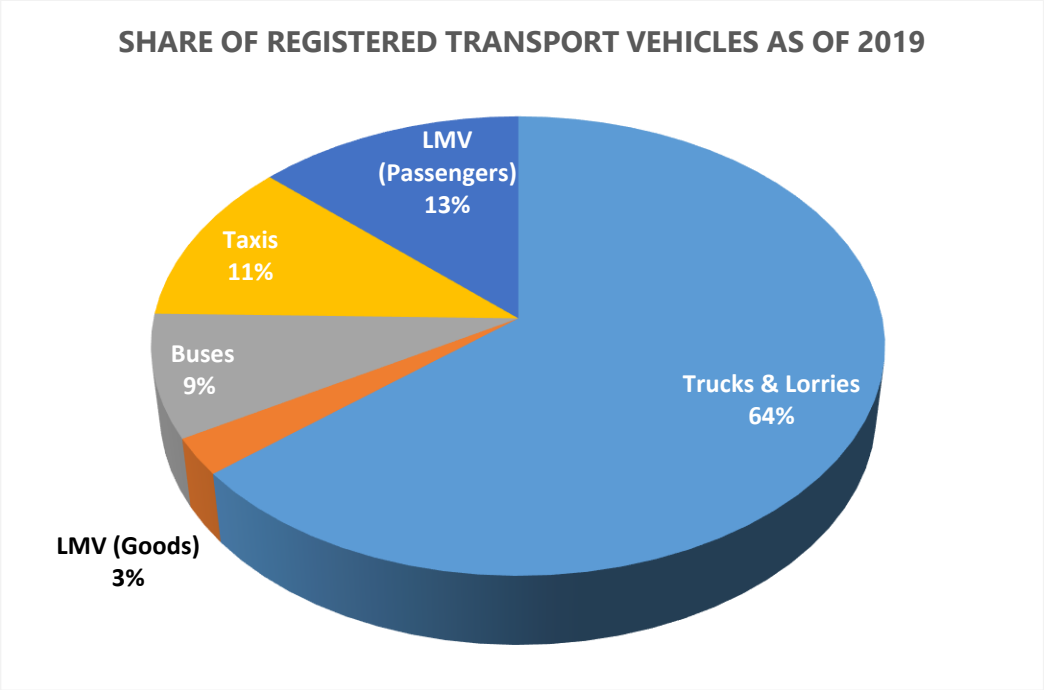


Figure 12: Share of Registered Transport Vehicles 2019[22]

Also, to achieve the desired target of Panchamrit, the state of Punjab has an EV Policy that aims for 25 percent of annual vehicle registrations to comprise EVs. The policy shall be valid for a period of 5 years from the date of notification with a detailed review to be undertaken annually. More than three-fourths of new vehicle registrations in the state comprise two-wheelers (motorcycles, mopeds, and scooters) during 2013-19. EV policy aims to increase the share of electric two-wheelers significantly to reach 80 percent of new sales over the policy period. It is also directed towards faster adoption of electric cycles and three-wheelers.

The figure below shows the forecasted electric vehicles for the financial year 2025 and 2030. The electric vehicle data has been referred from the Vahan Portal for FY 2019 and FY 2022, further for forecasting the number of vehicles in FY 2025 and FY 2030, the vehicle numbers are aligned with the Punjab EV policy.

[22] Source: Vahan Portal

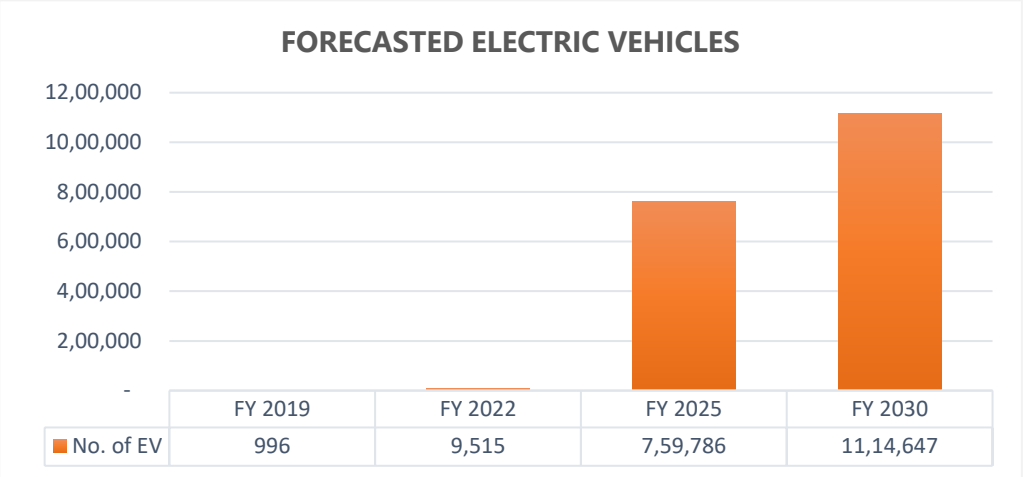


Figure 13: Forecasted Electric Vehicles[23]

A total CAGR of 6.43 % was estimated and used to project the energy consumption in transportation in the years 2026 and 2031, with base year as 2019.

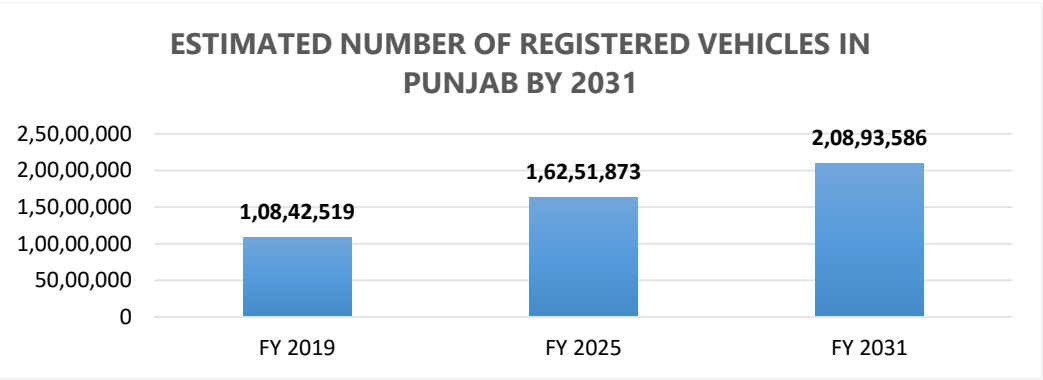


Figure 14: Estimated Number of Registered Vehicles by 2031[24]

6.2. Strategies in the Transport Sector

The Punjab EV Policy 2022 has proposed a long-term strategy for the transition to electric vehicles in the state. The strategy covers various aspects of the transport sector, including providing incentives to consumers for transitioning to

[23] Source: Vahan Portal (https://vahan.parivahan.gov.in/vahan4dashboard/vahan/view/reportview.xhtml) and Punjab EV Policy (http://olps.punjabtransport.org/Punjab%20Electric%20Vehicle%20Policy%20-%202022.pdf)

[24] Source: Vahan Portal (https://vahan.parivahan.gov.in/vahan4dashboard/vahan/dashboardview.xhtml)

EVs, converting the state's different types of vehicles into electric vehicles, transitioning to electric logistics transport, and developing a network of charging stations across the state. The strategy has been proposed in line with the national policy on ethanol blending.

Strategy #1 Infrastructure Development for EV charging stations and Incentives to Consumers for quick transition to EVs

Implementation Period: Long Term (Till FY 2026 & FY 2031)

The transition to Electric Vehicles (EVs) across all segments of vehicles will be instrumental in decarbonization of the sector and in bringing significant savings in fossil-fuel based energy consumption. In this strategy, it is proposed to convert new vehicles registered in the state till FY 2031 to electric vehicles along two different scenario trajectories, namely moderate scenario and ambitious scenario. The highest EV conversion rate is proposed for 2-wheelers because of it having the highest share in registered vehicles and taking into consideration the availability and affordability of 2-Wheeler electric vehicles. The EV conversion considerations for moderate and ambitious scenarios are given in Table 10.

Table 14: EV transition considerations for moderate and ambitious scenarios[25]

Moderate Scenario	Ambitious Scenario
• 80% of conventional 2-Wheelers convert to electric by 2031. • 80% of conventional 4-Wheelers convert to electric by 2031. • 30% buses in the state to transition to electric buses by 2031. • 40% of 3-Wheelers to convert to electric by 2031. • 30% of heavy vehicles (trucks and lorries) to convert to electric by 2031.	• 100% of conventional 2-Wheelers convert to electric by 2031. • 100% of conventional 4-Wheelers convert to electric by 2031. • 50% buses in the state to transition to electric buses by 2031. • 50% of 3-Wheelers to convert to electric by 2031. • 50% of heavy vehicles (trucks and lorries) to convert to electric by 2031.

[25] Source: Punjab EV policy (http://olps.punjabtransport.org/Punjab%20Electric%20Vehicle%20Policy%20-%202022.pdf) Page 5

Savings methodology for EV transition strategy:

In order to calculate the energy savings from EV Transition, the conversion target has been considered as shown in the table below.

The EV transition strategy can result in potential energy savings of 0.85 Mtoe and 1.18 Mtoe in the moderate scenario and ambitious scenario respectively.

Table 15: Energy Savings and Emission Reduction Potential by 2031

Particulars	Moderate Scenario	Ambitious Scenario
Energy Saving Potential (Mtoe)	0.85	1.18
Emission Reduction Potential ($MtCO_2$)	2.66	3.68

Actionable Items:

1. **Establishment of regulatory mechanism to develop EV charging Infrastructure**-

   Several regulatory mechanisms can be put in place to develop EV charging infrastructure in the state of Punjab. Some possible approaches are mentioned below:

   - Incentives for private companies to install charging infrastructure: The government can provide incentives such as tax breaks or subsidies to private companies that install EV charging infrastructure in the state.
   - Public-private partnerships: The government can enter partnerships with private companies to develop and operate EV charging infrastructure. This can include agreements on revenue sharing, investment, and maintenance.
   - Zoning regulations: The government can zone certain areas of the city for EV charging infrastructure, such as near highways or in commercial areas, to ensure that the infrastructure is developed where it is most needed.

- Time-of-use pricing: The government can introduce time-of-use pricing for EV charging to encourage drivers to charge their vehicles during off-peak hours when electricity is cheaper.

By implementing some or all of these regulatory mechanisms, Punjab government can encourage the development of a robust EV charging infrastructure that will help to support the transition to electric vehicles in the state.

2. Pilot projects on Battery Swapping stations -

The Punjab EV Policy has proposed the establishment of battery swapping stations across the state. The state government aims to set up battery-swapping infrastructure at key locations such as public charging stations, commercial hubs, and along highways. The policy also proposes incentives for private players to set up battery-swapping infrastructure in the state. Establishing battery-swapping infrastructure is expected to increase the adoption of electric vehicles in the state by addressing range anxiety and reducing charging times.

The policy also includes the provisions for the development of charging infrastructure across the state. The policy aims to establish a network of charging stations in the state to support the growing number of electric vehicles. The policy also includes provisions for setting up charging stations at public places like malls, parking lots, and petrol pumps to ensure easy accessibility for EV owners. The state government is also incentivizing private entities to set up EV charging infrastructure by providing financial assistance and other incentives. Additionally, the policy encourages the development of renewable energy-based charging infrastructure to promote sustainable energy usage in the state.

To ensure a shorter period of return of investment (ROI), it is proposed that the EV chargers be installed in places with higher density of vehicles and commuting population such as public recreation places, malls and shopping complexes, public offices, Multi-Level Car Parking (MLCP), parking areas of bus stands, railway stations, metro stations and airports.

Battery swapping of the electric vehicle can have several significant impacts on the adoption and usage of electric vehicles. Here are some key points to consider:

- Convenience and Range Anxiety: Battery swapping addresses one of the main concerns associated with EVs, which is range anxiety. Instead of waiting for a vehicle to charge for several hours, users can swap their depleted battery with a fully charged one in a matter of minutes. This convenience eliminates the need for long charging stops during road trips, making EVs more comparable to traditional internal combustion engine vehicles in terms of refuelling time.
- Increased Utilization and Efficiency: Battery swapping can increase the utilization and efficiency of EVs. With a swapping infrastructure in place, batteries can be quickly exchanged, reducing the downtime of vehicles waiting to charge. This leads to higher availability and utilization rates for EVs, especially for fleet operators, ride-sharing services, and delivery companies, who can keep their vehicles on the road for longer periods.
- Reduced Battery Degradation Concerns: Battery swapping can help address concerns about battery degradation. The swapping infrastructure can ensure that vehicles receive batteries with optimal health and performance, as worn-out or degraded batteries can be removed from circulation. Moreover, swapping allows for standardized battery packs that can be maintained and optimized more effectively, potentially extending the overall lifespan of batteries.
- Lower Initial Vehicle Cost: Battery swapping can potentially reduce the initial cost of EVs. Instead of purchasing a vehicle with an expensive battery pack, users can opt for a cheaper EV with a smaller or leased battery and pay for battery swapping services as needed. This approach reduces the upfront investment required to own an EV and can make electric mobility more accessible to a wider range of consumers.

- Infrastructure and Standardization Challenges: Implementing battery swapping infrastructure on a large-scale pose challenge. It requires establishing a network of swapping stations and ensuring the compatibility and standardization of battery packs across different vehicle models and manufacturers. Coordinating and maintaining this infrastructure can be complex and costly, necessitating collaboration between automakers, battery manufacturers, and charging network operators.
- Limited Applicability: Battery swapping is most beneficial for high-utilization vehicles like taxis, ridesharing, and delivery fleets. The advantages may be less pronounced for personal vehicles that have lower mileage and more predictable charging patterns. For personal use, home and workplace charging options might be more convenient and cost-effective.
- Environmental Considerations: Battery swapping has both environmental benefits and challenges. On the positive side, it can enable the reuse of batteries that may no longer meet the requirements for vehicular use, extending their overall lifespan. However, battery swapping infrastructure requires additional resources and energy for battery transportation, storage, and maintenance, which can have environmental implications if not managed efficiently.

Other action items include awareness programs for energy conservation technologies in the transport sector, and the introduction of demonstration or pilot projects on alternative fuel vehicles. Pilot projects will build the readiness of the state in adapting to vehicles run by alternative fuels such as Hydrogen Fuel Cell Vehicles (HCV). The awareness programs and pilot projects include:

3. **Pilot projects on Hydrogen Fuel Cell Vehicles (HCVs):** Pilot projects on hydrogen fuel cell vehicles (HCVs) can be an effective way to explore the potential of this technology and to identify any barriers or challenges to its widespread adoption. The results of the pilot project should be shared with

stakeholders, including the public, to raise awareness of the potential of HCVs.

4. **BEE Star Labelling of Batteries:** The objective of the BEE star labelling program is to offer consumers the necessary information for making informed choices when purchasing energy-efficient appliances. By incorporating lithium-ion batteries into the S&L program, it will drive technological advancements that improve the energy efficiency of these batteries, which are increasingly vital for electrifying transportation. Moreover, this inclusion will foster trust among battery users by ensuring that the manufacturer's claims regarding battery performance are reliable, while also eliminating sub-par products from the Indian market. According to BEE, this initiative is projected to save approximately 333.7 GWh of energy by 2030.

6.3. Energy Saving Targets & Monitoring Mechanism

Based on the strategy proposed for the transport sector, the total energy saving estimated is 0.85 Mtoe in the moderate scenario and 1.18 Mtoe in ambitious scenarios. The potential savings under moderate and ambitious scenarios is the overall estimated savings achieved through the strategy under the respective scenarios and can be considered as the energy saving targets for FY 2031 for the Transport Sector.

Table 16: Energy Saving Targets & Monitoring Mechanism

Strategies	Energy Savings in 2031 under moderate scenario (Mtoe)	Energy Savings in 2031 under ambitious scenario (Mtoe)
Transition to electric vehicles	0.85	1.18
Total	**0.85**	**1.18**

Monitoring Mechanism:

The monitoring framework for achieving the target of the transport sector can be easily set up by defining annual reduction targets of the sector. Monitoring of points mentioned below through the dashboard will support in monitoring of energy efficiency initiatives in the state.

- Development of dashboard to monitor the sale of electric vehicles sold in a year categorized under 2-wheelers, 3-wheelers, 4-wheelers, buses, and heavy vehicles.
- The dashboard can also include city-wise mapping of EV charging infrastructure across the state.
- The dashboard may be scalable to include alternative fuel vehicles such as Hydrogen Fuel Cell Vehicles.

Mechanism for data collection and reporting from various clusters and various energy efficiency initiatives may be done through Setting up a Sector Specific Energy Efficiency Cell (SSEEC) and Cluster Level Energy Efficiency Cell (CLEEC).

Setting up a Sector Specific Energy Efficiency Cell (SSEEC)

- The working of this cell will be different from the operations of SDA, the SSEEC will be responsible to collect data from all the cluster energy efficiency cells in the state and share the same with the SDA for tracking the achievement of the targeted goal.

Cluster Level Energy Efficiency Cell (CLEEC)

- The CLEEC will be responsible for gathering information and will report the same to the SSEEC at the end of each quarter.

AGRICULTURE SECTOR

7. Agriculture Sector

7.1. Current Scenario

Agriculture forms the backbone of Punjab's economy contributing 28.68% share in GSVA, and 24.6% in state employment. The agriculture sector in Punjab continues to rise with courtesy of Green Revolution (1960-1970) and agriculture mechanization.[26]

The majority of industries in Punjab are agro-based, the growth in the agriculture sector, add to the raw material required for the industries. The transportation of these products adds to the service sector. Punjab is one of the finest Indian states in terms of Agriculture performance. The Agriculture in Punjab state is highly intensive in terms of land, capital, energy, nutrients, agriculture inputs and water etc. With only 1.5% of geographical area of the country, Punjab has produced about 22% of wheat, 10% of rice and 13% of cotton of the total produce of these crops in the country[27].

The scope of increase in area under agriculture has reached at a saturation level as 98.8 percent of cultivable land in the State is already under plough. Agriculture production can only be increased to some extent through enhanced cropping intensity, change in cropping pattern, use of high yielding varieties, following good cultivation practices and availability of better post-harvest technology etc. This ultimately demands appropriate mechanization in the State. The State Govt. is trying to re-orient agriculture through diversification policy and other measures. However, a paradigm shift in agricultural mechanization is required to realize the goal of eco-friendly sustainable agriculture with reduced cost of production and high quality of produce.

Ground water has been extracted by electric tube wells and diesel pump sets. Consequently, the number of electric tube wells has increased over the period.

[26] Statistical Abstract of Punjab 2019
[27] https://farmech.dac.gov.in/FarmerGuide/PB/index1.html.

The power sector exerts a critical influence on the performance of the agriculture sector as it affects farmer access to end use of electricity for a variety of irrigation operations, particularly pumping ground water for irrigation.

Table 17: Land use statistics of Punjab[28]

Classification	Area in Sq. Km
Geographical Area	50.33
Reporting area for Land use	50.33
Area under Forest	2442
Land not available for cultivation	5.43
Land put to non-agri. use	5.01
Barren & Uncultivable Land	0.42
Uncultivable Land Excluding Fallow Land	0.26
Cultivable Waste Land	0.12
Permanent pastures & Other Grazing Land	0.04
Land under Misc. Tree Crops	0.1
Fallow Land	0.89
Net area Sown	41.19
Area sown more than once	37.05
Total Cropped Area	78.24
Cropping Intensity %	190%

The total pump sets as per the data provided in Statistical Abstract of Punjab 2019 is provided in Table below:

Table 18: Equipment's in Punjab (Source: Statistical Abstract of Punjab)

S. No.	Particular	Unit	FY 2016-17	FY2017-18	FY2018-19
1	Tractors	Number	-	-	4,46,354
2	Diesel Sets	Number	1,65,000	1,40,000	1,40,000
3	Electric Sets	Number	12,25,340	12,29,531	12,68,252
Total			**13,90,340**	**13,69,531**	**18,54,606**

The main sources of electricity consumption in this sector are agricultural machinery/ equipment and pump sets in the state. Different forms of energy are used for different purposes. Direct energy consumption includes the use of diesel, electricity, propane, natural gas, and renewable fuels for activities on the farm. Indirect energy consumption includes the use of fuel and feedstock

[28] Source: Statistical Abstract of Punjab (page 3 onwards)

(especially natural gas) in the manufacturing of agricultural chemicals such as fertilizers and pesticides.

7.2. Energy Efficiency Strategies in the Agriculture Sector

This section presents the proposed strategy in the agriculture sector along with their impact in terms of energy saving potential. The following strategy is proposed as part of the State Energy Efficiency Action Plan:

Strategy #1 Transition of conventional diesel pumps to Solar powered pumps

Implementation period: Long Term (Till FY 2031)

The proposed strategy in the agriculture sector is to transition from conventional diesel pumps to solar-powered pumps. This strategy is in line with the country's target to replace diesel with renewable energy sources in the agricultural sector to achieve the goal of zero diesel use in the irrigation sector. This transition is necessary to reduce the sector's dependence on fossil fuels and move towards a more sustainable and environmentally friendly energy source.

The first scenario is the moderate scenario, which aims to transition 75% of diesel-powered pumps to solar pumps by 2031. This scenario aims to achieve a significant reduction in the energy consumption of pumps used in irrigation, leading to significant energy savings.

The second scenario is the ambitious scenario, which aims to transition 100% of diesel-powered pumps to solar pumps by 2031. This scenario is the ideal goal and aims to achieve maximum energy savings in the agriculture sector by completely eliminating the use of diesel-powered pumps. This scenario will not only lead to energy savings but will also contribute to reducing carbon emissions, improving air quality and environmental sustainability.

It is also essential to note that the transition to solar-powered pumps will reduce the operational and maintenance costs as solar pumps do not require regular fuel refilling and have fewer moving parts, resulting in less wear and tear. Moreover, the installation of solar pumps will also provide an additional source

of income for farmers, as they can sell excess electricity generated by the solar panels back to the grid.

In addition to the benefits mentioned above, the transition to solar-powered pumps will also lead to increased reliability and stability of power supply, as solar energy is available throughout the day and is not subject to disruptions in fuel supply.

Savings methodology for Transition of conventional diesel pumps to Solar powered pumps:

In order to calculate the energy savings from transition of conventional diesel pumps to solar powered pumps, the number of diesel pumps in the State of Punjab has been considered and sourced from the State Statistical Abstract[29].

There are 1,40,000 diesel pumps as of FY2020 in the state, out of which it is assumed that 25% share (i.e., 35,000 pumps) belongs to each category of 3 HP, 5HP, 7.5HP and 10HP. It is assumed that 75% of each pump category are operational i.e., 26,250 out of 35,000 pumps. Based on average fuel consumption per hour, savings are calculated.

Overall, the transition from conventional diesel pumps to solar-powered pumps will lead to a total savings of 0.032 Mtoe in moderate scenario and 0.043 Mtoe in ambitious scenario by FY 2031.

Table 19: Energy Savings Potential in Transition of conventional diesel pumps to Solar powered pumps by FY 2031

Particulars	Moderate Scenario Saving by FY 2031	Ambitious Scenario Saving by FY 2031
Energy Saving Potential (Mtoe)	0.032	0.043

Actionable items:

1. **Greater outreach to relevant stakeholders:** It is crucial to engage and inform all relevant stakeholders, including farmers, Panchayat officials, and

[29] Source: https://punjabassembly.nic.in/images/docs/Statistical%20Abstract.pdf (Page No. 168)

other key players in the agriculture sector, about the benefits of the PM KUSUM Yojana. This can be done through awareness campaigns, workshops, and meetings at the local level. This will help ensure that everyone is aware of the program and its benefits and can work together to implement it effectively.

2. **Capacity building of Panchayat/Block level officials:** It is important to provide training and capacity building programs to Panchayat and Block level officials to ensure effective implementation of the program. This can include training on the technical aspects as well as on the administrative aspects of the program. This will enable officials to provide the necessary support and guidance to farmers and other stakeholders in their respective areas and ensure the successful implementation of the program.
3. **Budget allocation for providing subsidies under the PM KUSUM Scheme:** Increased budget allocation for subsidies under the PM KUSUM Scheme is essential to accelerate the adoption of renewable energy and energy efficient equipment. This will enable farmers to invest in solar pumps, which are a more viable option than traditional diesel pumps. By increasing the subsidy pool, we can empower farmers to make the switch to solar energy.

Strategy#2 Replacement of transmission lines supplying electricity for irrigation systems in rural areas

Transmission and distribution losses are very high in the rural areas. In pursuit of a more energy-efficient agriculture sector, it is essential to outline a strategy for the replacement of transmission lines supplying electricity to irrigation systems in rural areas. This strategy will enhance energy efficiency within the agriculture sector, focusing on optimizing the delivery of electricity to rural farming communities.

Actionable items:

1. **Conduct a Comprehensive Study for Losses in Transmission Lines in Rural Areas:** Initiating a comprehensive study of existing transmission lines and irrigation systems feeders in rural areas can help in identifying inefficiencies and areas of improvement. Additionally, collaborate with local

agricultural communities and utility companies to gather data on energy consumption patterns and peak demand periods.

2. **Prioritize Transmission Line Replacement:** Developing a prioritization framework based on the age, condition, and energy loss of existing transmission lines. Initial replacement efforts should focus on areas with the highest energy losses and where outdated infrastructure poses the greatest risk.
3. **Expand Renewable Energy Integration:** Explore the integration of renewable energy sources to power irrigation systems in rural areas. Evaluate the feasibility of installing small-scale renewable energy systems in proximity to agricultural facilities.
4. **Smart Grid Integration:** Invest in smart grid technologies that enable real-time monitoring and control of electricity distribution to agricultural sites. Implement demand response programs to shift energy-intensive irrigation activities to off-peak hours.
5. **Monitoring and Evaluation:** Establish a monitoring system to track energy consumption, transmission line replacement progress, and the impact on energy efficiency in the agriculture sector. Regularly assess the effectiveness of the strategy and make necessary adjustments based on data and feedback.

Strategy #3 Replacement of inefficient pumps (non-star rated) with BEE 5-Star rated electric pumps along with smart control panel

Implementation period: Long-term (Till FY2031)

Initiatives have been taken at both the Central and State levels for switching from diesel pumps to electric pumps. In addition to these initiatives, conversion of inefficient electric powered pumps with BEE 5 Star rated pumps is one strategy that can be assessed.

The first scenario is the moderate scenario, which aims to replace 50% of the inefficient electric powered pumps with BEE 5 Star rated pumps by FY2031. This scenario aims to achieve significant energy savings and improve the efficiency of pumps used in irrigation.

BEE Star rated pumps are designed to consume less energy and operate efficiently, resulting in cost savings for farmers in terms of lower electricity bills and reduced maintenance costs. A provision should be established to use BEE Star rated pumps for borewells.

The second scenario is the ambitious scenario, which aims to replace 70% of the inefficient electric-powered pumps with BEE Star rated pumps by FY2031. This scenario is the ideal goal and aims to achieve maximum energy savings in the agriculture sector by replacing the majority of inefficient pumps with energy-efficient ones.

Overall, this strategy will lead to a total saving of 0.0317 Mtoe in moderate scenario and 0.044 Mtoe in ambitious scenario.

Table 20: Energy Savings Potential in Transition of Replacement of inefficient pumps (non-star rated) with BEE 5-Star rated electric pumps

Particulars	Energy Savings in 2031 under moderate scenario (Mtoe)	Energy Savings in 2031 under ambitious scenario (Mtoe)
Energy Saving Potential (Mtoe)	**0.0317**	**0.044**

7.3. Energy Saving Targets & Monitoring Mechanism

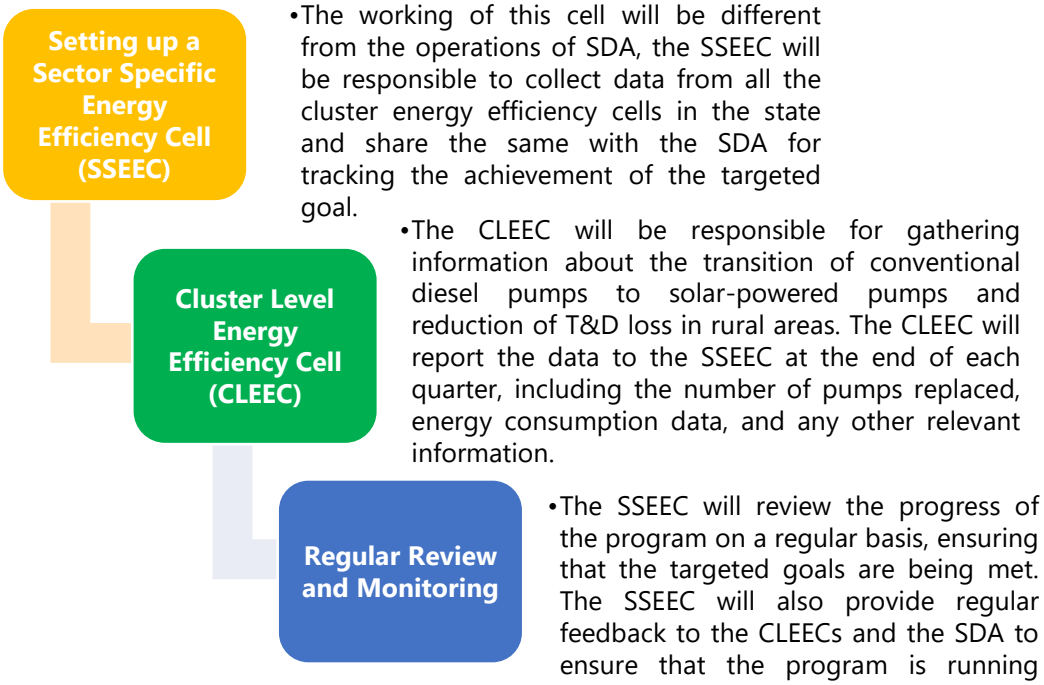
On the basis of the strategy proposed for the agriculture sector, the total energy saving estimated is 0.032 Mtoe in the moderate scenario and 0.043 Mtoe in ambitious scenarios. The potential savings under moderate and ambitious scenarios are the overall estimated savings from the strategy under the respective scenarios and can be considered as the energy saving targets for FY 2031 for the Agriculture Sector.

Table 21: Energy Savings from Agriculture Sector

Strategies	Energy Savings in 2031 under moderate scenario (Mtoe)	Energy Savings in 2031 under ambitious scenario (Mtoe)
Transition of conventional diesel pumps to Solar powered pumps	0.032	0.043
Replacement of inefficient pumps (non-star rated) with BEE 5-Star rated electric pumps along with smart control panel	0.0317	0.044
Energy Saving Potential (Mtoe)	**0.064**	**0.087**
Emission Reduction Potential ($MtCO_2$)	**0.200**	**0.273**

Monitoring Mechanism:

The monitoring framework for achieving the target of the agriculture sector can be easily set up by defining annual reduction targets of the sector.



8. Other Strategies

Budget allocation for Research and Development (R&D) and Research Institute on Energy Efficiency by Centre/State:

In order to facilitate collaborations between research institutions, industries, and local stakeholders in Punjab, budgetary resources are required from the Centre/State Government. This will accelerate the development and implementation of energy-efficient solutions.

The allocation of a significant share of the state budget to bolster R&D efforts in energy efficiency is essential to establishing a state-of-the-art Research Institute on Energy Efficiency. The institute's primary objective shall be to conduct cutting-edge research, support capacity building, and provide policy recommendations to enhance energy efficiency across the state. These actions are crucial to fulfilling Punjab's sustainability goals and promoting cleaner energy practices.

Punjab Energy Development Agency (PEDA) in collaboration with the research facilities and technical institutes can run the R&D programs for new and effective energy efficiency technologies. After the successful demonstration of the developed technologies, PEDA can implement those technologies at ground level with the support of various stakeholders.

Actionable Items:

1. **Need for Assessment:** A comprehensive assessment to determine the specific research and development needs in the field of energy efficiency. Identifying gaps, challenges and opportunities that can be addressed through R&D.
2. **Stakeholder Involvement and Strategic Planning:** Engagement of researchers, experts, industrial representatives, and relevant stakeholders to provide input on budget priorities and objectives. Develop a strategic plan outlining the goals and objectives of the R&D program and the research institute on energy efficiency.

3. **Budget Allocation:** Multi-year funding commitments to ensure the stability and continuity of R&D efforts. These budgets should be based on the identified needs and priorities.
4. **Monitoring and Evaluation:** Implementation of a robust monitoring and evaluation framework to track the progress, impact, and the outcomes of R&D initiatives. Use of performance metrics to ensure that allocated budgets are effectively utilized.

Replacement of inefficient sewerage and water pumps installed before the year 2008 with BEE 5-star rated pumps under all municipal corporations and rural areas of the state:

The strategy involves replacing inefficient sewerage and water pumps with more energy-efficient pumps, specifically the BEE 5-star rated pumps, in all municipal corporations and rural areas in Punjab. The pumps which were installed before the year 2008 may be considered in phased manner. In addition, all the new pumps to be installed must be BEE 5-star rated or maximum available star rating with respect to capacity of pump. By adopting these pumps, Punjab seeks to optimize energy consumption, reduce wastage, and minimize operational costs.

Actionable Items:

1. **Initial Assessment and Energy Audit:** A comprehensive assessment of the existing sewerage and water pump systems in all municipal corporations to identify inefficient pumps. Conduct energy audits to determine the potential energy savings by switching to BEE 5-Star rated pumps. Calculate the payback period and return on investment for the proposed upgrades.
2. **Funding and Budgeting:** Developing a detailed budget that covers the purchase of new pumps, installation costs, and any required infrastructure upgrades. Funding can be secured from the government grants, public-private partnerships, or municipal budgets.
3. **Training and Capacity Building:** Training of the municipal staff responsible for pump operations and maintenance on the proper use and

care of the new pumps. Establishing a maintenance schedule and procedures to optimize pump performance.

4. **Awareness Campaign:** Conducting awareness workshop and campaigns to inform residents and stakeholders about the energy efficiency upgrades and the benefits. Encourage water conservation practices among residents.
5. **Monitoring and Measurement:** Implementing a system for continuous monitoring of energy consumption and pump performance to track the energy savings and identify any issues promptly.

Development of Energy Efficiency Curriculum for School, Universities, ITI Colleges and other technical institutes:

The development of an energy efficiency curriculum for schools, universities, ITI colleges, and other technical institutes is an important step in promoting energy conservation in Punjab. The Department of Education, Punjab and Punjab Energy Development Agency (PEDA) can develop the curriculum to cover various topics on the basics of energy, the environmental impacts of energy use, the principles of energy efficiency, the benefits of energy efficiency, and the latest technologies for energy efficiency etc. The curriculum should be designed to be age-appropriate and engaging for students of all levels. It should also be relevant to the local context, so that students can learn about the specific energy challenges and opportunities.

By educating students about the importance of energy conservation, they can make informed choices about their energy use and help the state reduce its energy consumption.

Actionable Items:

1. **Need of Assessment:** To understand the specific needs and expectations regarding the need of energy efficiency education, there is a need to conduct surveys and interviews with educators, students, and industry professionals.

2. **Curriculum and Content Development:** The curriculum should be divided into modules that are progressively built upon each other. The content in these modules should include lectures, practical exercises, case studies, and assessment. These modules should be aligned with relevant educational standards and guidelines.
3. **Awareness and Training Programs:** Organize workshops, seminars and outreach programs to promote energy efficiency education within the community. Provide training and resources for educators to effectively teach the curriculum and keep them updated on the latest developments in energy efficiency.

Replacement of old and inefficient transformers with energy-efficient ones:

The strategy aims for the replacement of old and inefficient transformers with energy-efficient transformers across various sectors which includes Industries, Commercial and Domestic Buildings, Transport, Agriculture, Distribution Companies, Power Generation Plants etc. This strategy would be beneficial for reducing energy consumption, minimizing greenhouse gas emissions, and helping in reducing T&D losses. It would be a great initiative in strengthening the resilience of electrical distribution systems and in supporting the sustainable goals.

Actionable Items:

1. **Carrying out audits:** Carrying out assessment of the existing transformers to determine their conditions, efficiency and load capacity. Energy audit should be carried out of these existing transformers situated at hotels, commercial buildings, industries and utilities to determine the energy saving potential by calculating the energy losses in the current transformers.

2. **Cost – Benefit Analysis:** A detailed analysis should be carried out to determine the financial feasibility of the transformer replacement project. The cost of the energy efficient transformers, energy savings and payback period should be considered. The provisions providing soft loans, tax

rebates and subsidies should be offered to private consumers for promoting and motivating them to implement such schemes.

3. **Installation of energy efficient transformers:** The energy efficient transformers can be purchased from reputable and empaneled manufacturing companies. The transformers installation should be carried out by qualified professionals to ensure proper wiring, grounding, and safety compliance.

4. **Maintenance and Monitoring:** There should be a proper regular maintenance schedule for the new transformers to ensure their long-term efficiency and reliability. Implementation of monitoring systems to track the performance and energy consumption of the transformers.

9. Market Potential in Focus Sector

The energy saved as a result of the proposed strategies in all sectors will lead to avoided generation of equivalent amount. In order to implement the suggested strategies, there will be a need for investments in energy efficiency projects, development of new policies, and modification of existing policies. In order to estimate the investment potential generated from the suggested strategies in the focus sectors, the equivalent cost of the saved energy in terms of metric tonnes of oil equivalent has been calculated. The Ministry of Power, Government of India, in consultation with the Bureau of Energy Efficiency (BEE) has notified the price of per metric tonne of oil equivalent as INR 18,402 only for the year 2018-19. The same amount has been applied to energy savings under ambitious scenarios for the estimation of maximum investment potential. Total energy saving potential by implementing various strategies in the State of Punjab is shown in the graph below:

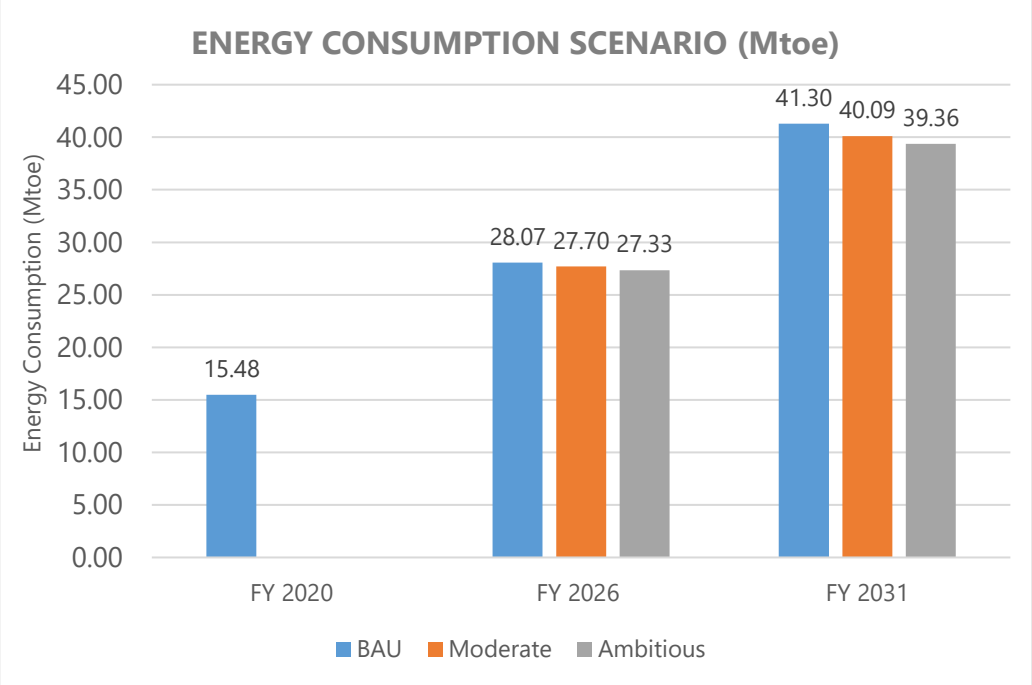


Figure 15: Energy Consumption Scenario (Mtoe)

It is estimated that with the implementation of various proposed strategies of Industries, Transport, Building and Agriculture sector, the energy saving of 1.207 Mtoe in moderate scenario and 1.940 Mtoe in ambitious scenario can be achieved. In the moderate scenario 2.92% energy saving and in ambitious scenario 4.70% can be achieved by FY2031.

Table 22: Energy Savings Summary and Investment Potential

Sector	Energy Consumption Reduction (Mtoe) - FY2031		Energy Consumption Reduction (MU) - FY2031		Emissions Reduction ($MtCO_2$) - FY2031		Market Potential (INR Crore)
	Moderate	Ambitious	Moderate	Ambitious	Moderate	Ambitious	
	Mtoe	Mtoe	MU	MU	$MtCO_2e$	$MtCO_2e$	
Industry	0.219	0.576	2,546	6,696	0.685	1.802	1,060
Buildings	0.076	0.100	884	1,160	0.238	0.312	184
Transport	0.85	1.18	9,868	13,684	2.66	3.68	2,165
Agriculture	0.064	0.087	743	1,016	0.200	0.273	161
Total	**1.207**	**1.940**	**14,041**	**22,557**	**3.779**	**6.071**	**3,569**

Energy Savings Summary (Year-Wise)

	2024		2025		2026		2027		2028		2029		2030	
	Mod	Amb	Mod	Amb	Mod	Amb	Mod	Amb	Mod	Amb	Mod	Amb	Mod	Amb
	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe
Industry														
Deeping and Widening of Perform, Achieve and Trade Scheme	0.0698	0.1831	0.0726	0.1904	0.0761	0.1995	0.0788	0.2061	0.0821	0.2146	0.0857	0.2236	0.1020	0.2651
Energy efficiency in MSME clusters	0.0843	0.2241	0.0890	0.2365	0.0939	0.2496	0.0991	0.2635	0.1047	0.2783	0.1106	0.2940	0.1169	0.3107
Buildings														
Effective Implementation of ECSBC	0.0004	0.0006	0.0007	0.0009	0.0009	0.0012	0.0012	0.0015	0.0014	0.0018	0.0017	0.0021	0.0025	0.0033
Replacement program for inefficient appliances	0.0250	0.0333	0.0257	0.0342	0.0264	0.0352	0.0434	0.0570	0.0446	0.0586	0.0459	0.0602	0.0727	0.0954
BEE Star Rating and Shunya Rating of Buildings	0.0001	0.0002	0.0002	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0007	0.0006	0.0010	0.0007	0.0010
Transport														
EV Transition and Charging Infrastructure	0.0648	0.0859	0.0995	0.1329	0.1527	0.2056	0.2345	0.3180	0.3600	0.4918	0.5527	0.7607	0.8485	1.1767
Agriculture														
Transition of conventional diesel pumps to Solar powered pumps	0.0062	0.0152	0.0082	0.0181	0.0107	0.0215	0.0141	0.0256	0.0186	0.0304	0.0245	0.0361	0.0322	0.0430
Replacement of inefficient electric powered pumps with BEE Star rated pumps	0.0052	0.0124	0.0070	0.0154	0.0095	0.0190	0.0128	0.0235	0.0173	0.0290	0.0234	0.0359	0.0317	0.0443
	0.256	**0.555**	**0.303**	**0.629**	**0.371**	**0.732**	**0.484**	**0.896**	**0.629**	**1.105**	**0.845**	**1.414**	**1.207**	**1.940**

10. Potential Fiscal Instruments and Incentives for implementing Energy Efficiency Projects

This section provides an overview of the market and fiscal instruments[30] available in India for mainstreaming energy efficiency in various sectors, as mentioned below:

S.No.	Type of Fiscal Instruments	Brief Description
1.	Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) Suitable Sectors: Building and Industry	**About:** It's a finical instrument, notified by MoP in May 2016, where the financial institutions (FIs) such as banks and Non-Banking Financial Company (NBFC) are provided with partial risk coverage associated with extending loan for the energy efficiency related projects. It has been estimated that this fund will mobilize investment of more than Rs 800 crores in the nation. Thus, would acts as a catalyst in mainstreaming energy efficiency in various energy intensive sectors in India. **Fund guaranteed:** It guarantees 50% of loan amount or Rs.10 crores per project, whichever is less.
2.	Partial Risk Sharing Facility (PRSF)	**About:** As the name suggest, this financial instrument, supported by BEE and established by Clean Technology Fund and Global Environment Fund, provides partial credit guarantee to Participating Financial Institutions (PFIs) to cover their risk associated with

[30] BEE, Ministry of Power, "Unlocking National Energy Efficiency Potential (UNNATEE)", 2019, https://beeindia.gov.in/sites/default/files/UNNATEE%20Final%20Report.pdf.
BEE, Ministry of Power, "Roadmap of Sustainable and Holistic Approach to National Energy Efficiency",2019, https://beeindia.gov.in/sites/default/files/Roshanee_print%20version%282%29.pdf
Organization for Economic Co-operation and Development, "Clean Energy Finance and Investment Roadmap of India", 2022, https://www.oecd.org/environment/cc/policy-highlights-clean-energy-finance-and-investment-roadmap-of-india.pdf

	Suitable Sectors: Building and Industry	extending loans for energy efficiency related projects. The energy efficiency projects should have been implemented via Energy Service Companies (ESCOs) post entering an Energy Saving Performance Contract (ESPC). **Fund guaranteed:** It guarantees 75% of the loan amount or Rs 15 crore, whichever is minimum.
3.	Venture Capital Fund for Energy Efficiency (VCFEE) Suitable Sectors: Building	**About:** As the name suggests, this financial instrument was established by the BEE, provides access to funds in the form of equity for the last mile financial support for the projects related to energy efficiency. This has been established under the Framework for Energy Efficient Economic Development of NMEEE. As of now, this has been leveraged only by government buildings, private buildings (commercial or multistory residential buildings) and municipalities. **Fund guaranteed:** It provides a maximum of 15% of total equity required, through Special Purpose Vehicles or Rs. 2 crores, whichever is less.
4.	Energy Efficiency Financing Facility (EEFF) Suitable Sectors: Industry	This financing initiative has been established by BEE specifically for the financing requirement of large-scale industries, project aggregation approach covering ESCO projects, MSME clusters, etc. This facility will be anchored by a Public Financial Institution. The facility will also follow a project aggregation approach across industries or clusters or technologies, for ensuring the inclusion of the small sized projects.
5.	Framework for Energy Efficiency Financing Suitable Sectors: Building, Industry, Agriculture, and Transport	This unique platform offers interaction between FIs and project developers to foster the implementation of energy efficiency projects.
6.	Energy-saving certificates (ESCerts)	On over achievement of set energy savings target, the designated consumers receive ESCerts. These ESCerts can be then traded and

	Suitable Sectors: Building and Industry	sold to the designated consumers who have under-performed i.e., who were not able to achieve their energy saving targets.
7.	On-bill financing (OBF) Suitable Sectors: Building	As the name suggest, in this type of financing mechanism, being done in partnership with a utility company, the consumer pays back based on the monthly utility bill generated.
8.	Capital subsidy (CS) Suitable Sectors: Building, Industry Sector, Agriculture and Transport	As the name suggest, in this financial instrument capital subsidy is granted by the state government towards the energy efficiency related projects/investments, to cover capital expenses incurred for during incorporating the energy efficiency improvement mechanisms.
9.	Revolving loan fund (RLF) Suitable Sectors: Building, and Industry	This financial instrument aids in increasing the availability of funds in the market which in turn would fast-track mainstreaming of energy efficiency in the select sectors. The borrower can take loan in line with standard prudent lending practices which allows the money to be returned to the RLF for make additional loans, on the loan repayment being done by the borrower.
10.	Accelerated Depreciation based incentivization (ADI) Suitable Sectors: Industry	In this instrument, the project developers get the opportunity to take the advantage of the higher depreciation during the initial years, which acts as a catalyst for incentivizing industries to implement energy efficiency schemes.
11.	Loan loss recovery/partial risk guarantee fund (PRGF) Suitable Sectors: Industry	As the name suggest, this financial instrument provides a partial guarantee over the associated risk, a pre-specified percentage of loan loss is covered.
12.	Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE) Suitable Sectors: Industry	This market instrument established by MoMSME, SIDBI, provides collateral-free credit guarantee of up to 85% on loans up to INR 200 lakh, to micro and small enterprises.

13.	Promoting market transformation for energy efficiency in MSMEs Suitable Sectors: Industry	This initiative, established by GEF, EESL, UNIDO, BEE, MoMSME, SIDBI act as a catalyst in increasing the availability of funds for MSMEs by setting up revolving fund mechanism, which would also ensure replicability of the project.
14.	SIDBI Venture Capital Limited (SVCL) Suitable Sectors: Agriculture and Industry	Under this funding mechanism, an investment management company under SIDBI extends equity capital to early-stage SMEs and start-ups for select sectors namely in manufacturing, agricultural and service.
15.	Other Central government financing schemes by government Suitable Sectors: Industry	• Production Linked Incentivization (PLI) scheme by Department for Promotion of Industry and Internal Trade. • Technology Upgradation Fund Scheme (TUFS) by Ministry of Textiles. • Integrated Development of Leather Sector (IDLS) by Ministry of Industries & Commerce. • Credit Linked Capital Subsidy Scheme for Technology Upgradation (CLCSS) by Ministry of MSME. • Technology & Quality Upgradation Support for MSMEs (TEQUP) by Ministry of MSME.

In addition to the mentioned list of financing mechanisms for mainstreaming energy efficiency, a few globally used financing Mechanisms could also be adopted in India namely Carbon finance (CF), Energy-savings insurance (ESI), Energy improvement mortgage (EIM), Securitization of loans for energy-efficient appliances (SLEE), Revenue decoupling models for DSM (RD), Energy conservation bonds (ECB), Interest rate buys down fund (IRBDF), Property assessed clean energy (PACE), Cross-border technology transfer and energy-efficiency financing facility (CBTT), Green receivables fund (GRF), Peer-to-peer lending (PPL), Operation lease/vendor financing (OL), Stranded project financing facility (SPFF), etc.

11. Way forward

The state energy efficiency action plan, through the research and interaction with various stakeholders, identifies the need, opportunity, and the potential of energy efficiency in the State of Punjab. While addressing the key focus sectors –Buildings, Industry, Transport and Agriculture, the action plan envisages to analyze consumption pattern, growth rates in alignment with GDP growth rate of the state and potential strategies for achieving savings.

The action plan lays out a plan for the state to implement the strategies, while at the same time being able to monitor implementation. It is imperative that implementation is carried out in the state through various stakeholders.

A market-based mechanism is anticipated to be developed through the implementation of the action plan which drives energy efficiency through better availability of energy efficiency products, financial instruments for improving the product reach and a wider adoption of energy efficiency schemes and policies curated by both state and central governments.

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13. Appendix

Appendix A: TFEC Projection

Years	GSDP (INR Lakh Crore)	TFEC (MTOE)	Energy Intensity (MTOE/INR Lakh Crore)	Average Historical Intensity (MTOE/INR Lakh Crore)
FY 2015	3.55	15.60	4.39	3.29
FY 2016	3.90	12.93	3.32	
FY 2017	4.27	13.50	3.16	
FY 2018	4.71	14.27	3.03	
FY 2019	5.13	15.09	2.94	
FY 2020	5.37	15.48	2.88	
FY 2021	5.33	17.51	➔ GSDP x Average Historical Intensity	
FY 2022	5.84	19.20		
FY 2023	6.77	22.26		
FY 2024	7.31	24.05		
FY 2025	7.90	25.98		
FY 2026	8.54	28.07		
FY 2027	9.22	30.32		
FY 2028	9.96	32.76		
FY 2029	10.76	35.39		
FY 2030	11.63	38.23		
FY 2031	12.56	41.30		
The YoY average of GSDP from FY2015-20 is 8%. The growth rate of GSDP as per Punjab Economic Survey 2021-22 is 6.80%. Taking into account 80% weightage of YoY average (8%) and 20% of growth rate of GSDP (6.6%), an average CAGR of 8% is obtained.				
GSDP FY2023-31 forecasted with a CAGR of 8% from FY2020.				
TFEC FY2021-31 forecasted using GSDP x Average Historical Intensity				

Appendix B: Electricity Consumption Forecast – Buildings

Electricity Consumption - Commercial Buildings			
Particulars	Electricity Consumption - Commercial (MTOE)	Electricity Consumption - Commercial (GWh)	Incremental Electrical Consumption (GWh)
FY 2015	0.28	3,266.00	
FY 2016	0.30	3,518.24	252.24
FY 2017	0.33	3,801.94	283.70
FY 2018	0.35	4,028.39	226.45
FY 2019	0.37	4,351.47	323.08
FY 2020	0.32	3,713.89	-637.58

Electricity Consumption - Commercial Buildings			
Particulars	Electricity Consumption - Commercial (MTOE)	Electricity Consumption - Commercial (GWh)	Incremental Electrical Consumption (GWh)
FY 2021	0.33	3,794.30	80.41
FY 2022	0.33	3,876.44	82.15
FY 2023	0.34	3,960.37	83.93
FY 2024	0.35	4,046.11	85.74
FY 2025	0.36	4,133.71	87.60
FY 2026	0.36	4,223.20	89.49
FY 2027	0.37	4,314.63	91.43
FY 2028	0.38	4,408.05	93.41
FY 2029	0.39	4,503.48	95.43
FY 2030	0.40	4,600.98	97.50
FY 2031	0.40	4,700.59	99.61
The electricity consumption has been forecasted for FY2021 to FY2031 using the CAGR of 2.17% obtained from FY2015 to FY2020			

Electricity Consumption – Domestic Buildings			
Particulars	Electricity Consumption - Domestic (MTOE)	Electricity Consumption - Domestic (GWh)	Incremental Electrical Consumption (GWh)
FY 2015	0.99	11,483	
FY 2016	1.04	12,108.24	625
FY 2017	1.12	13,080.39	972
FY 2018	1.19	13,796.31	716
FY 2019	1.27	14,816.97	1,021
FY 2020	1.16	13,546.20	-1,271
FY 2021	1.20	13,924.44	378
FY 2022	1.23	14,313.25	389
FY 2023	1.27	14,712.91	400
FY 2024	1.30	15,123.73	411
FY 2025	1.34	15,546.02	422
FY 2026	1.37	15,980.10	434
FY 2027	1.41	16,426.31	446
FY 2028	1.45	16,884.97	459
FY 2029	1.49	17,356.44	471
FY 2030	1.53	17,841.07	485
FY 2031	1.58	18,339.24	498
The electricity consumption has been forecasted for FY2021 to FY2031 using the CAGR of 2.79% obtained from FY2015 to FY2020			

Electricity Consumption - Commercial + Domestic Buildings			
Particulars	Electricity Consumption - Buildings (MTOE)	Electricity Consumption – Buildings GWh)	Incremental Electrical Consumption (GWh)
FY 2015	1.27	14,749.00	
FY 2016	1.34	15,626.48	877.48
FY 2017	1.45	16,882.33	1,255.85
FY 2018	1.53	17,824.70	942.37
FY 2019	1.65	19,168.44	1,343.74
FY 2020	1.48	17,260.09	-1,908.35
FY 2021	1.52	17,718.74	458.65
FY 2022	1.56	18,189.69	470.95
FY 2023	1.61	18,673.28	483.59
FY 2024	1.65	19,169.84	496.56
FY 2025	1.69	19,679.73	509.89
FY 2026	1.74	20,203.31	523.58
FY 2027	1.78	20,740.94	537.64
FY 2028	1.83	21,293.02	552.07
FY 2029	1.88	21,859.92	566.90
FY 2030	1.93	22,442.06	582.13
FY 2031	1.98	23,039.83	597.78

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