Punjab State Energy Action Plan (Executive Summary)

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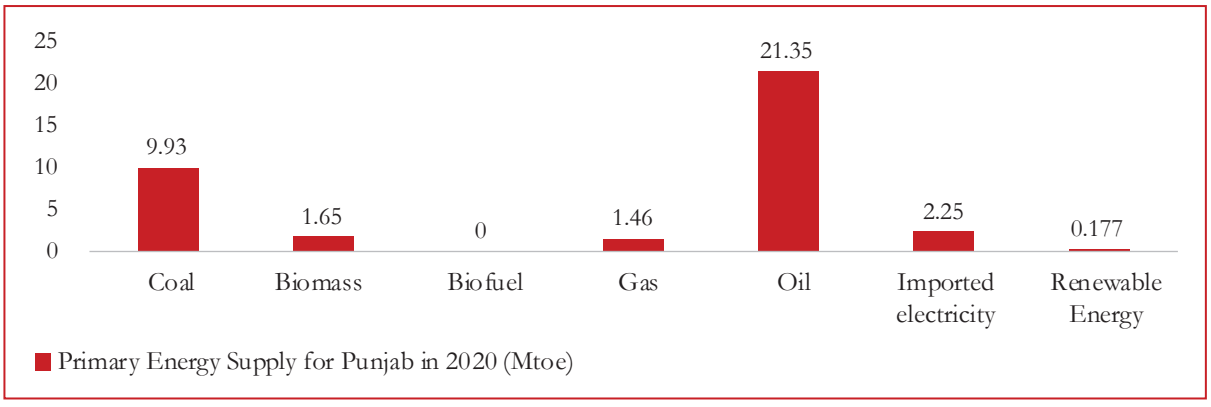
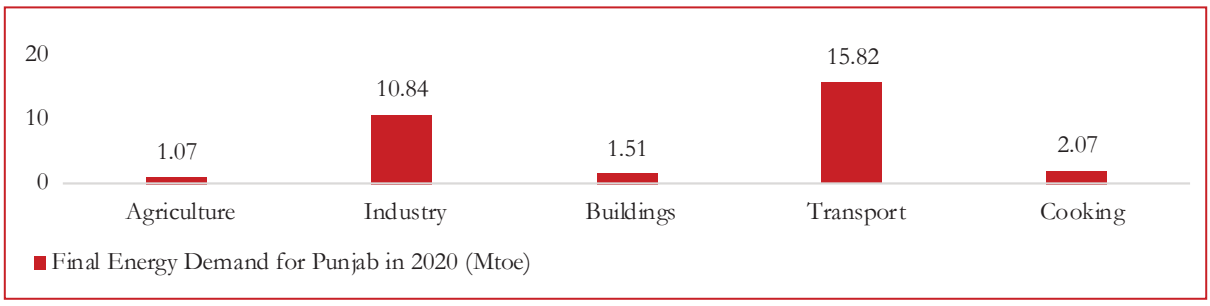
Executive Summary

The changes made in either energy supply or demand has a corresponding implication on the energy scenario and on the socio-economic and environmental aspects of one or more sectors. Hence, it implies that energy planning requires involvement across sectors and departments and a paradigm shift from the conventional approach towards integrated approach to ensure sustainable growth of the state in the coming years. In this context of energy planning, PEDA (under Department of Power), Government of Punjab and IGEN Access-II Program of GIZ India has undertaken this initiative to develop State Energy Plan followed by State Energy Action Plan (EAP) for the state of Punjab. Therefore, this report presents an energy action plan (EAP) for the state of Punjab, which stems from the results of modelling exercise carried out for the state. The fundamental objective of energy planning has been to link the energy sector to economy, society and environment through a causal chain relationship. The EAP has been designed to assist the state to take a cleaner and greener trajectory to bring GHG emission reduction and climate related benefits, while achieving other development goals. Through the EAP, the aim has also been to define/develop enabling policy measures, programme priorities as well as associated investment plans, while recommending necessary short, medium and long-term action plans that can be taken up by the state.

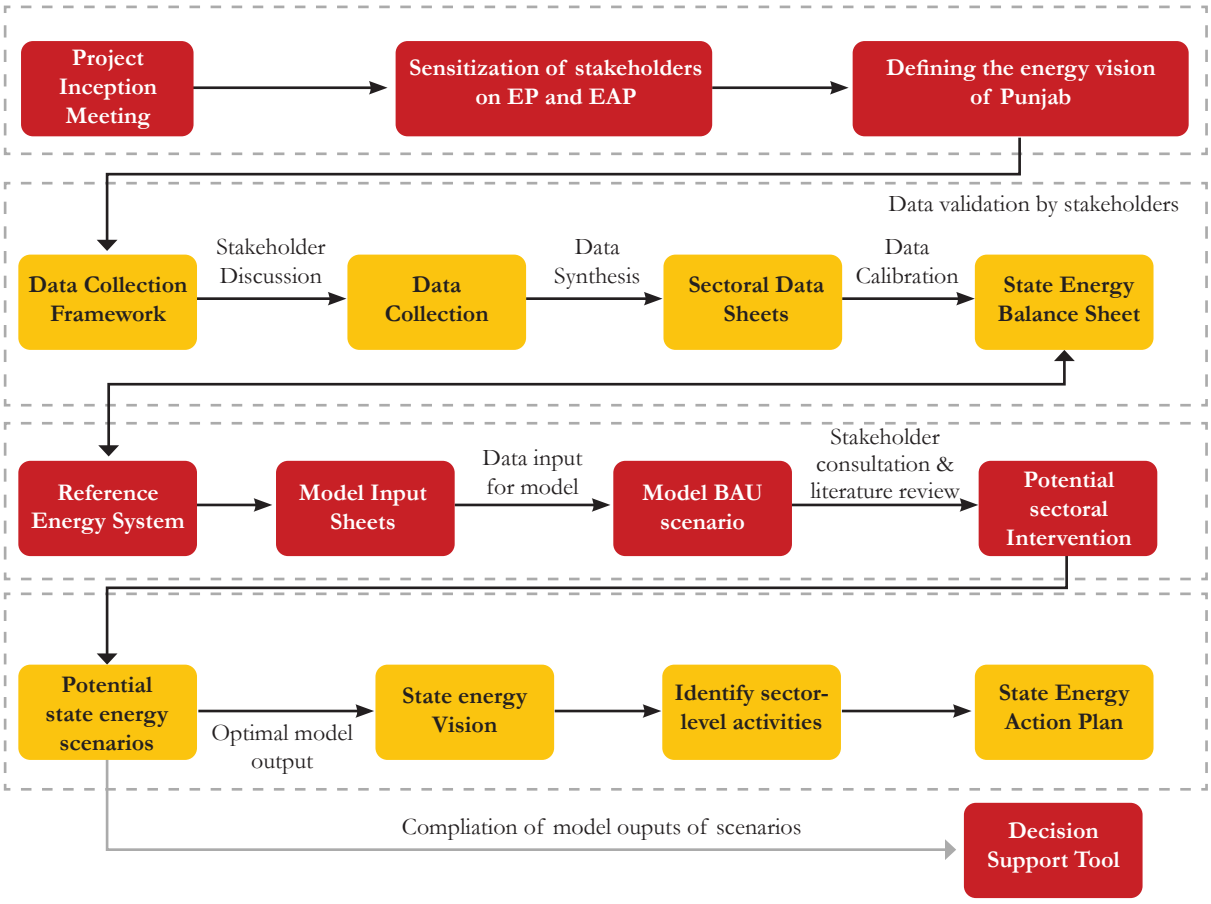
Firstly, an overview of the economic and energy profiles of the state of Punjab is presented. Punjab is one of the largest economies in India with INR 5.42 trillion (USD 74.61 billion) in FY2020-21 in gross state domestic product (GSDP) and a per capita GSDP of INR 172,340 (USD 2,374.16). Overall, the state's GSDP has increased at a CAGR of 6.78% and the per capita GSDP has increased at a CAGR of 5.40% between 2015-16 to 2020-21 (IBEF 2021). In terms of the state electricity profile, the total installed capacity of Punjab for FY19-20 was 14,079 MW. This includes central share of 4,385 MW. Further, the main source of electricity generation in the State is from thermal power plants (5,680 MW), Hydro (1,160 MW) and renewable energy sources (1,722 MW). In terms of primary energy supply, in 2020, the share of coal stood at 26.5%, gas at 3.87%, oil at 56.45%, and less than 1% coming from renewable energy.



On the demand side, the final energy demand for Punjab in 2020 stood at 31.8 Mtoe. In terms of sectoral energy use, transport is the highest at 49.7% followed by industry (34.04%) and buildings (4.7%) in 2020.



Next, detailed approach and methodology for developing the EAP for the state is explained. In order to prepare the Energy Action Plan for Punjab a series of activities have been performed which have been divided in to three activity groups viz. data collection and database preparation, data analysis and ultimately, development of the Action Plan as shown below:



Building on this logical sequence, the next chapter briefly describes the results of the baseline scenario, primarily, the primary energy supply, electricity generation mix, capacity mix, final energy use by demand sectors and GHG emission profile of the state. The baseline assumptions are based on the understanding that energy supply, energy demand and related assumptions follow historic trends which may or may not meet the targets for the renewable energy and energy efficiency development set by the state in the State Vision Document 2030, NRSE Policy of Punjab and SDG targets. Detailed analysis of the baseline scenario has been presented in the "Baseline Assessment Report for Punjab".

This twin effect of population growth coupled with a healthy economic growth is expected to increase energy consumption by 4% between 2020 and 2040 under the business-as-usual (BAU) scenario. Moreover, a combined effect of continuing the BAU scenario coupled with a change in market dynamics of the energy sector is expected to lead to the following implications that can potentially impact the growth path that the State is envisaging:

Positive Factors	Pessimistic Factors
Increased penetration of EVs: Transformation from traditional oil driven vehicles to electric vehicles (EVs) in transport sector, provides a potential of reducing the dependence on oil.	**Increase in emissions due to increased dependency on fossil fuel:** Carbon Emissions of the state is expected to increase from 100.3 Million Tonnes of CO2 in 2020 to 211.6 Million Tonnes of CO2 in 2040.
Renewable Energy and Energy Efficiency as a focus in near future: cutting down on wasteful power consumption in demand sectors by adopting energy efficiency measures can reduce power requirement and, in addition, shifting to renewable energy, can lead to reduced emission.	**Coal is and remains a major source of energy with inefficiencies in conversion process:** While the expected share of coal in the state's primary energy supply in 2040 stands at 20.9%, the share decreases in the final energy level thereby indicating inefficiencies in energy conversion processes and providing scope for further decreasing emissions.
Optimal utilization of existing power generation units: By increasing PLF, proportion of auxiliary consumption would reduce, and expenditure of new power generation assets can be avoided, which can have a positive effect on the power generation costs.	**Poor financial health of DISCOM:** optimal utilization of power generating assets and reduction in T&D loss coupled with increased electricity demand through EVs can potentially reduce power costs as well as increase power sales for DISCOM.
National focus on solar power: Even though the state has a potential of 7.5 GW of solar power generation capacity (through conventional solar technologies)[1], it is estimated to have 4.3 GW of solar power generation capacity by 2040. Scaling up solar power generation can potentially reduce the dependence on thermal power plant, thereby reducing emissions as well as enhance energy security for the state.	
New investment opportunities in energy sector: Development of the state market in energy efficient technologies, new age technology like EV, Smart Metering etc. and adoption of new regulations like ECBC can potentially open up new investment areas	

Thereafter, the energy vision for the state has been defined. Briefly, Punjab State Energy Vision is to provide affordable, reliable and clean energy to all in the State and to contribute towards sustainable development of the State and the country as a whole. The three pillars of vision defined are as follows:

- Achieving higher living standard of the people of the State by providing access to modern energy in an affordable and reliable manner.
- Ensuring cleaner environment to the people of the State by reducing pollutions and other environmental externalities.
- Increasing the wealth of the State by ensuring the growth of natural capital of energy and its related resources

The Energy Vision for the state has been developed to address the sustainability issue as well, thereby ensuring an overall economic, social and environmental development of the state. The detailed vision for each sector has been detailed

[1] *Such utility-scale solar, roof-top solar, solar pumps, decentralised solar, etc.*

out in the chapter. In order to successfully implement such activities, a robust institutional framework has been put in place along with requisite policy and regulatory support. Thus, Energy Plan, apart from being multi-sectoral, is also be multi-dimensional, catering to various functional areas as well. An idea of how this has been achieved in case of Punjab is given in succeeding sections. Next, results of the low carbon pathways for the state of Punjab have been presented. Continuing the multi sector approach followed while developing the energy plan for the state, for both the energy supply and demand side, low carbon scenarios have been prepared. As an alternate to the BAU scenario, a set of four scenarios has been developed. These scenarios developed consider different set of cleaner options to meet the sectoral energy demand. These include clean energy substitution measures, renewable energy source measures, capacity utilization measures (including utilization of biomass), the industrial energy efficiency measures, energy conservation in buildings, transport modal shift, motor fuel efficiency, etc. The detailed assessment of the low carbon scenarios developed for Punjab has been presented in the "Low Carbon Scenario Report for Punjab".

Based on consultations with the state nodal agency, two low carbon scenarios, focusing on developing the EAP assuming that all RE and EE potential will be tapped by 2040 and 100% decarbonization of demand will be achieved, were considered as future pathways for the energy sector in the state viz. aggressive scenario (LC scenario 3) and decarbonization scenario (LC scenario 4). The aggressive scenario developed for each of the sectors is based on the assumption that the entire renewable energy and energy efficiency potential available in the state is being exhausted and the decarbonisation scenario is a step ahead of the aggressive scenario. This is to mean that the decarbonisation scenario developed for each of the sectors is based on the assumption that, in addition to the entire renewable energy and energy efficiency potential available in the state being exhausted, 100% decarbonisation in the demand sectors in being achieved through a complete shift away from fossil fuels to cleaner fuels.

The two scenarios have been generated through energy systems modelling and will provide a long term energy horizon for the state and assist in strategic energy and integrated assessment of energy-engineering-economy-environment systems.

Thereafter, the detailed energy action plans for the energy supply and energy demand sectors is presented. For each sector, the existing initiatives that have been undertaken by the Government of Punjab and at the national level have been listed followed by the comparative analysis of the alternative low carbon pathways and the sectoral vision. Following this, the detailed action plans are provided – segregated into short-term, medium-term and long-term with the potential implementation agency listed next to the proposed intervention. Further, this chapter explains the cross-sectoral initiatives that need to be undertaken to implement the core sectoral activities under the sectoral action plans.

Realizing the state's RE and EE will require concerted efforts by the state cutting across policy, regulation, finance, infrastructure and market-related interventions. Sectors of the economy will need to grow with lesser impacts on the environment, managing wastes, natural resources, and enhancing energy efficiency. Hence, a growth path of Punjab, , needs to be oriented towards a green growth path..

Alternative energy growth pathways for Punjab

Aggressive Scenario

The aggressive scenario emulates an efficient, less polluting and improved energy system in the State by the year 2040. The scenario is developed based on the assumption that the entire renewable energy and energy efficiency potential available in the state is being exhausted.

Decarbonization Scenario

This scenario is an extension of the aggressive scenario. It also assumes that the entire renewable energy and energy efficiency potential available in the state is being exhausted. In addition, this scenario assumes a demand side shift in the state with the 100% decarbonization of the demand sectors.

Comparative analysis of energy scenarios of state

In order to understand the implications of the outcomes of the future energy scenarios of the state, a table providing a comparison of the values of key indicators in the terminal year of projections i.e., 2040 is given below:

Scenario	Primary Energy Supply (Mtoe) in 2040	Final Energy Demand (Mtoe)	Emission ($MtCO_2$/ Yr)	Power generation mix	Key energy source
Baseline	81.4	69.7	295.6	RE: 14% Import: 67%	Oil (43%) Electricity (20%) Gas (13%) Coal (12%) Bio-Energy (10%)
Aggressive	61	55.9	152.3	RE: 16% Import (RE): 84%	Oil (34%) Electricity (27%) Bio-Energy (19%) Gas (12%) Coal (7%)
Decarbonization	100.8	50.2	0	RE: 34% Import (RE): 66%	Electricity (57%) Hydrogen (23.5%) Bio-Energy (17%)

Note: In case of BAU, investment requirement includes only investments in the supply side viz. capital expenditure on power generation capacity addition (conventional and non-conventional), coal and gas extraction costs. Since, there is no additional initiatives undertaken in the demand side to transform the energy mix, there is no demand side investment in BAU. In case of LC scenarios, the incremental investment as compared to BAU is due to the uptake of new technologies like EVs, gas based thermal power, energy efficient technologies etc. in the demand side as well as investment on power generation and gas extraction infrastructure on the supply side.

Energy Action Plan

The Energy Action Plan has been developed to achieve the targets provided in the energy demand and supply side sectors under the aggressive and decarbonization scenarios. These action plans have been developed separately for each sector and have been further classified into three time frame: Short Term (2022-2025), Mid Term (2022-2030) and Long Term (2022-2040) and the sub-activities have been sequenced based on the relative importance of activities.

- The sub-activities are also further classified into four categories to help assign roles and responsibilities within the implementation agencies. These categories include technical, financial, institutional, policy / regulatory, Capacity building/Awareness generation and market development. .

The Energy Action Plans are developed for the major sectors in the state including energy supply, agriculture, building, cooking, industry and transport. These action plans focus on emerging technologies, need for changing the existing regulations, evolving consumer behavior, possible environmental hazards and sectoral opportunities. Each recommended action outlines the following:

- Nature of action (i.e. regulatory / policy, institutional, financial, technical, etc.)
- Time horizon (i.e. short, medium, long term)
- Lead and partner department / agencies
- Quantification of financial requirement / gap, where needed

The energy action plans for energy supply sector are defined in Chapter 7 and for energy demand sectors, the action plans are defined in Chapter 8.

The key activities that need to be undertaken in each sector that will help achieve the targets given under these scenarios is given below:

Energy Supply sector

Need for establishing the potential of renewable energy in Punjab:

- A conclusive assessment of renewables potential of the state would be critical in developing an updated renewable policy more attuned to the actual resources available within the state.
- As an outcome of the study, a district wise potential assessment of the various renewable sources (especially for biomass availability) would be helpful for planning activities aimed at developing a particular renewable source.

Unleashing the potential of Agro PV in Punjab:

- Even if ~25% of the net sown area is used for development of agro PV, total capacity of over 470 GW can be added through agro PV installation in the state.
- Agro PV also offers to generate additional income for the farmer.
- A variation in agro PV that can be of special interest to Punjab is the use of bifacial panels arrayed in widely-spaced rows, which in addition to the different generation properties, reduces dust accumulation.
- The state government could provide early-stage support indirectly through loan guarantees via commercial lenders, or by direct support mechanisms, such as capex subsidy.
- In terms of a direct subsidy support to the developer, an arrangement similar to PM KUSUM can be thought of. State government could provide 30% subsidy on the capex on per MW basis.

Promoting development of biomass power plants to increase share of renewables within state:

- According to Action Plan for Control of Burning of Crop Residue, approximately 10 million tons of paddy is still being burnt annually which can be used to generate power.
- The GCV, SHR and fuel cost need to be factored in to make is viable for the private sector to develop biomass power plants in the state.

Updating and Implementing NRSE Policy:

- The Focus Areas and Strategy section should be amended to reflect the emphasis on increasing solar power generation along with co-generation capacity.
- RE project financing section should include the proposed Clean Energy Fund (described under cross-sectoral initiatives).
- Regulatory Issues section should be modified to incorporate regulatory changes that are required to increase penetration of solar rooftop.

Facilitating grid integration of renewables:

- The unpredictable forecast of power injection into the grid from renewable sources leads to power generation scheduling challenges from conventional power sources.
- In order to resolve this issue, implementation of high quality forecasting techniques need to be incorporated.

Modernization of power distribution system:

- It entails installation of a smart grid and control the power flow or curtail the load to match generation in real time.
- Improving the existing grid to make it smarter: smart grid system is essential to implement Demand Response System (DRS), Dynamic Pricing and other advanced power management initiatives in future to enable reducing losses, assist in peak load management as well as ensure efficient consumption of power.

Demand Sectors

Agriculture sector

The vision for the agriculture sector is such that state shall ensure positive impact on the livelihood of farming community and maximize utilization of resources by reducing the costs involved in fuel consumption for irrigation, harvesting and other farm activities. State shall also promote doubling farmers' income by providing options of reducing fossil fuel consumption and replacing the same by CBG and by providing support for off-grid solar installation.

Distribution of energy efficient pumps to replace existing inefficient electric pumps:

- Bureau of Energy Efficiency (BEE) had undertaken the replacement of agricultural pumps in 8 states across 11 DISCOMs, wherein inefficient agricultural pump sets were being replaced with BEE 5 star-rated energy efficient pump sets.
- Punjab can work with BEE to expand the program in Punjab where it would on a similar model.

Based on the information developed in the Punjab Energy model, investment requirement for replacement of energy efficient pumps in Punjab in aggressive and decarbonisation scenarios is presented below:

Term (aggressive scenario)	Total Cost (INR Crore)	Power savings (MU/yr)	Cost savings/yr (INR Crore)
Short	485	10	54
Medium	1754	35	197
Long	1727	34	194

Term (decarbonisation scenario)	Total Cost (INR Crore)	Power savings (MU/yr)	Cost savings/yr (INR Crore)
Short	1563	31	175
Medium	2542	50	285
Long	2940	58	329

Provide financial support for procurement of solar pumps and energy efficient pumps by farmers:

- Penetration of solar pumps can be increased by providing loans at less-than-market rates through co-operatives and gram panchayats.
- The co-operatives shall be adequately supported by civil society organizations (CSOs) mobilized by the State Government.
- The CSOs shall be provided with technical know-how to provide technical assistance to farmers willing to opt for solar pumps and educate them about the operational.
- Based on the penetration of solar pumps obtained from Punjab Energy Model, the following investment potential has been derived for aggressive and decarbonisation scenarios:

Aggressive scenario:

Term	Cost of solar pumps (INR Cr)	Annual interest (INR Cr)	Annual diesel savings (INR Cr)	Actual Cost savings (INR Cr)
Short	8,038	161	2,686	2,123
Medium	14,220	284	4,752	3,756
Long	18,519	370	6,188	4,892

Decarbonisation scenario:

Term	Cost of solar pumps (INR Cr)	Annual interest (INR Cr)	Annual diesel savings (INR Cr)	Actual Cost savings (INR Cr)
Short	15894	318	5311	4199
Medium	28248	565	9439	7462
Long	39254	785	13117	10369

Promoting energy efficient cold storage working on solar power:

- Firstly, replacement of existing compressors with new energy efficient compressors with water cooled head cooling arrangement and oil cooling arrangement could be explored.
- Secondly, there is a need to commission solar-based cold storages in the future along with retrofitting existing cold storage units with solar power.
- A conventional cold storage has a designed refrigeration load of 120-150 W/m2. With the application of modern technology in energy efficiency for cold storage, this load can come down to 75 W/m2 and in case of larger stores, a load of 50 W/m2 is also achievable.

Continued promotion of micro irrigation and crop diversification to increase water use efficiency in irrigation:

- Traditionally, the farmers had followed the Maize-Wheat or Sugarcane-Maize-Wheat cropping pattern but during last about four decades, they have shifted to Wheat-Rice cropping pattern thereby leading to increased demand on irrigation water.
- Out of 50,362 Sq.km area of the State, 39,000 Sq. km area (78%) shows a decline in water levels (Gupta 2020).
- As such a sustained emphasis on micro irrigation practices is needed to be given. This can give irrigation efficiency as high as 80% in case of drip irrigation and 60-70% in case of sprinkler irrigation as compared to normal irrigation efficiency of 30-40%.
- Crop diversification would also break the current rice-wheat cycle and it will also help to check depleting water table.
- The state government could consider providing financial assistance to farmers on various machinery and equipment needed for mechanized cultivation.
- More sustained focus should be given on training of trainers (TOT) for creating awareness among the farmers around crop diversification and switching of area from water gushing crops to less water consuming crops.

Facilitation of e-tractors for farmers:

- Electric tractors, with their relatively economical costs, can become the most suited replacement to traditional diesel-driven tractors in the state.
- For promoting the adoption of e-tractors in the state, implementation of the Punjab EV Policy is a pre-requisite.
- The policy enables the development of a Centre of Excellence (CoE) in e-mobility in partnership with an academic partner. which shall encourage R&D for development of electric tractors in collaboration with industry players.
- E-tractors will also result in lower CO2 emissions, promote green farming, and will take a step towards a circular economy.

Building Sector

Model regulations for Punjab ECBC Rules 2020 for its incorporation and implementation roadmap along with requisite supporting infrastructure in the state by various stakeholder departments:

- Guidance for developing a regulation more attuned to the regional considerations of Punjab can be taken from the Hyderabad model by incorporating an online building approval system (DPMS) of urban local bodies and empanelling ECBC third party assessors with PEDA and MCs.
- In order to facilitate a seamless implementation of the ECBC Rules, an implementation roadmap needs to be developed, highlighting the roles and responsibilities of various key stakeholders.
- A building approval committee comprising the officials from GMADA, Department of Local Government, and Municipal Corporation along with independent building certified energy auditors could review the submitted building plans and ensure the compliance with ECBC requirements.

Encouraging development of building integrated PV:

- To begin with, Government buildings can be targeted for solar integration. BIPV can be installed on building façades in addition to the roof.
- As solar panels are glass-based, components that contain glazing such as windows, skylights, glass façades, roofing sheets, tiles and doors can easily be planned to be energy-producing solar panels.
- New commercial buildings can be mandated to incorporate BIPV in their building design.
- MNRE, Government of India is implementing the solar building demonstration programme whereby financial support for construction of demonstration solar buildings will be provided by the Ministry up to 10% of the cost construction, subject to a maximum of INR 50 lakhs for each project.

Undertake awareness programs on building energy conservation and efficiency as well as building labelling systems:

- End-users' buy-in is crucial for successful implementation of ECBC code and realizing its objectives.
- The state shall conduct regular meetings/ awareness/ capacity building programs for key stakeholder departments and build training materials and short/ conceptual factsheets and flyers on basics, requirements and brief overview of ECBC code.
- For wider reachability, state shall also conduct ECBC benefit analysis to show the energy saving potential and economic savings and its comparison with other building energy programs.
- Focus on developing pilot case studies on ECBC for building developers, architects, engineers and building industry professions and city level studies that can help the departments to have a broader view of impact of ECBC code.

Provide institutional and regulatory support to businesses providing ECBC compliant building material and building energy management system

- Need to ensure presence of such local market suppliers in Punjab as this is a pre-requisite for ECBC implementation in the state.
- PEDA can undertake pilot studies to establish the market potential arising out of implementation of ECBC in the short to medium term.
- PEDA can act the leading agency which will co-ordinate and organize the events (roadshows, conferences, exhibitions etc.) for reaching out to the market for developing their businesses in Punjab

Replacement of inefficient electrical equipment/ appliances with BEE star labelled energy efficient appliances and solar water heaters in buildings:

- To increase the annual energy savings and coverage of buildings, a target oriented approach shall be initiated wherein, different categories of commercial buildings can be taken up as the demonstration projects and the same may be replicated by the individual departments.
- Planned and target-oriented studies shall help the state government to monitor, track and calculate the exact impact of savings and accordingly, reach out to the larger set of buildings.

Financial incentives to increase uptake of solar water heaters in residential and commercial buildings:

- In order to promote the solar water heaters in residential and commercial sector, government subsidy/ rebate can be provided to beneficiaries (Government Subsidy for 100 lpd ETC: INR 4500 fixed by PEDA).

Decarbonisation scenario:

Timeline	No. of Solar Water Heaters (lakhs)	Total Investment (INR Crore)	Government Subsidy (INR Crore)
Short	4.17	709.51	187.81
Medium	8.28	1408.94	372.95
Long	21.11	3587	949.50

Develop implementation roadmap of ECBC code for residential buildings

- Defining the responsibilities for adoption and enforcement tasks to mainstream ECBC in residential buildings is paramount between PEDA and ULBs in Punjab.
- Synergies could be drawn with ECO Niwas Samhita 2018 and 2021, an Energy Conservation Building Code for Residential Buildings (ECBC-R) for ECBC implementation in residential buildings in Punjab.

Cooking

Increase the penetration of LPG in rural households:

- In order to address the issue of transportation, the state government can facilitate introduction of LPG distribution centres at local co-operatives and enable self-help groups and other local outlets to become extension counters for rural distributors.
- Kisan Seva Kendras could be directed to stock up to 20 nos. 5 kg cylinders, or several 2 kg cylinders, to facilitate better access to the rural customers.
- Enabling self-help groups (SHGs) and other local outlets to become extension counters for rural distributors
- SHGs under the NRLM could support the purchase of LPG cylinders by facilitating smaller pay-outs through group lending for rural households.
- Rural Development and Panchayats (RD&P) Department can mobilize the gram panchayats to create awareness around benefits of switching from biomass to LPG

Promoting biogas plants through setting up co-operatives in rural areas:

- Village co-operatives taking up the initiative of setting up and maintaining the biogas plants. Two such cases have been implemented in the state and can be referred to for drawing key learnings
- The initial funds for setting up the plant can be provided by the State Government in the form of interest-free loan. The co-operative can recover the costs by charging usage fee on the biogas supplied.
- Use of biogas for cooking needs be aggressively promoted in areas or households with favourable conditions. An enterprise-based model can be promoted where the household level plants could be operated and managed by a local enterprise with trained personnel, ensuring plant uptime and performance.

Developing an implementation roadmap for electric cooking in Punjab:

- Technical studies to be conducted in the medium to long term to establish the requirement for distribution network in the designated area for adoption of e-cooking.

- The government's ambition to provide all households with 3-phase power 24x7 by 2022 will be instrumental in unlocking the potential of electricity-based cooking in rural areas.
- Improving the energy efficiency of induction cook stoves. A few companies have set up government approved R&D centers to improve the efficiency of induction cook stoves
- To encourage adoption, PSPCL can provide a one-time discount in the electricity bill to those consumers who will provide the invoice for acquisition of an induction cook stove/ electric cooker. This could be in the form of a discount on SGST. Net subsidy calculation based on 50% discount in SGST.

Increase penetration of piped natural gas in urban and rural areas:

- For faster penetration of piped natural gas, the downstream infrastructure in terms of distribution pipelines, city gas distribution (CGD) infrastructure, city gas stations, etc. needs to be rolled out.
- The rapid completion of the state gas grid with innovative funding mechanisms could be considered to help connect demand centres that would remain unconnected beyond the current network and ongoing builds.
- For CGD, accelerating the bidding of remaining districts, setting up single window clearances and improving the execution speed of network build-out could be considered by Punjab.
- Lessons could be learnt from international experience whereby trucks are already being used to reach LNG demand centres where scale does not permit pipeline builds.

Promoting solar energy for institutional cooking in Punjab

- The first use case of such cooking would be for the cooking of mid-day meal (MDM) in government schools in Punjab.
- Lessons could be learnt from Nepal where the use of institutional cooking using solar is widespread practice in areas where the grid is unable to reach.
- For the large scale adoption of institutional solar cooking in the state, incentives would be required by the state government to ensure their financial attractiveness.
- Incentive structure could be kept similar to the Jawaharlal Nehru National Solar Mission (JNNSM) whereby 30% advance financial assistance in the form of capital subsidy was being provided for procurement and installation of decentralised solar cookers. Here 70% could the installer's equity.

Industry

- With the decarbonization agenda, and state's immense potential of biomass, utilization of bioenergy in industrial sector along with electrification and green hydrogen can provide significant emission mitigation.
- The state houses 40 DCs spread across 9 sectors, which includes chlor-alkali, pulp & paper, cement, fertilizer, thermal power plant, textile, petroleum refinery, railway, and electricity distribution company (DISCOM).
- The state also have a significant presence of MSMEs, which accounts for close to 60% of the industrial energy demand in 2020.
- While the large industries have established processes and performance improvement measures, process in the MSMEs are variers and the interventions differs from case to case.
- The key measures towards energy saving are classified into 2 categories, (I) key measure for energy saving and emission mitigation in large industry through technical improvement, and (II) Equipment specific energy saving opportunity.

Industry Sector	Energy conservation and emission mitigation measures
Cement Industry	⊙ High efficiency clinker coolers ⊙ Waste Heat recovery ⊙ Co-processing & preprocessing platform for increased alternative fuel utilization ⊙ Kiln surface heat recovery system
Chlor-Alkali	⊙ Zero-gap membrane electrolysis cells with oxygen-depolarized cathodes ⊙ The bipolar membrane electrolysis cells ⊙ Energy-efficient rectifier ⊙ Energy-efficient PVC drier
Pulp and Paper	⊙ Utilization of Rice Straw and other Non-Conventional Raw Materials for Production of Various Grades of Pulp ⊙ Precipitation and acidification to isolate lignin ⊙ Regasification of black liquor ⊙ Oxy-fuel combustion in lime kiln & black liquor boilers ⊙ Bi0-methanation for agro-based plants ⊙ Continuous digester
Textile	⊙ Energy efficient boiler ⊙ Economizer for heat recovery for exhaust air ⊙ Biomass briquette fired boiler ⊙ Heat recovery from hot wastewater
Fertilizer	⊙ Using adiabatic pre-reformer in ammonia production ⊙ Install purge gas recovery unit in Ammonia synthesis ⊙ Improving conversion efficiency in Urea reactor ⊙ Waste Heat recovery from reformer flue gas ⊙ Use of flash steam as motive fluid in booster ejector in Urea Plant
Electricity Distribution Company (DISCOM)	⊙ Load balancing ⊙ Segregation of feeders/Bifurcation of feeders ⊙ Smart metering ⊙ Pricing signals for demand response

⊙ To ensure higher energy conservation and clean energy transition in the industrial sector, the sectoral roadmap is provided with the key focus on development of industrial benchmarking for the large industries and MSME clusters in the state. Various measures like financial support, technology support, pilot demonstration, adoption of Industry 4.0, partnership among various stakeholders has been considered in the roadmap.

Transport Sector

The sector's energy consumption is projected to grow at a CAGR of 3.2% between 2020 and 2040. The total energy demand would increase from 15.8 Mtoe in 2020 to 29.9 Mtoe in 2040 under the aggressive scenario and from 15.8 Mtoe in 2020 to 21.5 Mtoe in 2040 under the decarbonization scenario. Electrification in the sector is leading the pathway for clean energy transition. In addition to electrification of the transport sector, utilization of CBG and green hydrogen will further decarbonize the sector. Electrification can largely decarbonize the light vehicles mainly for passenger and partly freight transportation, while hydrogen and CBG can provide clean transportation opportunity to the heavy freight transportation sector. For effective decarbonization of the transport sector, the state needs to take various initiatives, which includes following:

Implementation of the EV policy:

- The state at the moment has a electric vehicle (EV) policy. The delay in implementation of EV policy by Punjab is acting as a stumbling block in the sale of electric vehicles, especially four wheelers.
- In the absence of the policy, there is no incentive on buying electric vehicles within the state

Confluence of EV policy and vehicle scrappage policy in Punjab:

- In one of the recent announcements, the Government of India has come up with vehicle scrappage policy (Ministry of Road Transport & Highways 2021) with the aim of removing old and inefficient vehicles running on the Indian roads and recycled sustainably.
- The scrappage policy provides various incentives to the vehicle owners to scrape old vehicles and buy a new vehicle, providing a greater opportunity to make the user transit from conventional ICE engine vehicle to EV with the various fiscal incentives.
- Under the policy, scrap value of end-of-life vehicles (ELV) is fixed at 4%-6% of the ex-showroom price of the new purchase. For the state of Punjab, the policy could be a move towards achieving green recovery.

Create adequate charging infrastructure:

- Alongside promotion of private charging infrastructure in the state (as part of the EV policy of Punjab), Punjab should also look at installing public charging stations for EVs.
- The infrastructure can be gradually improved to encourage the sale of electric vehicles in the state.

- A macro-level geospatial analysis can be conducted to identify potential charging demand and the resultant public charging requirements at a unit area level.
- At the area level, site selection for installation of public chargers can be carried out on-ground, in consultation with landowners and municipal corporations.

Market development for CBG:

- At present, lack of an established ecosystem in terms of pricing and gas offtake is holding entrepreneurs back from installing the CBG plants in the state and selling the CBG produced to OMCs.
- It is understood from discussion with companies interested in setting up CBG plants in the state that OMCs are unable to guarantee 100% offtake of CBG from day one. The companies may take up to 18 months to offtake full capacity after the plant is constructed. That is causing an ecosystem challenge.
- Besides, pricing is also an issue. While the Ministry of Petroleum and Natural Gas has asked city gas distribution companies to feed CBG through their pipelines, the gas companies have said they will not pay INR 46 / kg as per SATAT scheme, but most of the time, that commitment is not being met (based on discussion with existing and potential CBG plant owners in Punjab). This is acting as a make-or-break situation for entrepreneurs in the state.
- Punjab needs to promote development of a guaranteed market for CBG off-take.

Hydrogen based transportation system:

- While EVs are anticipated to become economical in the near future, long distance heavy payload transport requires further evaluation as the high energy storage reduces the payload capacity of the commercial vehicles.
- Hydrogen based Fuel Cell Vehicles (FCV) can fill in the gap and provide the sector a zero emission solution to the long haul HCVs.

The adoption of low carbon scenarios, namely, aggressive and decarbonization scenarios, within the state can have significant environment benefits for the state across all key sectors:

Sector	GHG emission reduction possible under Aggressive Scenario compared to BAU scenario	GHG emission reduction possible under Decarbonization Scenario compared to BAU scenario
Energy Supply	86%	100%
Agriculture	Pumping – 100% Machinery – 2%	Pumping – 100% Machinery – 100%
Cooking	21%	100%
Industry	44%	100%
Transport	Freight – 38% Passenger – 35%	Freight – 100% Passenger – 100%

- For the energy supply sector, GHG emissions under BAU scenario stand at 60.8 Mt GHG / year in 2040, 8.7 MT GHG / year in 2040 under aggressive scenario and 0 MT GHG / year in 2040 under decarbonization scenario.
- For the energy demand sector, the GHG emissions under BAU scenario stands at 234.9 Mt GHG / year in 2040, whereas it would be 143.6 Mt GHG / year in 2040 under aggressive scenario and 0 MT GHG / year in 2040 under decarbonization scenario due to complete decarbonization of the demand sectors in Punjab by 2040.

Cross-Sectoral Initiatives:

In order to implement the core activities provided under each sector of the Action Plan, there are a number of supporting activities/initiatives that need to be undertaken which are cross-sectoral in nature.

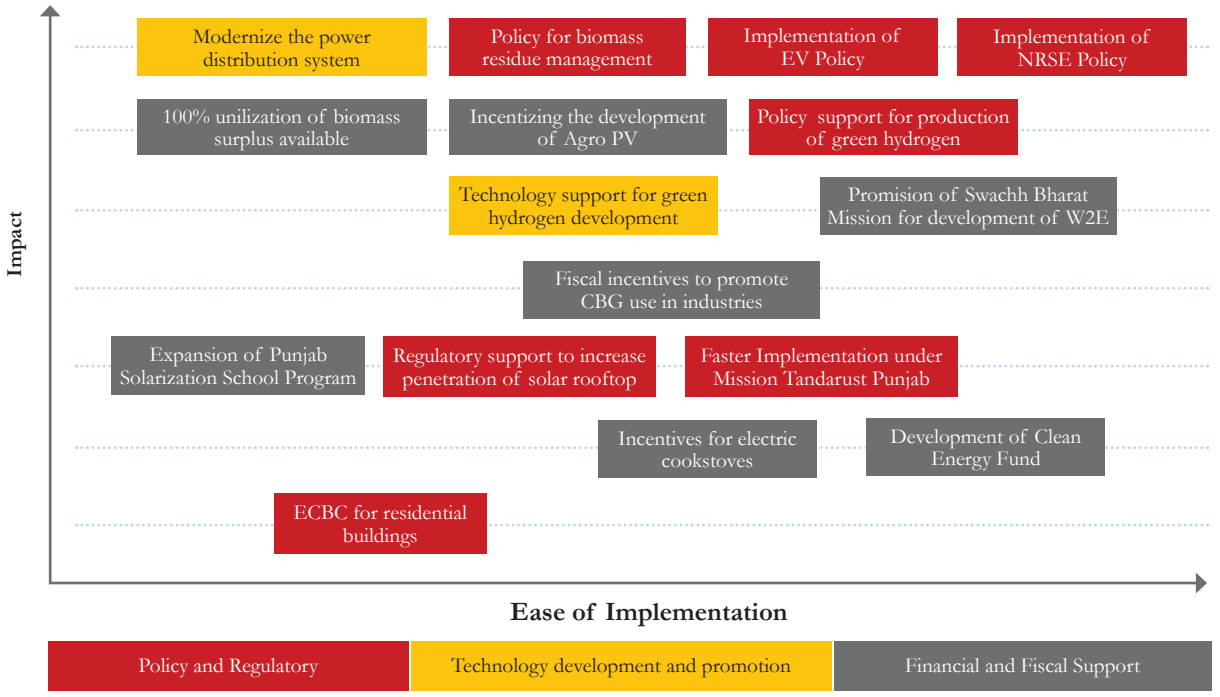
- Undertaking awareness generation and capacity building activities
- Sectoral studies to periodically update the state energy database
- Development of a webtool to support assessment of power consumption of domestic consumers
- Preparing "Green Procurement Guidelines" to promote procurement of energy efficient technology/equipment/components by public entities.
- Preparing a Green Budget for Punjab addressing environmental concerns
- Addressing the energy-water-agriculture nexus in Punjab
- Exploring convergence between State Rural Livelihood Mission and Policy for developing and promoting Decentralised Renewable Energy Livelihood Applications
- Developing a biomass trading platform
- A Cross-Sectoral Steering Committee Monitored Implementation of Biomass-based Pilot Projects
- Integrating Renewable Energy in Healthcare Sector in Punjab
- Developing a Clean Energy Fund which can help overcome financial barriers for adopting clean energy technologies.

Punjab can leverage the business promotion platforms such as Invest Punjab and International Business Summit to showcase the initiatives undertaken and existing opportunities to improve energy conservation and efficiency and to seek funding or technical assistance for specific initiatives in the clean energy sector. This can potentially create investment options and help to increase engagement with international partner countries or national organizations to enhance economic activity in the state as well as achieve better results in energy conservation efforts being undertaken by the state. As an outcome of the investments, there is a considerable potential for job creation in the state in modern technology. The areas where the state can look for opportunity on collaboration is given below:

S. N.	Area	Type of Collaboration
	Solar	
1.	⊙ Manufacturing of solar panels ⊙ Manufacturing of bifacial solar panels for development of agro PV ⊙ Manufacturing/assembly of supporting power ⊙ Equipment required for solar rooftop viz. bi-directional meter, isolation transformers, inverters, protection devices	Investment partnership/ Technology collaboration
2.	⊙ Supply of solar PV panels and supporting power equipment ⊙ ESCO services for installation and maintenance of rooftop solar systems ⊙ ESCO services for installation and maintenance of agro PV systems ⊙ Stand-alone installation and maintenance services	Access to market

S. N.	Area	Type of Collaboration
	Power transmission and distribution	
3.	⊙ Manufacturing and installation of power transmission equipment viz. digital switch gear and smart substations ⊙ Manufacturing and installation of power distribution equipment viz. smart meters, smart controllers, Remote ⊙ Terminal Units, SCADA systems, distribution transformers, aerial bundled (AB) cable, meters with ⊙ Low Power Radio Frequency (LPR) communication capabilities	Investment partnership/ Technology collaboration
4.	⊙ Grid and transmission line expansion to account for increased consumption of electricity	Access to market
5.	⊙ Technical expertise for assessment of grid synchronization and smart grid installation	Technology collaboration
	Electric Vehicles	
6.	⊙ Assembly and manufacturing of EV components	Technology collaboration / Investment partnership
7.	⊙ Installation and maintenance of EV charging stations ⊙ Service providers for vehicle repairing facilities	Access to market
8.	⊙ Expertise for technical assessment of sites for EV charging ⊙ R&D on improved manufacturing techniques for EV/ EV components	Knowledge partnership
	Energy efficient services	
9.	⊙ Designing energy efficient building ⊙ Technical expertise for developing energy optimization systems ⊙ Development and implementation of industrial energy management systems	Technology collaboration / Access to markets
10.	⊙ Develop R&D centers specializing in developing supporting tools and software for efficient operation of equipment / systems	Knowledge partnership
	Equipment manufacturing	
11.	⊙ Technology transfer/technical assistance for setting up units manufacturing energy efficient household appliances ⊙ Setting up semiconductor fabrication plant that can supply components for manufacturing smart appliances and equipment.	Investment partnership/ Technology collaboration
12.	⊙ R&D on designing and manufacturing energy efficient equipment ⊙ Development of State-of-the art testing laboratory for manufactured products	Knowledge partnership

Figure below shows key action items with high impact potential in terms of local economic growth, jobs creation and rural livelihood improvement which can be launched / continued as flagship initiatives.



- In the short term, the action plan focuses more on Policies and Institutional strengthening.
- Development of projects for the private sector side and creation of new markets will be undertaken in the medium term once the supporting policies and institutional mechanisms are in place.
- The recommendations on financial schemes that can have a potentially high social impact are suggested for immediate uptake.

Lastly, the requirements for implementation of the Decision Support Tool which shall capture the results of different scenario simulations against pre-selected indicators has been provided. This chapter also provides the details of how the results on the DST will look like.

NOTES

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