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Multi Sectoral Energy Action Plan for the State of Uttarakhand

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Address

Indo-German Energy Programme - Access to Energy in Rural Areas II (IGEN-ACCESS II)
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
B-5/2, Safdarjung Enclave,
New Delhi-110029, India
T + 91 11 4949 5353
F + 91 11 4949 5391

E info@giz.de
www.giz.de/india

Responsible
Ms. Nidhi Sarin - Project Manager
Indo-German Energy Programme - Access to Energy in Rural Areas II
GIZ India
E: nidhi.sarin@giz.de

Author
University of Petroleum and Energy Studies (Lead partner)
The Celestial Earth (Consortia Partner)

Reviewed and edited by
Mr. Manoj Kumar Mahata, Energy Advisor, GIZ India
and
Mr. Jitesh Kumar, Energy Advisor, GIZ India

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List of Abbreviations

AMI	Advanced Metering Infrastructure
AMSC	Agriculture Machinery Service Centres
BAU	Business as Usual
BEE	Bureau of Energy Efficiency
BIPV	Building Integrated Solar PV
CAGR	Compound annual growth rate
CBG	Compressed Biogas
CEA	Central Electricity Authority
CGD	City gas distribution
CO2	Caron dioxide
CO2e	Caron dioxide equivalent
CoE	Centre of Excellence
Cr	Crore
CSO	Civil society organizations
DC	Designated Consumers
DISCOM	Distribution Company
DoP	Department of Power
DPMS	Development Permission Management System
DR	demand response
DRS	Demand Response System
DSM	demand side management
EAP	Energy Action Plan
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EEPS	Energy Efficient Pump Set
EESL	Energy Efficiency services ltd
ELV	End-of-life vehicles
EP	Energy Plan
ESCO	Energy service company
ESOPB	Economic & Statistical Organisation, Government of Uttarakhand
EV	Electric Vehicle
FBC	Fluidized Bed Combustion
FCV	Fuel Cell Vehicles
FCV	Fuel Cell Vehicles
FY	Financial Year
Gcal	Giga Calorie
GCV	Gross calorific value
GHG	Green House Gases
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOI	Government of India
GSDP	Gross State Domestic Product
GSVA	Gross State Value Added
GW	Gigawatt
GWh	Gigawatt Hour
HH	Household
IBEF	India Brand Equity Foundation
IGEN	The Institution of Green Engineers

IISD	International Institute for Sustainable Development
INR	Indian Rupee
IPDS	Integrated Power Development Scheme
IPP	Independent Power producers
JNNSM	Jawaharlal Nehru National Solar Mission
KV	Kilovolt
kWh	Kilo Watt hour
LC	Low Carbon
LMV	Light Motor vehicle
LNG	Liquified Natural gas
LPG	Liquified petroleum gas
LPR	Low Power Radio Frequency
MDM	Mid-day meal
MNRE	Ministry of New and Renewable Energy
MoPNG	Ministry of Petroleum and Natural Gas
MSME	Micro Small and Medium enterprises
MSW	Municipal Solid Waste
MT	Metric Tonne
MtCO2	Million tonnes of CO2
Mtoe	Million tonnes of Oil Equivalent
MU	Million Units
MW	Mega Watt
NMEEE	National Mission for Enhanced Energy Efficiency
NRSE	New and Renewable Sources of Energy
OMC	Oil Marketing Companies
PAT	Perform Achieve & Trade
UREDA	Uttarakhand Renewable Energy Development Agency
PES	Primary Energy Supply
PLF	Plant load factor
PM KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana
PMU	Project Management Unit
PMUY	Pradhan Mantri Ujjwala Yojana
PNG	Piped natural Gas
UPCL	Uttarakhand State Power Corporation Limited
PV	Photo Voltaic
PVC	Polyvinyl chloride
R&D	Research and Development
RD&P	Rural Development and Panchayats
RE	Renewable Energy
RES	Reference Energy System
SAPCC	State Action Plan on Climate Change
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable development Goals
SGST	State Goods and Service Tax
SHG	self-help groups
SHR	Station heat rate
SLDC	State Load Dispatch centres
SPEED	State Partnership for Energy Efficiency Demonstrations
T&D	Transmission and Distribution
Toe	Tonne of Oil equivalent

TOT	Training of Trainers
TPD	Tonnes per day
TWh	Tera Watt Hour
UJALA	Unnat Jyoti by Affordable LEDs for All
USD	United states Doller
VFD	Variable frequency drive
WAM	Wide Area Measurement

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Executive Summary

Uttarakhand is a hilly state located in northern India with a total area of 53,483 sq.km. It has a relatively small population compared to other Indian states of around 1.14 Cr. and is primarily dependent on hydroelectric power for its energy needs. Economically, Uttarakhand has made significant progress since its formation as a separate state in the year 2000. The state has witnessed growth in various sectors, including tourism, agriculture, industry, and services.

Uttarakhand's economy relies heavily on agriculture, with a large percentage of the population engaged in farming. The state is known for its production of crops like rice, wheat, maize, and fruits like apples, oranges, and strawberries. Additionally, horticulture, floriculture, and animal husbandry are important agricultural activities. Uttarakhand attracts a considerable number of tourists due to its scenic landscapes and pilgrimage sites. Popular tourist destinations include Rishikesh, Haridwar, Mussoorie, Nainital, and the holy shrines of Badrinath, Kedarnath, Yamunotri, and Gangotri. Tourism contributes significantly to the state's economy, generating employment and revenue. However, the State is growing its industrial activities as well. Uttarakhand has seen the establishment of various industries, particularly in the manufacturing and pharmaceutical sectors. The state offers incentives and subsidies to attract investment, and industrial areas have been developed in cities like Haridwar, Rudrapur, Pantnagar, and Sitarganj. Some prominent industries in the state include automobiles, textiles, food processing, and pharmaceuticals. Construction of highways and improved connectivity has facilitated transportation and boosted trade and commerce. Uttarakhand has immense hydropower potential due to its numerous rivers and hilly terrain. The state is known as the "Hydropower Capital of India." Several hydropower projects have been set up, contributing to the state's energy generation, and providing employment opportunities.

Nevertheless, Uttarakhand faces certain challenges, including geographic vulnerability to natural disasters such as earthquakes and floods. These events can impact the socio-economic conditions of the state and require continuous efforts in disaster management and preparedness. Due to increasing climate induced extreme events, the State economy is facing challenges to continue its growth and development while managing the damages caused by the natural disasters. Every year the State is facing varieties of natural disaster caused by climate change and other natural causes. Floods and landslides have become regular events in the State which are causing colossal loss of lives and properties. Uttarakhand is highly susceptible to landslides due to its hilly terrain and geologically fragile landscape. Heavy rainfall, earthquakes, and human activities like deforestation and construction in vulnerable areas can trigger landslides. These landslides have caused significant damage to infrastructure, disrupted transportation routes, and claimed lives in various instances. Uttarakhand also falls in a seismically active zone and experiences occasional earthquakes. While most earthquakes have been of moderate intensity, some have caused significant damage. The Chamoli earthquake in 1999 and the Uttarkashi earthquake in 1991 are notable examples that resulted in the loss of lives and destruction of infrastructure. In the recent past, the State has also started experiencing forest fires which has added new threat to the State's development pathway. Uttarakhand's vast forested areas are susceptible to wildfires, especially during the dry season. Forest fires can cause ecological damage, destroy vegetation, and threaten wildlife. They also pose risks to human settlements and can lead to air pollution and respiratory health issues. Uttarakhand has numerous glaciers, and the melting of these glaciers due to climate change can lead to the formation of glacial lakes. In certain situations, the sudden release of water from these lakes can result in glacial lake outburst floods. Such events can cause flash floods downstream, damaging infrastructure and posing risks to human settlements.

However, with continued natural calamities and disaster, the State could perform well in economic growth over the last several years. The Gross State Domestic Product (GSDP) of Uttarakhand for 2022-23 (at current prices) is projected to be Rs 2,76,677 crore. This is a growth of 9% over the revised estimate of GSDP for 2021-22 (Rs 2,53,832 crore). In 2021-22, GSDP is estimated to grow by 8.2% over the previous year (at current prices). The State's inherent economic power lies with its agrarian activities which are heavily climate dependent indeed. Also, tourism is the second largest contributor towards the State exchequer. It is also observed that even after the State is having huge hydro energy potential and has need for energy for development, allocation of fund for

energy projects are the lowest (less than 0.8% of total budget) which is very compared to the national average of 4.4%.

Uttarakhand has significant hydroelectric power potential due to its numerous rivers and mountainous terrain. The state has several hydroelectric power projects, including Tehri Dam, Maneri Bhali Phase I and II, Chilla, and many smaller projects. These projects contribute a significant share of the state's electricity generation capacity. The State is also exploring the development of other renewable energy sources such as solar and wind power. While their contribution to the state's energy mix is currently relatively low, efforts are being made to increase renewable energy capacity. The residential sector is a major consumer of electricity in Uttarakhand. With the growth of urban areas and increasing electrification in rural areas, the demand for electricity in the residential sector has been steadily rising. Uttarakhand has a few industrial areas, primarily focused on small and medium-scale industries. These industries contribute to the electricity demand in the state. The commercial sector, including businesses, offices, and institutions, also accounts for a portion of electricity consumption but mostly driven the tourism related activities. As a matter of fact, the State of Uttarakhand has historically faced an energy deficit, meaning the electricity demand has exceeded the available supply. As a result, the state has been dependent on power imports from the national grid to meet its energy requirements. To address the energy deficit and meet the growing electricity demand, the government of Uttarakhand has been working on various initiatives, including expanding hydroelectric power capacity, promoting renewable energy projects, and improving transmission and distribution infrastructure.

Given the facts of the State's potential for development and need for growth and prosperity along with the State's increasing climate disasters and corresponding damages, Uttarakhand ("Devbhoomi" ~ land of saints and pilgrimages) needs a comprehensive plan for energy sector development. Energy could play a crucial role in the wholistic growth prospect of the State while providing access to modern energy to the remote parts of the States throughout the year and making the State more energy independent. State is already using clean and green energy like electricity from hydro sources to fuel its growth. However, there are several other activities which are still dependent on fossil fuels like transportation and industrial energy consumption. 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, UREDA (under Department of Power), Government of Uttarakhand and IGEN Access Program of GIZ has undertaken this initiative to develop State Energy Plan followed by State Energy Action Plan (EAP) for the state of Uttarakhand.

Therefore, this report presents an energy action plan (EAP) for the state of Uttarakhand, which stems from the results of an analytical 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. This is even crucial for the State like Uttarakhand where climate adaptation and resilience building within the societies are important for survival during natural calamities. No plan for the State of Uttarakhand will be helpful unless it deals with the issues of climate disaster and corresponding resilience building. 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 like adaptation and enhancing resilience by having self-dependent energy supply, while achieving other development goals. Utilization of the State's own resources for energy generation (including electricity) can provide necessary resilience to climate change and can help improve the socio-economic condition through creating green jobs and bringing green investments. 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.

In the process of developing the State Energy Plan and Action Plan, the study first developed the State Energy Vision which has provided the guiding principles of developing the EAP. **Uttarakhand 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.**

The **three pillars** of State Energy 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 while increasing the resilience of the society towards climate hazards.

The Energy Vision for the state has been developed to enhance the climate resilience and sustainable development of the State, ensuring an overall economic, social, and environmental development of the state. 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 multi-dimensional, catering to various functional areas as well. An idea of how this has been achieved in case of Uttarakhand is given in succeeding sections.

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 three scenarios has been developed. These scenarios developed considering different set of cleaner energy options to meet the sectoral energy demand. These include clean energy substitution measures, renewable energy 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 Uttarakhand has been presented in the "Low Carbon Scenario Report for Uttarakhand".

Based on consultations with the state nodal agency, three low carbon scenarios, focusing on developing the EAP assuming that all RE and EE potential will be tapped by 2040 and with that focussing on to achieve 100% decarbonization of demand sector, were considered as future pathways for the energy sector in the state viz. **ambitious scenario**, **state vision scenario** and **aggressive scenario**. The aggressive scenario developed for each of the sectors assumes that the entire renewable energy and energy efficiency potential available in the state is being exhausted and the ambitious scenario is a step ahead of the aggressive scenario. This is to mean that the ambitious scenario developed for each of the sectors assumes 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 and necessary climate resilience is achieved through self-sustaining energy system while ensuring access to modern energy supply to all even during the natural disasters.

Alternative energy growth pathways for Uttarakhand

Ambitious scenario

- An efficient, less polluting and improved energy system in the State by the year 2040.
- Certain share of renewable energy utilization with a combination of fossil fuel and energy efficiency

State Vision Scenario

- Full utilization of renewable energy and energy efficiency potential available in the state
- Adoting demand side fuel shift with the objective of 100% decarbonization of the demand sectors.

Aggressive Scenario

- Full renewable energy and energy efficiency potential available in the state are utilized.
- Taking measures to move more twoards RE based economic activities in transport, industry and tourism.

Comparative analysis of energy scenarios of state

Scenario	Primary Energy Supply (Mtoe) in 2040	Final Energy Demand by 2040 (Mtoe)	Emission by 2040 ($MtCO_2$/Yr.)	Power mix	Primary Energy Mix by 2040
Ambitious	14.6	13	31	Within State: 53% Import: 47%	Biomass (1%) Biofuel (6%) Coal (0%) Oil (20%) Gas (29%) Hydro (28%) RE (16%)
State Vision	14.5	11	23	Within State: 64% Import: 36%	Biomass (0%) Biofuel (4%) Coal (0%) Oil (19%) Gas (19%) Hydro (33%) RE (25%)
Aggressive	14	10	14	Within State: 78% Import: 22%	Biomass (0%) Biofuel (1%) Coal (0%) Oil (9%) Gas (15%) Hydro (45%) RE (30%)

Note: In the 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.

Uttarakhand Energy Action Plan (UKEAP)

UKEAP has been developed to successfully achieve the targeted objectives set under different scenario pathways for the State. These action plans have been developed separately for each sector and have been further classified into three different time frames: 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, the 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.

Energy Supply Sector

Need for assessing the potential of renewable energy in Uttarakhand:

- Assessment of renewable energy potential of the state is essential for developing an updated renewable policy more attuned to the actual resources available within the state.
- District wise potential assessment of the various renewable sources (especially for solar, biomass availability and small hydro plants) would be required for planning activities aimed at developing climate resilient and adaptation-based action plan.
- To manage with lesser Renewable Energy, The state should run the Energy Efficiency enhancement an De-Carbonization programs parallelly

Unleashing the solar potential in Uttarakhand:

- The entire state receives good amount of solar insolation, about 4.5–5.5 kWh/m2. Even if ~20% of the net sown area is used for development of agroPV, total capacity of over 15GW 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 Uttarakhand is the use of bifacial panels arrayed in widely spaced rows, which in addition to the different generation properties, reduces dust accumulation.
- providing early-stage support indirectly through loan guarantees via commercial lenders, or by direct support mechanisms, such as capex subsidy may boost the adoption of solar energy harvesting.
- In terms of a direct subsidy support to the developer, an arrangement like PM KUSUM can be thought of. State government could provide 30% subsidy on the capex on per MW basis.

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

- Approximately 2 million tons of paddy straw is unutilized annually which can be used to generate power.
- Pine-needles could be a good source of biomass in the State for energy. Annually around 1.5 million ton of pine needle is produced in the State which can be utilized for power and other form of energy generation.
- State can also produce around 0.8-million-ton (0.72 million ton as per MNRE) biomass annually from agricultural residue, crops, and lantana) which can also be used for energy generation. State has 93~150 MW of power generating potential from biomass annually (Invest India, 2023)[1].
- Utilization of cattle dung and other forms of waste for energy generation. Home cooking gas supply, grid connected power generation or even co-generation can be considered for the State to utilize its available biomass.

Demand Sectors

Agriculture

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. Uttarakhand's agricultural sector faces challenges such as limited land availability, fragmented landholdings, dependence on rainfed agriculture, transportation issues in hilly areas, and vulnerability to natural disasters which are required to be addressed. Uttarakhand has also gained recognition for its focus on organic farming. The state government has actively promoted organic agriculture to maintain the ecological balance and ensure the production of healthy and chemical-free food. Several regions

[1] https://www.investindia.gov.in/state/uttarakhand/renewable-energy-incentives#:~:text=Uttarakhand%20is%20highly%20rich%20in,forests%20(excluding%20wildlife%20area) & https://mnre.gov.in/img/documents/uploads/file_s-1685625362098.pdf

in Uttarakhand, such as the hill districts of Almora, Pithoragarh, and Chamoli, have been declared as organic farming zones. The State shall develop an efficient Agri-horticulture sector which is the backbone of the State economy. Renewable energy utilization in various farming and non-farming activities within the sector shall provide additional source of income to the farmers and can provide climate resilience during the natural disasters.

- ✓ **Replacement of energy inefficient irrigation 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. Uttarakhand can work with BEE to expand the program in Uttarakhand where it would on a similar model.
- ✓ **Implementing KUSUM program successfully and enhance the scope of solarization of the pumps.**
  - 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 on operational issues.
- ✓ **Promote renewable energy based cold chain facilities in the State.**
  - Replacement of existing compressors with new energy efficient compressors.
  - Explore the options of solar-based cold storages to facilitate the Agri-horticultural business development in the State especially for hilly and remote terrains.
- ✓ **Promoting micro irrigation and crop diversification to increase water use efficiency in irrigation and reduce energy consumption.**
  - Out of 53,483 Sq.km area of the State, plain areas of the state show a decline in water levels. Therefore, sustained emphasis on micro irrigation practices is needed. 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% which all can contribute towards lower energy consumption for irrigation.
- ✓ **Promoting electric tractor or RE based tractor use in the State.**
  - 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 Uttarakhand EV Policy is a pre-requisite.

Building

Model regulations for Uttarakhand 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 Uttarakhand 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 UREDA and MCs.

Encouraging development of Solar Rooftop:

- 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.

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.

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

- Encourage and promote the energy efficient gadgets for buildings like LED Lights, BLDC Motors/fans, five-star AC etc.
- Need to ensure presence of such local market suppliers in Uttarakhand as this is a pre-requisite for ECBC implementation in the state.
- UREDA can undertake pilot studies to establish the market potential arising out of implementation of ECBC in the short to medium term.
- UREDA 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 Uttarakhand.

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

- To promote the solar water heaters in residential and commercial sector, government subsidy/ rebate can be provided to beneficiaries.
- Promote and encourage the society for the use of passive heating.

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 UREDA and ULBs in Uttarakhand.
- 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 Uttarakhand.

Cooking

Increase the penetration of LPG in rural households:

- 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.
- 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 Uttarakhand:

- 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.
- Improving the energy efficiency of induction cook stoves. A few companies have set up government approved R&D centres to improve the efficiency of induction cook stoves.
- To encourage adoption, UPCL 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 Uttarakhand.
- 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 Uttarakhand

- The first use case of such cooking would be for the cooking of mid-day meal (MDM) in government schools in Uttarakhand.
- 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 may be kept like 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 industries spread across various sectors, which includes Paper mills, Sugar mills, Cloth mills, Flour and Rice mills, pharmaceutical industries, Mentha oil units, Stone Rolling mills etc.
- The state also has 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 barriers 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.
- 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 Transport sector is projected to grow at a CAGR of 18% between 2020 and 2040. The total energy demand would increase from 3.9 Mtoe in 2020 to 8.2 Mtoe in 2040 under the Baseline scenario, 6.8 Mtoe in 2040 at 6% per annum growth rate under the ambitious scenario, 5.8 Mtoe in 2040 at 5% per annum growth rate under State vision scenario and 4.6 Mtoe in 2040 at 4% per annum growth rate under aggressive 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:

Developing and implementing EV policy

- Develop and implement the EV Adoption policy in the State along with the promotion of alterative low carbon transport system such as ropeways/cable cars.
- Promote and encourage electric two wheelers and three wheelers.
- Need to have frequent and comfortable public electric transport on various routes.

Create adequate charging infrastructure:

- Alongside promotion of private charging infrastructure in the state (as part of the draft EV policy of Uttarakhand), Uttarakhand should also look at installing public charging stations for EVs.

GHG Emissions Reduction Potential

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

Sector	GHG emission reduction possible under Ambitious Scenario compared to BAU scenario	GHG emission reduction possible under Aggressive Scenario compared to BAU scenario
Energy Supply	65%	100%
Agriculture	Pumping – 100% Machinery –60 %	Pumping – 100% Machinery – 100%

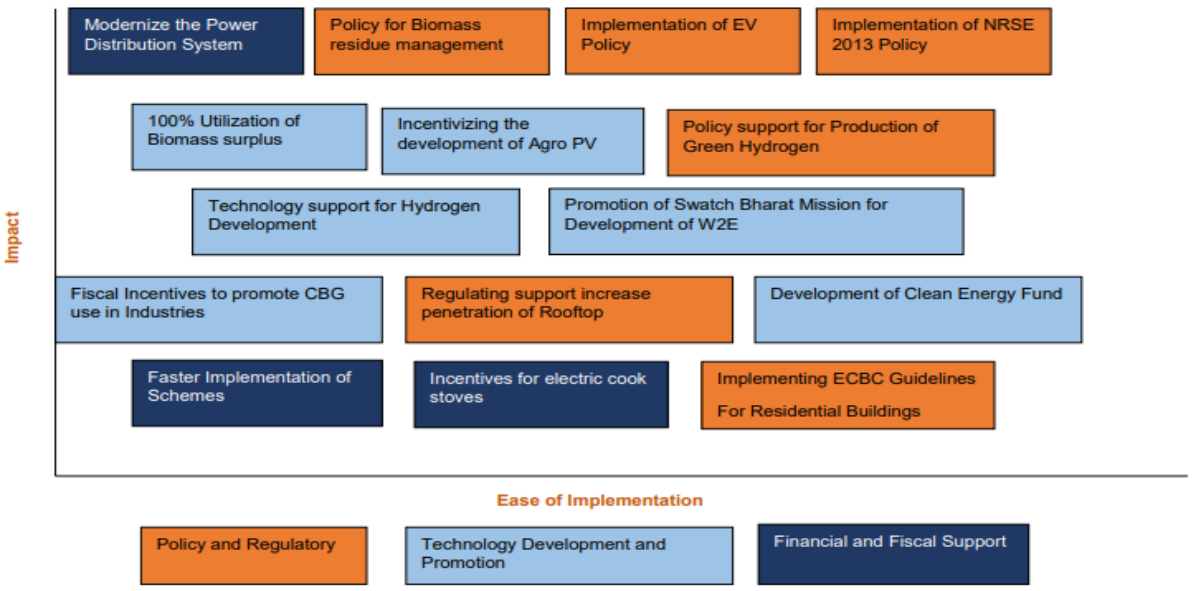
Cooking	60%	100%
Industry	60%	100%
Transport	Freight –50 % Passenger –60 %	Freight – 100% Passenger – 100%

Cross-Sectoral Initiatives

To implement the core activities provided under each sector of the Action Plan, there are several 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 Uttarakhand addressing environmental concerns
- Addressing the energy-water-agriculture nexus in Uttarakhand
- 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 Uttarakhand
- Developing a Clean Energy Fund which can help overcome financial barriers for adopting clean energy technologies.

Uttarakhand can leverage the business promotion platforms such as Invest Uttarakhand 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. 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. Figure below shows the mapping of impact vs ease of implementation of various action plans of the proposed UK-EAP.

1.Introduction

Energy is an integral component of a country's development agenda as it cuts across all facets of daily life and addresses larger economic priorities of the country. The declining costs and large-scale deployment of clean energy systems coupled with advancement in demand side techniques are driving decarbonization of sectoral energy use while creating economic development Opportunities in urban and rural areas of the state. Climate change is an increasing threat to the environment, ecosystem, human and animal health, safety and prosperity of the nation and the States. At the same time, clean energy economy is creating opportunities to create new jobs and can propel the State of Uttarakhand to become market competitive for trade and business through minimizing the cost of production. Government of Uttarakhand has also published the 'State Action Plan for Climate Change 2030' prioritizing goals, targets, and objectives in line with the Sustainable Development Goals. Uttarakhand recognizes the pivotal role of energy in creating a poverty free, prosperous, and healthy state with opportunity, equity, and access to all. As energy is linked directly or indirectly to all SDGs, the state envisions a future where everyone will have access to affordable, reliable, and sustainable modern energy.

The Uttarakhand Energy Vision - 2047 will serve as a foundation to develop an energy roadmap which will reflect the changing energy needs, promote economic growth, and ensure affordable and reliable energy access in Uttarakhand. It is in line with the Uttarakhand Vision 2030 and aims to bring about greater alignment across all aspects related to energy, given the catalytic role of energy in achieving all SDGs. The vision for energy under the Uttarakhand Vision 2030 reflects the state's commitment towards enhancing resident's quality of life and creating new employment avenues. These commitments resonate with Uttarakhand's core values of halting biodiversity loss, preserving cultural identity of the state, and anchors around sustainable energy initiatives and promotion of energy resources available within the state.

1.1 Economic Profile of Uttarakhand

During 2020-2021, Uttarakhand has recorded economic growth (GSDP) of around 4.3% at 2012-13 constant price compared to 4.2% of National Growth Rate (GDP) during the same period. Uttarakhand's per capita income was around INR 2.02 lakh at current prices in 2019-2020, which is 6.8% times higher compared to national average of INR 134K at current price in 2019-2020 (GoI, 2021). Uttarakhand's total population, its growth rate and limited number of households could provide demographic advantages of handling structural changes in its energy system while transitioning towards RE. Scale of operation is often a challenge for larger economy which warrants for significant amount of initial investment and financing.

The Gross State Domestic Product (GSDP) of Uttarakhand for 2021-2022 (at current prices) is Rs 2,78,006 crore. National average for per capita income was Rs. 1.34 lakh for financial year 2019-20, it was 2.02 lakh in Uttarakhand. It added that while the national growth rate of economy in 2019-2020 was 4.2%, it was 4.3% in Uttarakhand.

1.2 Uttarakhand State Energy Profile

The government of Uttarakhand published a draft version of the "State Action Plan on Climate Change for the state of Uttarakhand from 2030" (SAPCC 2014) claiming that more than 51% of the land area of the state is vulnerable to landslides which is immensely concerning for the state. The SAPCC published for public review in 2014 lists out the goals, targets, and objectives in line with the SDGs and the NDCs. In the SAPCC document, each of the departments has shared their departmental version to adopt the practices to counter climate change. However, due to recent national targets of net-zero by 2070, the state needs to update their targets proportionate to national targets as well.

The total installed capacity of the state of Uttarakhand as of Dec 2022 is 4556.05 MW. This includes central share of 2629 MW. The main source of energy generation in the State is from hydropower plants (4001.15 MW),

(and renewable energy sources (295 MW). The breakup of the source wise installed capacity in the state of Uttarakhand as on FY 2021-22 is tabulated below:

Table 1: Total Installed Capacity FY 2021-22

Sr. No.	Description	Value (MW)
1.	Large Hydro	4001.15
2.	Mini/ Micro Hydro	186.90
3.	Solar	295
4.	Biomass	73
5.	Share from Central sector	2629
6.	**Total Capacity (with central sector share)**	**4556.05**

Source: Uttarakhand State Power Corporation Limited (UUPCL) and UREDA

Over the years, the total RE installed capacity in the state has increased further to reach a total of 4556MW. Majority of this capacity comes from solar, amounting to 295MW. The remaining capacity is dividing between biomass power plants, co-gen plants, mini-hydel and waste-to-energy plants. The breakup of the source wise RE installed capacity in the state of Uttarakhand as of August 2022 is tabulated below:

Table 2: Total Installed RE Capacity of Uttarakhand as of May 2019

S.No.	Project	Cumulative Achievement (MW)
1	Grid Connected Projects	523
2	Bio Energy Programme	72
3	Solar Energy Programme	254
4	Solar PV power plant	216
5	UPCL Solar rooftop & small plant	18
6	Solar Canal bank/top Power Projects	20
7	Micro, Mini and Small Hydro Power Plants	196
	Off Grid Projects	**68**
1	Biomass / Bagasse Co-generation Power Project	59
2	Solar decentralized PV power plant	3.7
3	Mini Hydel Projects	5.9
	Grand Total	**592**

Other than this, the state has also installed bio-CNG / CBG plants and off-grid rooftop solar projects. In addition, through participation in different state and national level schemes, several distributed RE projects have been developed in Uttarakhand. Details of installed capacity / number for installations under these schemes is provided below:

Table 3: Total Installed RE Capacity / numbers as part of different schemes as of

S.No.	Project	Cumulative Achievement
1.	Bio-CNG/ CBG Projects	73
2.	Off Grid Solar PV Rooftop Systems	3.66

3.	SPV Street Lights	41,940
4.	SPV Home Lighting Systems	54.16 Lakhs
5.	PM KUSUM Component B Agriculture Solar Pumps (Off- Grid)	431
6.	Solar Water Heating Systems (LPD-Litre per day)	25,91,520 LPD
7.	Solar Cookers	6419
8.	Biogas Plants	6304

Further, the total power generation as on FY 2020-21 in the state of Uttarakhand was 14,527 BU, which includes 13,477 BU from hydro power plants (state owned and IPPs) and 1050 BU from renewable sources and mini hydro sources of energy. The breakup of the source wise total power generation in the state of Uttarakhand as on FY 2020-21 is tabulated below:

Table 4: Total Energy Generation in Uttarakhand for FY 2020-21

Sr. No.	Description	Value (BU)
1.	Large Hydro	13,477
2.	Renewable Sources (Solar, Biomass, Mini/ Micro Hydro, etc.)	1,050
3.	Total Generation	14,527

Source: CEA. In UPCL

In terms of electricity consumption, the per capita consumption of electricity in the State has increased from near 930.4 kWh in 2009-10 to 1467 kWh in 2018-19 (Mospi 2019). The agriculture sector is the third largest consumer of electricity in the state trailing behind domestic & industrial sectors.

- According to the Uttarakhand State Power Corporation Limited (UUPCL), the electricity generation in the state has increased by ~30% (i.e., from 3038.8MU in 2000-2001 to 12,688.46MU in 2016-17).
- UPCL owing to significant improvement in power supply, the state witnessed almost no short fall in FY20, which is considerably lower than the national average of energy shortfall of 0.5% (CEA 2020).
- In terms of peak power requirement as well, the state has performed significantly better than the national average, as the peak deficit has been zero compared to 0.7% of the national average in FY20 *(CEA 2020)*. However, the average plant utilization of the state is around 26.71%for the state-owned capacities and ~50%for IPPs; the state is still having a certain energy deficit which corroborates the need for systematic energy planning.

The state has also engaged in energy conservation projects and has been able to Mus as of July 2022 through such initiatives. The details about different energy conservation measures undertaken by the state are tabulated below:

Table 5: List of different energy conservation projects undertaken in Uttarakhand as of 2019

Sr. No.	Name of the component	Project (Achieved so far)	Cumulative Energy Saved
1.	State Partnership for Energy Efficiency	309 nos. of energy efficient rural water pump-sets Installed	8831727 kW
2.	Building Energy Efficiency Project (BEEP) in Municipal Buildings	LED Lamps, LED Tube-light, Ceiling Fans Star rated AC	0.72 MU
3.	PAT Cycle-I & II	From 8 Sectors around 478 Nos. (Cycle-I) of Designated Consumers saved energy and designated consumers increased to 621 in Cycle -II	8.64 Mtoe

4.	UJALA	LED Bulbs Distributed till August 2019 = 54.16 Lakhs	303577 MWh
5.	Building	Commercial buildings have been ECBC compliant in the State.	NA
6.	Street Light National Program (SLNP)	41,940 LED Street lights has been installed in Dehradun; 30536 lights installed till 24th Apr 2018 and for 11404 lights installed till 12th June 2019.	NA

Overall, Uttarakhand has shown significant economic growth over the past five years with the state's GSDP increasing at a CAGR of 4.3% between 2018-19 to 2020-21. Further, significant growth has been observed in the State economy due to implementation of various agriculture sector friendly and industry sector friendly policies, promotion of service sector and overall economic growth in the country.

In case of Uttarakhand, economic growth and energy consumption are correlated, which further indicates that energy availability and consumption is essential for the state to move up in the ladder of economic and social development. Energy is one of the major resources in the economy which integrates all other sectors in one common thread and thus a comprehensive assessment and planning for energy production and consumption in the economy is an essential task.

The broader energy sector in the state is poised to go through a transformation in the coming years. Any endeavour to draft the energy action plan, which is also futuristic in nature, must take into cognizance of these emerging trends. State Government also introduce many energy conservation schemes with improved policies for the better growth and achieving goals. **The opportunities and challenges** arising from these trends are as follows:

A. Low to moderate growth in energy demand

There is a major thrust on introducing energy efficient appliances in households by EESL under its various programs - introduction of UJALA in Uttarakhand in 2015 (UREDA 2015) resulting in savings of over 303577 MWh of power (UREDA n.d.). Subsequently there are plans to introduce other energy efficient appliances as well. Considering that around 9% of State's power demand comes from the domestic segment, increased penetration of energy efficient appliances is expected to result in decrease in power demand (Power For All 2016). Additionally, there is a clear thrust on implementation of Energy Conservation Building Code (ECBC) for commercial and residential sector buildings. ECBC was launched by the Bureau of Energy Efficiency and notified by the Uttarakhand Government on 2017, for its mandatory use in commercial buildings (UREDA 2020) which is further reducing energy intensity in the buildings sector.

Industrial sector will also witness slower growth in power demand due to increasing low energy intensive manufacturing and service sector growth. Uttarakhand has a high concentration of energy-intensive industries that include a mix of DCs as well as SMEs and performance of industries is monitored through PAT scheme. In industries, PAT Cycle-II (2016-19) has resulted an energy savings of (~8.64Mtoe).

Energy efficiency through agriculture demand side management: Uttarakhand has also been promoting energy efficiency through agriculture demand side management by reduction in overall power consumption, improving efficiencies of ground water extraction, reducing subsidy burden on state utilities and also investment in power plants through avoided capacity (UREDA 2020). This is likely to reduce the energy intensity of agriculture pumping sector by carrying out efficiency up gradation of agricultural pump sets.

B. New demand drivers

Increasing electric mobility: The government of Uttarakhand is bringing and implementing an EV policy to promote electric mobility within the state. The state is pushing for EV adoption as well as EV manufacturing with a combination of subsidies and tax exemptions in three segments, namely, consumer incentives, charging infrastructure incentives, industry incentives, etc. These initiatives indicate the intention of the state government to increase the penetration of EV across public and private transportation, leading to increased power demand and reducing demand for fossil fuels. To support such initiatives, adequate charging and storage infrastructure should also be scaled up accordingly.

Upcoming industrial infrastructure viz. industrial parks: To provide impetus to rapid industrial growth in the state, Uttarakhand is planning to develop major Industrial Parks and other Industrial Parks covering general and sector specific requirements of various industrial sectors (Investors Summit 2018 2018). The state also plans

to set up MSME industrial clusters. Such as pharma cluster in Selaqui, manufacturing of goods in Haridwar or IT Park in Sahastradhara etc. This would increase the energy demand as well as necessitate development of standards/benchmarks for clusters/parks. MSME clusters including new Economic Zones and industrial parks also pose opportunities for setting standards for EE infrastructure and processes.

Promotion of e-cooking in Uttarakhand: The Ministry of New and Renewable Energy (MNRE) has requested the Ministry of Petroleum and Natural Gas (MoPNG) to divert a part of the cooking gas and kerosene subsidy (around Rs 25,000 crore/year) towards electric cooking (IISD 2019). Further, after the recent hike in LPG prices, cooking using LPG cylinders has become more expensive. These factors are likely to give a huge push to electric cooking within the state and increase the energy demand as well as necessitate development of standards/benchmarks for e-cook stoves.

C. Demand for cleaner energy production

Renewable mix in the grid would necessitate new skills to handle the power management: The Government of Uttarakhand published the 'Uttarakhand Vision Document 2030' prioritizing goals, targets, and objectives in line with the 2030 Sustainable Development Goals. Supply side and demand side targets have been set in the Vision Document 2030 to increase the share of renewable energy.

Renewable energy being intermittent and infirm, would require adequate forecasting skill, scheduling capability, development of ancillary services and flexible thermal generation – which would necessitate development of skilled work force. Additionally, ancillary services represent new revenue opportunities for state utilities and other private players.

Special thrust on utilization of biomass in the state for power production and CBG generation: Uttarakhand has set specific targets for utilization of biomass residue available in the state for power and gas production. Around 15 million tons of pine needle is generated every year. Cotton stalk is available as waste of cotton crop in southwest districts of Uttarakhand. Bagasse, wheat straw and paddy husk are already being used profitably. Other agro / processing wastes like maize cobs, sugar cane trash, sunflower stalk, and wooden saw dust and mandi reject of paddy are also available locally, seasonally and in decent quantities for utilization. In addition, Uttarakhand also has additional potential of CBG production from animal wastes and municipal solid wastes as estimated to be 9.9 Mtoe using cattle dung, poultry waste and municipal solid waste. If enabling environment (regulatory, institutional, financial and technological) is created on time, extraction of these resources could bring a shift in the energy mix of the State and may open up the possibility of exporting energy in the region.

2. Approach & Methodology

To prepare the Energy Action Plan (EAP) for the state of Uttarakhand, a series of robust activities have been executed and following approach was developed viz. Data collection and State Energy database, Data Analysis and finally the development of State Energy Action Plan. There are **four major steps used to prepare the UK-EAP**: 1. Data collection and preparation, 2. Model building, 3. Simulation (baseline and LC scenarios) and 4. Analysis and EAP preparation. Figure below shows the detailed step by step approach used for this EAP preparation.

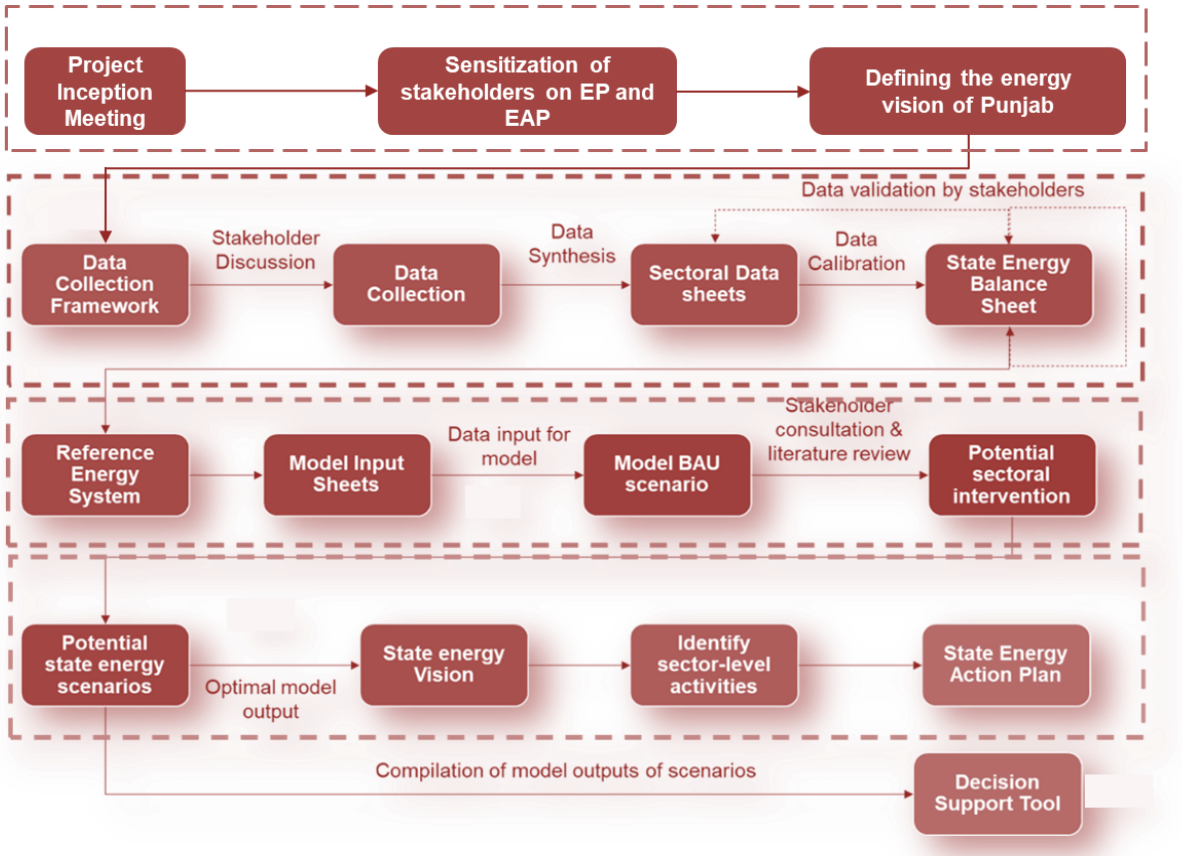


Figure 1: Flow of activities for developing State Energy Action Plan

2.1 Data Collection

An integrated methodology comprising of primary and secondary research was carried out at the energy supply and demand sectors at the state level. The primary data of past 15 years i.e., 2005 to 2020 was collected through various rounds of stakeholder meetings / discussions held with state government departments in sector specific data collection framework. Whereas, in the absence of primary data, the gaps were collected through desk based secondary research such as government websites namely, Economic & Statistical Organisation, Government of Uttarakhand, upUPCL.org, des.uk.gov.in, etc., reports (Uttarakhand statistical abstracts, Infrastructure statistics of Uttarakhand, Economic survey of Uttarakhand, etc.), news articles, etc. Post data collection, sectoral datasheets highlighting data received from primary sources and data collected from secondary sources was validated by respective stakeholder departments of Govt. of Uttarakhand. Following this, state energy balance sheet was prepared which went through several rounds of data validation and was calibrated to the base year i.e. FY 2019-20. It was undertaken to ensure robustness of the data and hence opting a more streamlined baseline assessment for the state of Uttarakhand. The following methodology/ approach for data collection and state energy database was adopted:

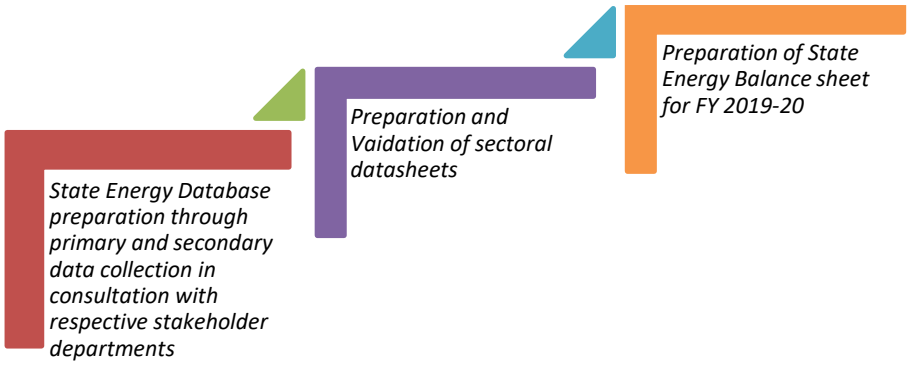


Figure 2: Methodology adopted for data collection and state energy database.

2.2 State Energy Database Preparation

To develop the and Energy Action Plan (EAP), there is a need to build a robust state energy database that covers information regarding all existing and available energy through primary and secondary research. The primary purpose of state energy database is to comprehensively capture all major sectoral energy data and information on a historical basis. To complete this activity, the team cohesively worked with the Project Management Unit (PMU) formed at the State level that comprised of stakeholders from all relevant line ministries and departments. The focus has been given on various parametric values which are state specific.

The departments' inputs were sought on the following guiding questions on supply and demand side, upcoming strategies, targets, plans and priorities and incorporated in the study:

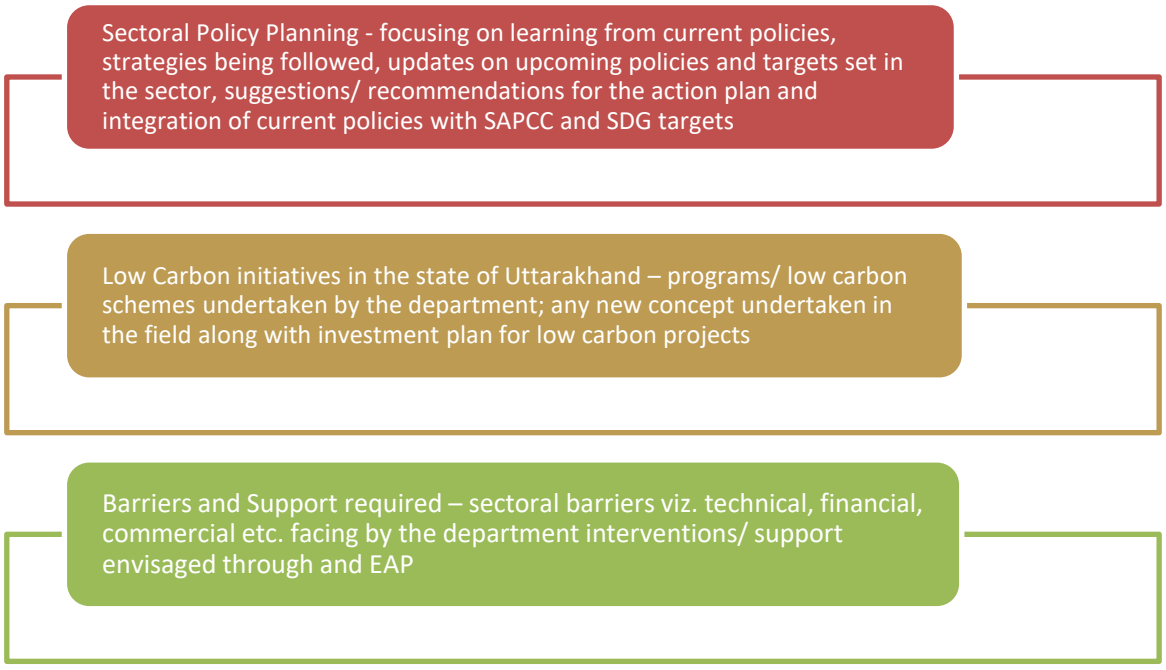


Figure 3: List of questionnaires used for energy database preparation.

For the study, the entire energy sector of the state was divided into five demand sectors and one supply sector based on preliminary stakeholder consultation. While energy demand sectors included buildings, transport, industries, agriculture and cooking, energy supply sectors comprised both primary (viz. coal, oil, and gas) and secondary sources (viz. electricity). Post data collection, sectoral data sheets were prepared for compiling sectoral information. In the process, data sensitization was carried out and irrelevant and outlying data points

were sieved. The same was then validated by the relevant experts and concerned state government departments.

2.3 Uttarakhand State Energy Profile

The Government of Uttarakhand is continuously focusing on usage of renewable sources of energy in the state. Whereas on national level total energy consumption increased by 9% in 2021 to 951 Mtoe, after a 5.9% drop in 2020. It increased rapidly from 2010-2019 (3.7%/year). Coal is the country's top energy source with a share of 46% in 2021, followed by oil (23%) and biomass (21%). As per the analysis of historical trends, in terms of sectoral electricity consumption in the state, transport sector had the highest energy consumption in 2019-20 which stands at 45.7% followed by industry (27.04%) and buildings (15%) in 2020. It was also observed across sectors, economic activities have been steadily growing that can be directly linked to the growth in electricity consumption.

2.4 Key Sectoral Highlights

The following section describes various sources and information used to prepare the State energy database which was used to develop the State energy model and conduct subsequent scenario analysis leading towards the development of the EAP.

A> Energy Supply

The major source of power generation in the state includes large hydro, and renewables (solar, mini/ micro hydro, biomass). For power generation, the primary data with respect to installed capacity of power plants and annual energy generation from conventional and non-conventional sources and other performance indicators viz. PLF/ APC/ Efficiency etc. has been collected from UPCL and UREDA. The details of primary and secondary data under EAP are provided below:

Table 6:List of primary and secondary data collected for energy supply sector.

Particulars	Data indicators	Year	Source
Primary	Installed Capacity and Energy Generation for conventional sources including: • Solar (state owned & IPP) • Hydro Power	2005 to 2021	Data received from relevant departments of Uttarakhand Government
	Installed Capacity and Energy Generation for non-conventional sources i.e., Renewables- Solar, Biomass, Micro/Mini Hydro	2005 to 2021	
	Plant Load Factor (PLF)/ Capacity Utilisation Factor (CUF), Auxiliary Power Consumption (APC)	2005 to 2020	
	Plant Load Factor (PLF)/ Capacity Utilisation Factor (CUF), Auxiliary Power Consumption (APC)	2016 to 2020	
Secondary	No. of Bio-Gas Plants installed in the state of Uttarakhand		Statistical Abstract of Uttarakhand (2015 to 2020)
	Consumption of Petroleum Products	2006 to 2020	

Installed Capacity of Power Plants in Uttarakhand

As of July 2021, total capacity within the state of UK is around 4460 MW which is predominantly covered by large hydro projects across the State. Around 3.8 GW of installed capacity is there followed by 210 MW of small hydro projects. Solar PV is around 295 MW. As a matter of fact, Uttarakhand's power supply is almost decarbonized in the context of within the State generation. Figure

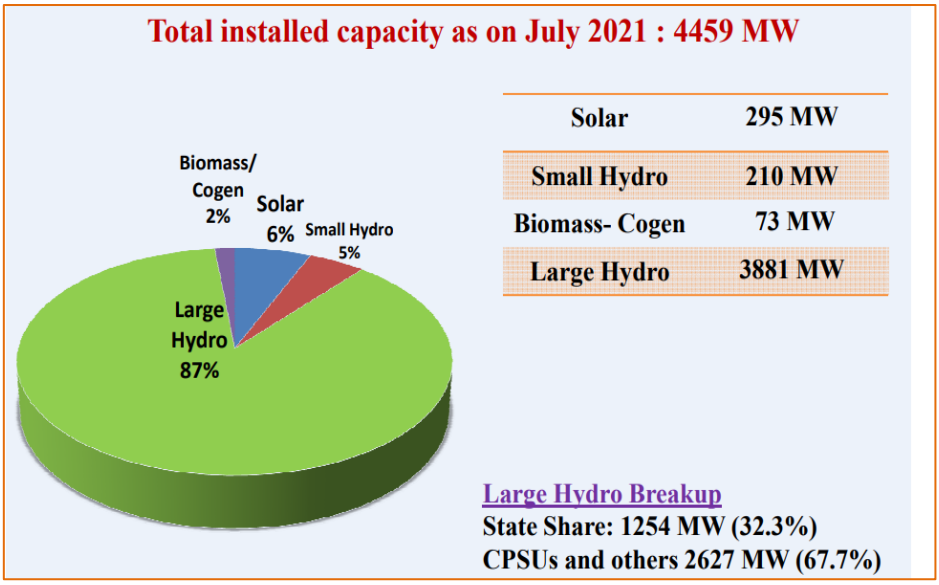


Figure 4: Generation capacity mix of the State

Note: **Total installed capacity of Hydro as of December 2022 is as follows:**

- Small Hydro – 186.90 MW (Excluding UREDA's Micro and Mini Projects)
- Medium and Large Hydro – 4001.15 MW (> 25 MW)

Medium and Large Hydro Breakup

- State Share – 1372.15 MW (34.29 %)
- CPSUs and others – 2629 MW (65.71 %)

The solar based power projects have been increased since 2015 (5 MW in 2015 to 300 MW in 202) indicating a positive sign towards energy transition. The generation through large hydro power plants still contribute more than 60% of the state's power requirements. The generation from Renewables has contributed significantly to the total generation mix in 2020.

B> Energy Demand

Agriculture

Uttarakhand is a well irrigated state with majority of the cropped area under irrigation. Uttarakhand's share in total geographical area of India is 1.6%. The main sources of energy consumption in the sector are tractors, thrashers, and pump sets in the state of Uttarakhand.

On the cultivation side, the major agricultural (principal) crops grown in Uttarakhand include rice, wheat, maize, pulses, sugarcane etc. For calculating the RE potential from biomass, a conversion factor of 1.5 ton per MW power per hour is taken. This means annually 700 MT of biomass is required for producing 1 MW of power production. **Assuming the entire available surplus is utilized for power production, a surplus biomass ranging between 11-12 million tonnes per annum will be able to produce between 15.7-17 GWh of power every year.**

Building

Buildings constitute a big proportion of electricity consumption in the state. Within the building sector (including govt. buildings), domestic sector forms the bulk consumer and has been growing consistently. The electricity demand is rising sharply because of rapidly increasing use of electrical energy because of urbanization, increasing affluence and intensive rural electrification programme.

The domestic sector accounted for 9% and commercial sector with 6% of the total electricity consumption in the state in FY 2018-19. The commercial sector constitutes government & private establishments, hospitals, hotels, restaurants, educational institutions, malls etc.

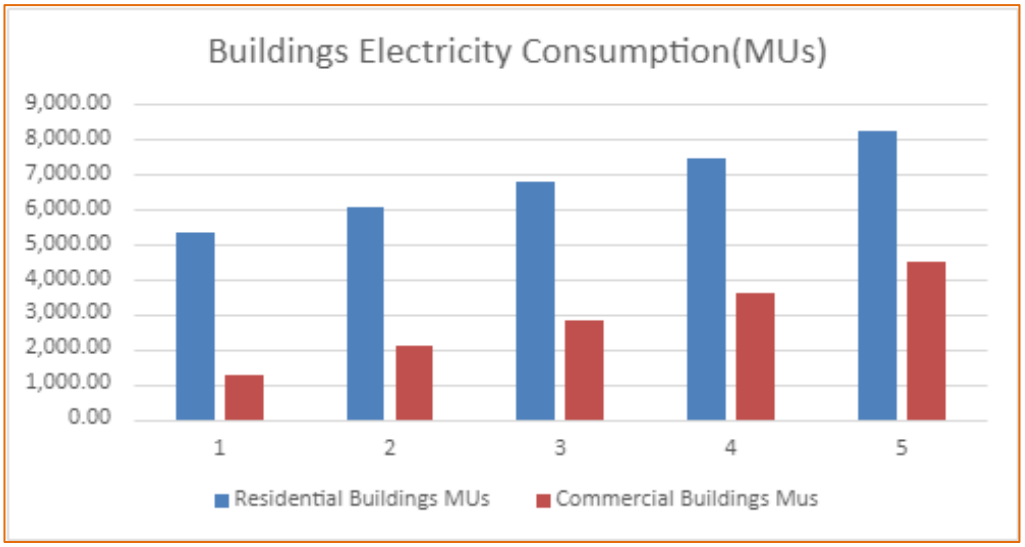


Figure 5: Building electricity consumption pattern of UK (2015-2020)

Cooking

The main fuels used in the cooking sector are solid hydrocarbons (i.e., coal and biomass), liquid hydrocarbons (i.e., LPG and kerosene), gaseous hydrocarbons (i.e., PNG and biogas) and electricity. As per Uttarakhand Census 2011, there are in total more than 18 lakh households in the state of Uttarakhand, rural households have 69.77% of the contribution and remaining 30.23% is contributed by the urban households. As per the Census of India 2011, more than 90% of the households in Uttarakhand utilize firewood and LPG as a major fuel for cooking. Almost half (48.68%) of the households in the state are using biomass as a fuel for cooking. In rural households of the state, the share of biomass in cooking further increases to 63.29%. This may be attributed to easy availability of biomass or agricultural residues at zero private cost from nearby forests or agricultural farms to rural households in Uttarakhand. Apart from biomass, LPG is also used widely for cooking in the state with 44.23% of households dependent on LPG. The percentage of LPG using households in urban areas is 79.42% and for rural areas, it is 29.40%.

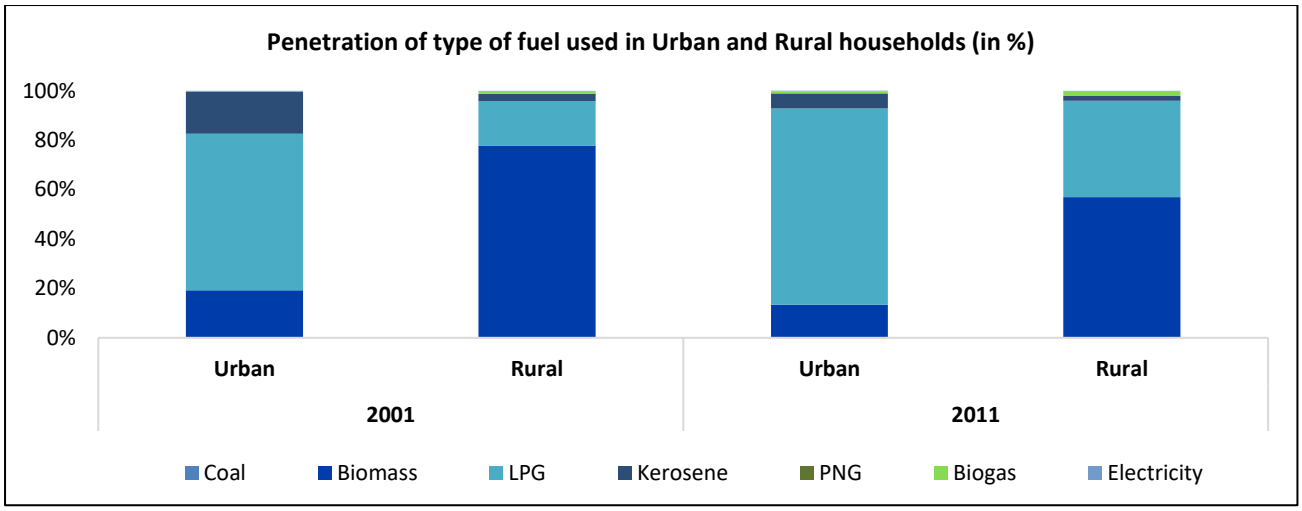


Figure 6: Penetration of type of fuel used in Urban and Rural households of Uttarakhand (%)

Industry

Uttarakhand has a strong base of industrial units clustered into key sectors namely- Auto Components, Agriculture Implements, Bicycle Parts, Hand Tools, Foundry, Forging, Steel Re-Rolling Mills etc. The main sources of energy in the industry are electricity and various other hydrocarbon fuels namely, solid, liquid, and gaseous hydrocarbon. Table below shows the share of industrial outputs by type of industries which indicates that chemicals and fertilizer, MSME (others) and Iron & Steel are the major consumers of energy in the State.

Industry Type	Toe	Share
Textiles	2,705.82	2.5%
Paper & Pulp	1,038.70	1%
Petrochemicals	1,762.19	2%
Chemicals and Fertilizer	30,700.65	29%
Others	63,279.80	61%
Iron & Steel	4,801.85	4.5%
Total Consumption	**104,289.01**	**100%**

Transport

The use of passenger transport is considerably higher in the state of Uttarakhand. 2-wheelers and private cars are more prevalent in the state as compared to taxis, buses, and LMV-passenger. The total no. of registered vehicles has witnessed a 12.76% CAGR growth rate between 2007 to 2017 in the state of Uttarakhand. Out of the total number of registered vehicles, over 90% of the transport-passenger vehicles run on petrol-majority of these vehicles being 2-W and remaining running on diesel and penetration of electric vehicles being minimal in 2021.

2.5 Overall approach of developing the EAP

Data analysis was undertaken by building an energy model using MESSAGEix integrated framework which is a versatile, open-source, dynamic systems-optimization model. To build the model, the first step was to create a Reference Energy System (RES) for the base year, which maps the energy flow, starting from its primary level i.e., resource extraction to final energy level i.e., demand level utilization. The RES presents all inflow and outflow of energy, conversion efficiency, losses etc. for each energy commodity used in the system. After this,

model simulation has been done to forecast energy supply and final energy demand (Agriculture, Building, Cooking, Industry and Transport) of the state up to 2040.

After building the model, baseline, or business as usual (BAU) scenario of optimal energy supply and demand situation of the state was run. Thereafter, potential future scenarios namely, state vision scenario, ambitious, and aggressive scenarios based on sectoral visions, targets, and objectives in consultation with stakeholder departments were validated and developed. Based upon the model results, list of short-term, medium-term, and long-term measures/ recommendations in each sector to be undertaken in the coming years was developed to achieve the objectives of the preferred future scenarios.

The fundamental objective of energy planning is to link the energy sector to economy, society, and environment through a causal chain relationship. Energy generation is linked to demand of energy which is further linked to economic growth and development. The following figure depicts the flow of information/ activities followed in the overall process of preparation of energy action plan for the state of Uttarakhand:

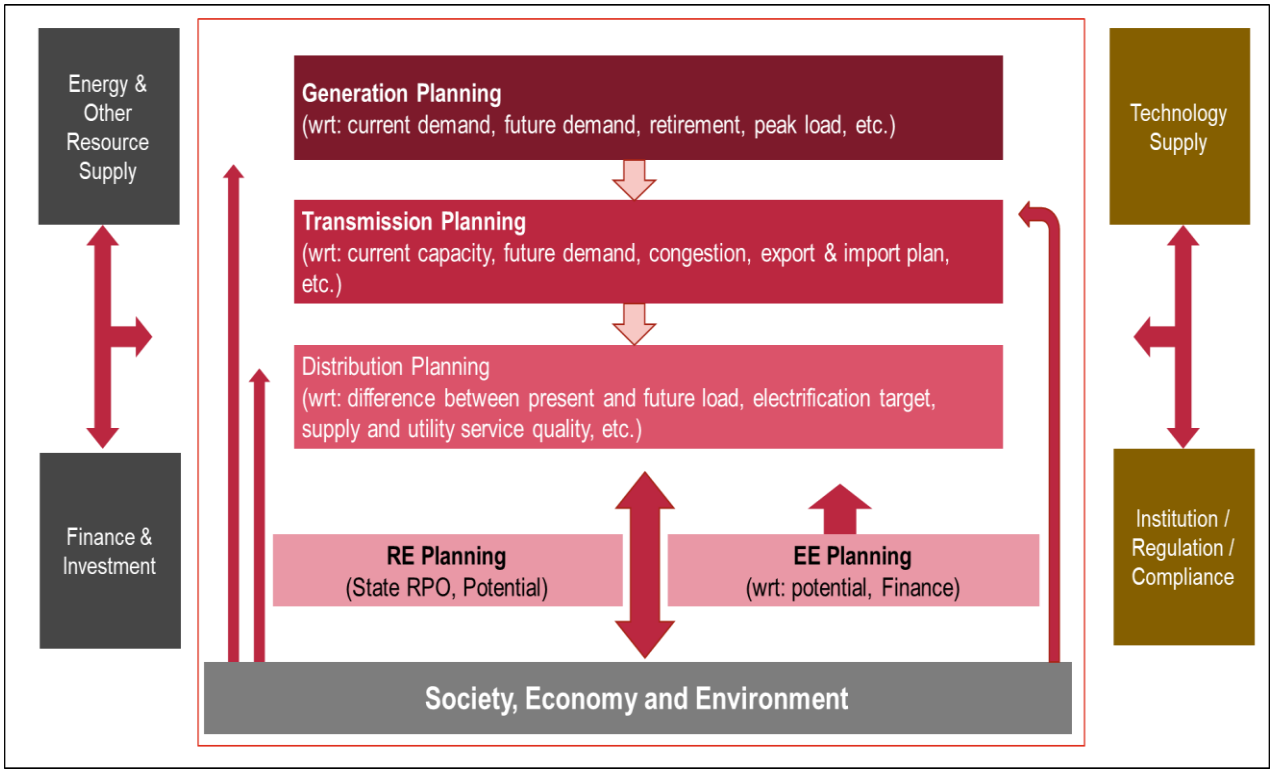


Figure 7: Schematics of State Energy Planning

2.6 Structure of the Energy Action Plan

Given the complexity of macroeconomic scenario of any state along with cross-linkages with energy demand and supply sectors, it is important to develop an action plan which is integrated in nature and comprehensive in coverage. Keeping these two issues in mind the study has developed a detailed set of Energy Action Plans for the State based on the assessment of an optimization model.

The fundamental objective of energy planning is to link the energy sector to economy, society, and environment through a causal chain relationship. Energy generation is linked to demand of energy which is further linked to economic growth and development. Economic development takes place through social development, employment creation and other economic activities. Generation of energy has a variety of negative externalities, the most crucial one being air pollution and GHG emissions. Thus, generation technologies need to be upgraded to higher efficiency and cleaner technologies so that negative externalities can be minimized. Access to finance is critical for adoption of such advanced technologies in the market as well as increased awareness among end users on the benefits to adopting such technologies. To successfully implement such activities, a robust

institutional framework should be in place along with requisite policy and regulatory support. Thus, Energy Plan, apart from being multi-sectoral should also be multi-dimensional, catering to various functional areas as well. An idea of how this has been achieved in case of Uttarakhand is given in succeeding sections.

3.0 Baseline Assessment

The baseline scenario assessment provides the optimal energy supply and demand situation for the State until 2040. The optimal condition identifies the least cost energy supply mix to meet the given energy demand in the state for each time step. The main purpose of identifying the optimal baseline condition is to define the reference for assessing the alternative scenarios of developmental pathways. The baseline assumptions are based on the understanding that all the existing government policies and plans are implemented successfully in the given timeline and energy demand and related assumptions follow historic trends.

The useful energy demand and technical parameters for each energy consuming component of the energy system are provided as input to the model. The major economic assumptions considered in the assessment are shown below. Based on various Governmental documents, departmental meetings and expert opinions the study further assumes the projected future of the State in various context of energy supply and demand until 2040. These projections are based on the understanding that there are certain policies and plans already adopted by the Uttarakhand State Govt. and in the process of implementation. The assumptions are as follows:

- ✓ To achieve around 5% plus GSDP growth rate in the State, the industrial energy demand shall grow minimum at the rate of 5% per annum.
- ✓ Under the National Solar Energy Mission, State shall promote solar energy and will made effort to utilizes its full capacity of 2 GW by 2040.
- ✓ State shall explore full exploitation of its small hydro potential of 1.5 GW by 2040 to reduce the purchase of expensive power from the grid or exchange.
- ✓ State is producing around 15 million ton of crop & other forest (including pine needles) residue along with other biomass and solid waste per year.
- ✓ Uttarakhand 2030 Vision document mentions that the State shall use 100% LPG and CBG for cooking purposes by 2030 replacing all forms of biomass utilization including fire-wood and commercial biomasses.
- ✓ To achieve higher utilization of biomass in non-cooking sector, use of agriculture residue for power generation and compressed biogas production is important. The State shall use around 20-25% of total biomass production from crop residues.

Based on the expected economic growth and prosperity of the state, it is assumed that the primary, secondary, and tertiary sectors of the economy are required to grow at a certain rate. Using the sectoral growths at the state level required to achieve the overall economic development the following energy demand outlooks are defined for the state to achieve by 2040.

Table 7: Sector-wise projected Annual Energy Demand Growth Rate (2020-40)

Sector	Growth Rates
Agriculture (Crop/ Horticulture)	-1.3% (Pumping Energy Demand) -3.3% (Machinery Energy Demand)
Building (Residential & Commercial)	4% for Commercial 6% for Residential
Industry	4.6% (Electrical and Thermal Energy)
Transport	2.6%
Cooking	5.65%

As the optimization model used in this study (MESSAGEix) is based on the principle of least cost optimization, the prime exogenous factor for the modelling analysis is the useful energy demand in the economy. The useful energy demand as explained in the previous section indicates the energy required to obtain economic services in the system, therefore the study assumes the useful demand for the state until 2040 for five major economic demand sectors as shown in the figure below:

3.1 Electricity Generation Mix

The electricity generation mix of the state comprises of imported electricity, hydro, coal, and solar systems. Under the baseline condition, the generation mix will grow at a CAGR of 2.5% between 2020 and 2040. The projected total generation of electricity will be around 28 TWh in 2020, and 47 TWh in 2040. Under the baseline scenario, imported electricity comprises the major share of electricity generation within the state. In 2020, it is observed that imported/ purchased electricity in the state comprises almost 44% of total power supplied followed by hydro (78.3%), biomass (1%), solar (5%) and small hydro (5.05%). Through the assessment of current policy conditions and based on cost optimization. The figure 9 below presents the electricity generation mix for the state between 2020 and 2040:

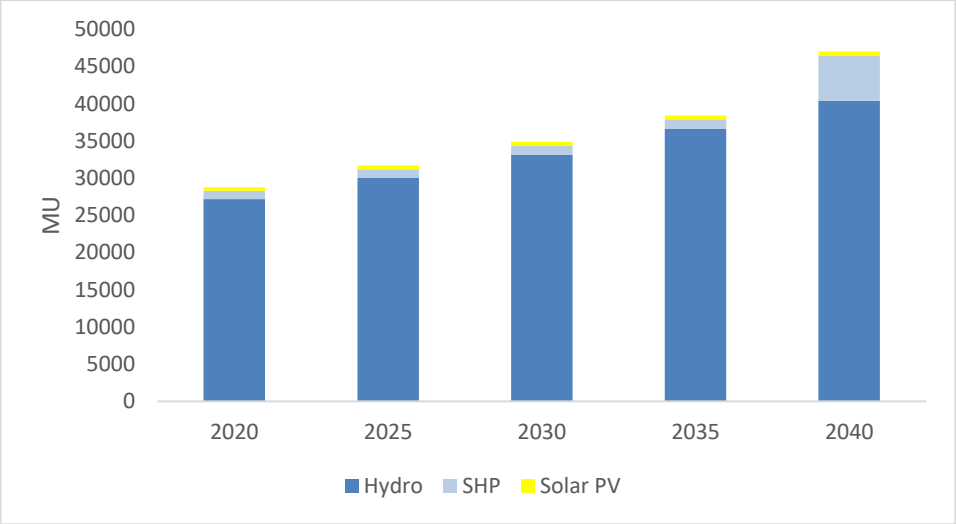


Figure 8: Electricity generation (TWh) mix of Uttarakhand

3.2 Capacity Mix

The state of Uttarakhand is expected to see slow growth of capacity addition (2.6%) commensurate to the electricity consumption growth rate (2.5%) between 2020 and 2040. Under the baseline condition, the installed capacity is projected to increase from 4.4 GW in 2020 to 7.4 GW by 2040. It is observed that state's major electricity generation is from hydro while the share of renewables (solar) is increasing from 2020 due to the progressive policies being contemplated by the state. The figure below presents the technology wise capacity mix in the state from 2020 to 2040:

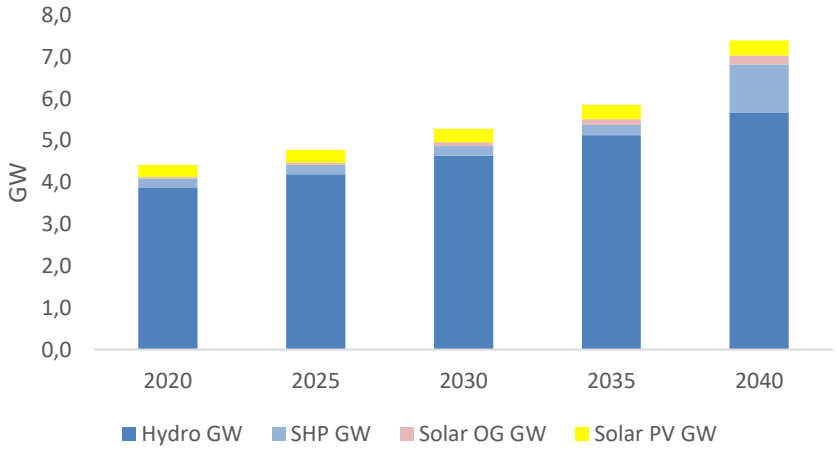


Figure 9: Power Plant Capacity (GW) by source in Uttarakhand

3.3 Final Energy Use

Energy demand at the end use point is considered as final energy demand here. The total final energy demand for Uttarakhand is an assessment of the final energy requirement across the following demand sectors – agriculture, building, industry, transport, and cooking. The final energy demand is projected to increase from 6 Mtoe in 2020 to 13 Mtoe in 2040 growing at a CAGR of 4%. It is observed that around 45% of the total final energy consumption in the state until 2040 is supplied through oil. The share of coal use at final energy level is expected to reduce from around 20% in 2020 to 12% in 2040. Also, the share of gas at final energy use is increasing from 4.52% in 2020 to 12.87% in 2040. Similarly, the share of traditional use of biomass is also reducing from 14.58% to 1.35% by 2040 due to the increased penetration of electricity, gas, CBG and solar. Figure 11 shows the final energy demand projection of the State.

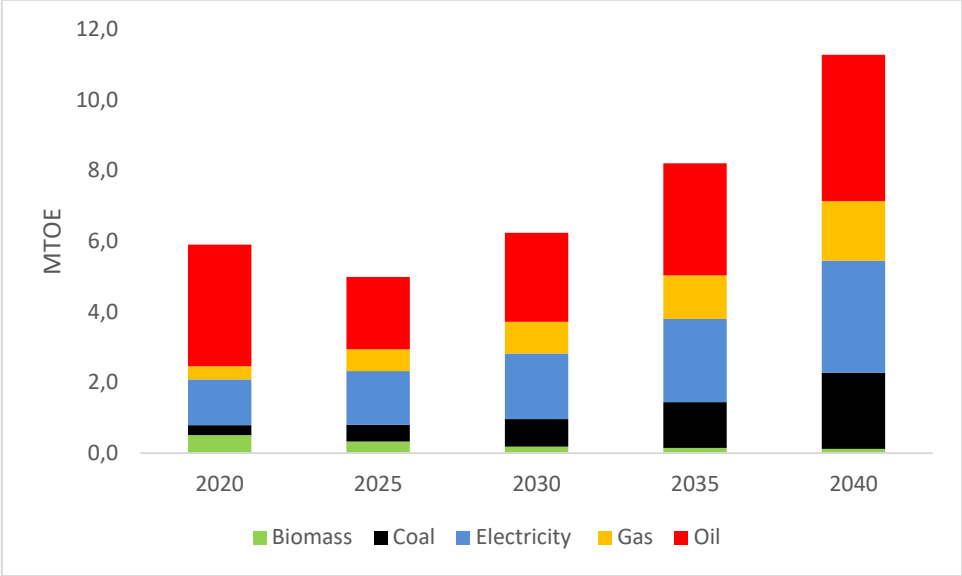


Figure 10: Final energy demand by fuel type

In terms of sectoral energy use, in 2020, transport is the highest followed by industry and buildings. Under the baseline condition, it is projected that the share of industrial energy consumption may reduce by 2040 given the current rate of industrial development and continuous energy efficiency improvement. The below figure highlights the fuel wise final energy consumption in the state under baseline scenario between 2020 and 2040:

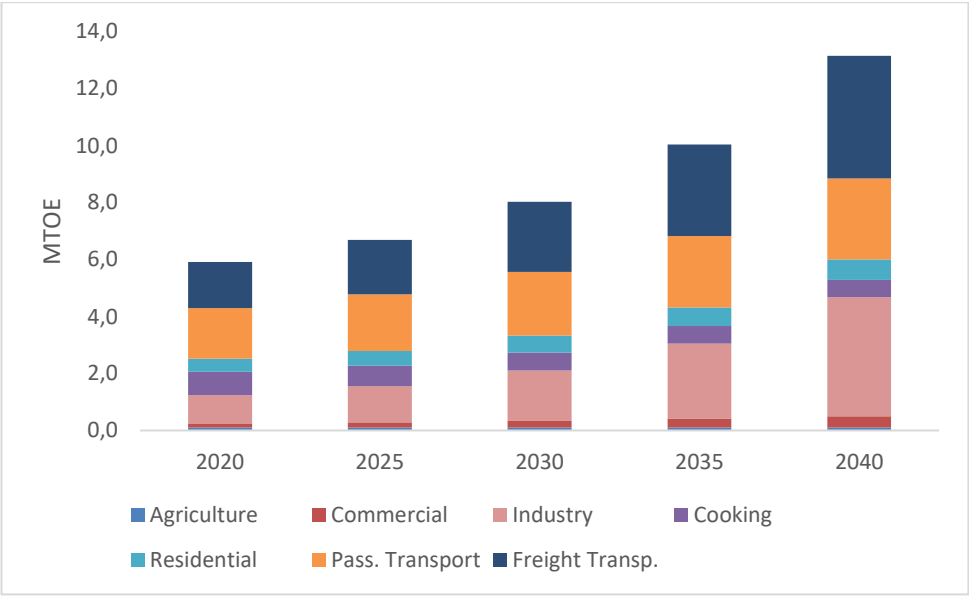


Figure 11: Final energy demand by Sectors

3.4 GHG Emissions profile of the State

Due to increasing energy production and consumption, the CO_2 emissions in the state are expected to grow steadily at an annual rate of 4.6% between 2020 and 2040. Under the baseline condition the CO2 emissions for the state from the energy sector of Uttarakhand would emit in total around 15 million Ton of GHGs (Mt CO2) in 2020, 20 MtCO2e in 2030 and 37 MtCO2e in 2040 of greenhouse gas (GHG) emissions.

Further, the emissions from the demand sectors are predominantly from the transport sector due to the increasing use of oil followed by the industry and cooking sectors. By 2030 more than 65% CO2 emissions in the State will come from transport sector followed by 22.7% from the industry. By 2040, industrial Co2 emissions (excluding process emissions) will reach the share of 33.5% while the transport sector emission share will slightly reduce to 60% primarily due to efficiency improvement and fuel shift towards electricity and gas. The figure below shows projected CO2 emissions by sector in the State of Uttarakhand between 2020 and 2040 under the optimal energy supply and demand condition.

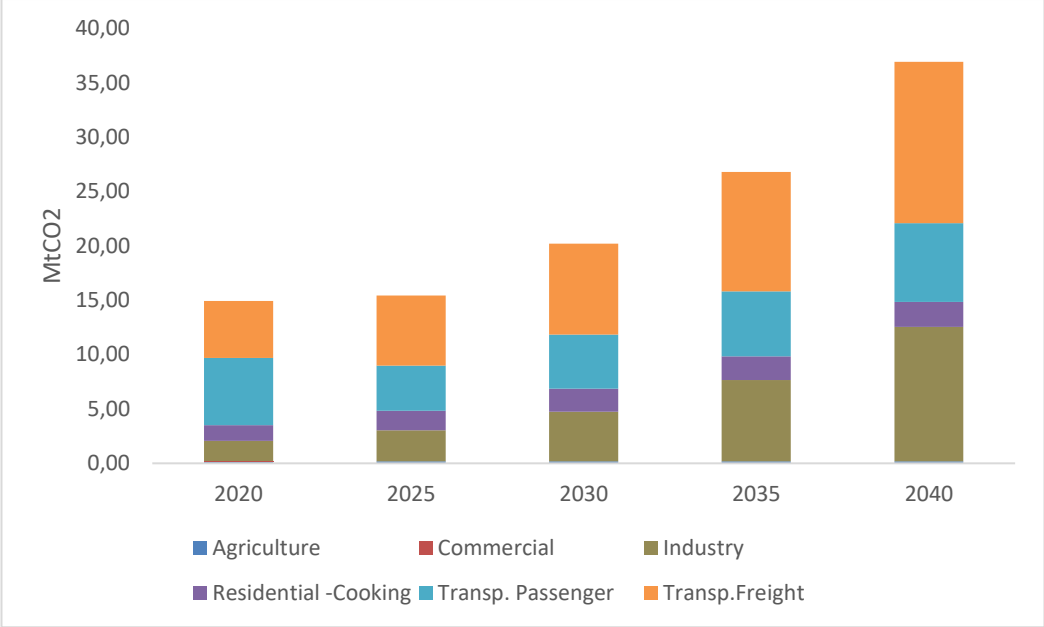


Figure 12: CO2 emissions projection by sector

The state at present is meeting its energy demand mostly through fossil and hydro based energy sources (including power generation). These fossil sources include Coal, Oil, and gas, of which all these resources are being imported from outside of the state. In addition to this, the agrarian state and with ever green forest cover exhibits a high biomass production, through agricultural residue along with other biomass wastes like pine needle, etc. Oil is observed to be maximum energy provider (58% in 2020) to the state fulfilling the energy demand for transport and agriculture sector, and the trend is expected to continue under the baseline conditions. Coal based energy supply is expected to increase in the State if no action is taken especially in the industry use by 2040. The coal share is expected to be around 20% by 2040 from 5% in the current year. Electricity which is mostly coming from hydro source provides more than 22% of energy supply in the State as of 2020 and is expected to become 30% by 2040 under the BAU condition. This also indicates the State is also naturally in the process of decarbonization which will be an added advantage of the State to become net zero or deeply decarbonized.

4.0 State Energy Vision & Action Plan

Economic and infrastructural development in the state has led to degradation and over exploitation of natural resources of the state especially water, landslides in mountains and biodiversity, indicating that the state is rapidly exhausting its resources, thereby jeopardizing future generations. Hence, for maintaining the state's economic prosperity in future, concerted efforts would be required to protect the environment and promote sustainable use of natural 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. Moreover, the state vision also focusses on promoting energy self-sufficiency through reduction in import of fossil fuels and increasing in supply of energy resources generated within state and by increasing resource use efficiency across the value chain in various economic activities.

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 multi-dimensional, catering to various functional areas as well. Based on the discussion, the state's Energy Vision has been developed, as presented below:

Higher Living Standard

•Access to modern energy in an affordable and reliable manner.

a)Increasing per capita energy and electricity consumption in the State and thereafter, total electricity consumption and improving the standard of living.

b)Providing adequate supply of clean energy in the State in an affordable and reliable manner.

c)Creating scope of employment in the State in clean energy sector as State Government already launches schemes under MSSY scheme.

Cleaner Environment

•Reducing pollutions and other environmental externalities.

a)Utilization of full potential of renewable energy resources available in the State.

b)Promoting use of efficient technologies in energy production and consumption to reduce the consumption of natural resources.

c)Implementing the principles of circular economy by adopting 3R policies in energy production and consumption.

Wealthy State

•Ensuring the growth of natural capital of energy and its related resources

a)Ensuring optimal use of energy resources in the State by bringing resource use efficiency in the system.

b)Reducing dependency on imported fuels and increasing optimal use of domestic resources.

c)Recognizing the importance of resource use nexus, creating an integrated planning and monitoring framework for energy production and consumption in the State

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4.2 Mapping of State Energy Visions

State energy visions are classified into three main categories: Improved Energy Access, Green Energy Production and Growth of Natural Capital. Energy Action Plan has been developed in a way such that all three areas are fulfilled through several set of activities over the period until 2040. Following table shows the mapping between different sectoral interventions proposed for Uttarakhand to act upon and the State Energy Vision. This mapping is extremely important for the policy makers to understand the impacts areas of a new policy and to revise and update the existing policies in the future.

Table 8: Mapping of Energy Vision and Action Plan

Sectoral Intervention	Access to modern energy	Cleaner Energy Production & Consumption	Growth of Natural Capital
A. A. Energy Resource			
Promoting resource extraction efficiency		✓	
Exploration of new resources	✓		✓
Creating infrastructure for efficient transportation of resource materials		✓	
B. Electricity Generation			
Increasing utilization of existing assets	✓		✓
Promotion of renewable energy generation	✓	✓	
C. Transmission and Distribution			
Reduction of T&D losses	✓		
Creating new assets for improved capacity of power evacuation	✓		✓
D. Agriculture sector			
Fuel shift in irrigation activities (diesel to electricity)	✓	✓	✓
Renewable energy use in irrigation pumping	✓	✓	✓
Renewable energy use in tractors	✓	✓	✓
E. Cooking Sector			
Fuel shift from biomass to LPG	✓	✓	
Higher penetration of electricity as cooking fuel	✓	✓	✓
Introduction of PNG in urban areas	✓	✓	✓
F. Residential and Commercial Sector			
Implementing stricter building energy efficiency plans		✓	
Stricter use of energy efficient cooling technologies		✓	

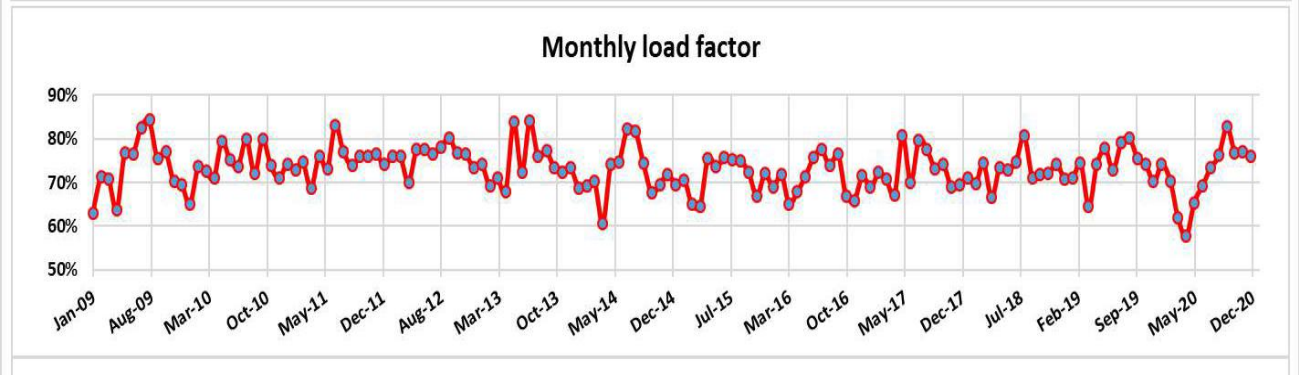
Use of renewable energy for heating and lighting demand	✓	✓	
G. Industry Sector			
Fuel Shift towards cleaner fuel	✓	✓	✓
Process efficiency improvement (mainly small and medium scale industries)		✓	✓
Renewable Energy Technology	✓	✓	✓
Reduction of specific energy consumption of industrial sector by following PAT norms		✓	✓
H. Transport Sector			
Fuel shift (Shifting to electric mobility)	✓	✓	✓
Modal shift (shifting to efficient transportation mode ~rail/metro)		✓	✓
Fuel efficiency (Greater emissions reduction)		✓	

5.0 Low Carbon Pathways for the State

Hydro is primary source for electricity generation in the state and accounted for 78% of the total electricity supply in the state and coal close to 35% of the industrial energy demand in 2020. As the state has no coal reserves, the state is dependent on the coal imports from eastern part of India, where most of the Indian coal reserves located. With the economic growth and electrification under the baseline condition.

The state is endowed with plenty of biomass and renewable resources comprising of small and micro hydro, solar and waste to energy. The state's own potential of large-scale hydro (>25 MW) is around 25000 MW which is yet to be fully exploited. Besides, that state is endowed with 3000 MW of small hydro (SHP) potential followed by around 2000 MW of solar potential (4~7 kWh/m^2 solar insolation).

At present, the UUPCL is procuring expensive renewable energy under the RPO obligation from within the state generators. UPCL's IPP power purchase agreements are also biased towards the generators who are protected under the clause of mandatory fixed charges of payment from UUPCL irrespective of power generation. Such inherent bottlenecks and challenges further exacerbate the expensive nature of power in the state thereby placing it in a vulnerable situation. As per the study conducted by Power System Operation Condition (POSOCO) in 2016, Uttarakhand's peak demand is almost 120% of the lean demand recorded throughout the year. As a matter of fact, as of March 2023, Uttarakhand required around 2,400 MW per day of peak demand capacity while only 500 MW is available from the state's own resources. The remaining 1900 MW power is being mobilized from Energy Exchange. The power demand remains high for winter four months (Oct-Jan) and it starts reducing after that. It is also a matter of concern for the State as during winter the State's major hydro supply units run under less water and corresponding production due to snow and less rain. As a matter of fact, State's drawl from the exchange increases significantly during the winter season.



Based on the above description of the state energy supply and demand and long-term estimation under the baseline conditions, the following section will discuss about the multiple low carbon (LC) scenarios developed for the state evaluating various low carbon interventions required and their impact on the overall energy demand of the state.

Given the State of Uttarakhand's power demand profile which is seasonal and load factor varies between 56% to 85% depending upon the supply, the EAP of the State promotes three possible Low Carbon scenarios with majorly promoting the State's untapped hydro potential including large and small and decarbonising the sectoral energy demand by replacing fossil fuels with various renewable sources. The following section explains the scenarios in detail.

5.1 Low Carbon Scenarios

There are three different low carbon scenarios developed after detailed stakeholder meetings in the State involving all major beneficiary departments. The following section describes how the scenarios are built for the State following the stakeholders and experts' guidance and recommendations.

Based on consultations with the state nodal agency, three low carbon scenarios have been developed focusing on harnessing different level of renewable energy potential in the State by 2040. The scenarios are also built on various levels of energy efficiency improvement in energy consumption by sectors, fuel and mode shift in passenger and freight transport segment etc. The scenarios are also built on use of various levels of biofuels and biomass in the respective use segments like transportation and industrial use. Scenarios are also built on the idea of making the State of UK more self-reliant by augmenting its existing hydro capacity.

Thus, three low carbon scenarios are developed such as: **ambitious scenario**, **state vision scenario** and **aggressive scenario**. The aggressive scenario developed for each of the sectors assumes that the entire renewable energy and energy efficiency potential available in the state is being exhausted and the ambitious scenario is a step ahead of the aggressive scenario. This is to mean that the ambitious scenario developed for each of the sectors assumes 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 and necessary climate resilience is achieved through self-sustaining energy system while ensuring access to modern energy supply to all even during the natural disasters.

Figure 13: Alternative energy transition pathways of Uttarakhand

5.1.1 Power Sector

For LC scenarios in the power sector, synergies have been drawn from State vision to promote renewable energy. The state has already a major share of electrical energy being generated from Hydro based power. Currently, the state of Uttarakhand is a surplus state in electricity but moving on with the new demand with increasing population. Hydro, SHP, and Solar PV are the potential resources for additional power supply produced within the State. This scenario focuses on utilising Hydro and SHP are as follows by scenarios:

Table 9: Capacity addition target under different scenarios

RE Technologies	Ambitious Scenario		State Vision Scenario		Aggressive Scenario	
	Power	**Emission reduction**	**Power**	**Emission reduction**	**Power**	**Emission reduction**

Solar PV	300 MW	0.185 MMT	340 MW	0.2209 MMT	360MW	0.2222 MMT
Large Hydro	3000 MW	9 MMT	8000 MW	24 MMT	10,000 MW	30 MMT
Small Hydro	1400 MW	0.5 MMT	1600 MW	0.57 MMT	1600 MW	0.57 MMT

The Investment cost for Solar PV plant is approx. INR 85 million per MW. However, it is for large Hydro Plant and Small Hydro Plant is approx. INR 60 million per MW and INR 65 million Per MW respectively.

5.1.2 Cooking Sector

This scenario focuses in promoting Electric based cooking in rural areas and PNG and Electric based cooking in Urban areas as indicated in Draft National Energy policy by NITI Aayog. Electric based cooking is cleaner way to achieve Low carbon pathway in cooking sector whereas PNG is effective and efficient way to use Natural Gas a s source for cooking energy.

Ambitious scenario:

Family size biogas plants has been already promoted under Uttarakhand Bioenergy Programme[2]. A total of 6304 biogas plant have been installed in different districts of the state under this programme. A target of 5% share in cooking energy focuses on increasing the number of biogas installation to approximately 25000 Family size plants by 2040.

State Vision Scenario

As the name suggests, this scenario focuses on balanced use of Central and State visions to promote all the cleaner sources of cooking energy. The rationale is to use a balanced mix of energy sources and to use domestic renewable potential to meet the needs of cooking energy demand. Compared to Ambitious scenario further shift of cooking energy demand by 10% in rural cooking and 18% in urban cooking from LPG to Electric based cooking is expected towards further reduction of emissions from cooking sector by 2040.

Since the state has already available green sources of electrical energy, the electric based technology becomes most suitable option for decarbonization of demand sectors like cooking.

Aggressive Scenario

This scenario focuses on aggressive use of electricity-based cooking to achieve at least 40% of its cooking energy needs in rural areas and 50% of cooking energy needs in urban areas by 2040.

PNG is a possible effective and efficient way to transport gas-based cooking energy to households. Uttarakhand has already started building up PNG Networks in important cities like Roorkee and Haridwar[3]. This scenario also looks at the aspect of meeting a significant gas-based cooking demand in urban areas via use of PNG Network.

Table 11 summarises the cooking fuel mix shares under different scenarios used in this study.

Table 10:Cooking fuel mix under different scenario

Cooking Fuels	Ambitious Scenario	State Vision Scenario	Aggressive Scenario

[2] https://ureda.uk.gov.in/dpages/bio-energy-schemes
[3] https://www.hngpl.in/Pipeline-Network

Biomass Cooking in Rural	10%	5%	5%
Biogas Cooking in Rural	5%	10%	15%
Electric Cooking in Rural	20%	30%	40%
LPG Cooking in Rural	65%	55%	40%
Biomass Cooking in Urban	2%	0%	0%
Biogas Cooking in Urban	5%	10%	15%
Electric Cooking in Urban	30%	40%	50%
LPG Cooking in Urban	58%	40%	15%
PNG cooking in Urban	5%	10%	20%

5.1.3 Industry Sector

For industries in Uttarakhand the most dominant fuel in terms of thermal use is coal. Though the energy use share in Industry is less compared to other sectors the fuel mix for Industry must be shifted to green sources of fuel to promote sustainable energy use in Industries of Uttarakhand. Providing infrastructure for cleaner fuel sources for industry can help promote Industrialization in Uttarakhand.

Ambitious scenario:

Ambitiously shifting the coal use to a mix of gas and hydrogen can help industries in Uttarakhand to develop a green Industrial landscape. In this scenario 65% of thermal use in industries is met through use of gas reducing the significant amount of coal use. Along with use of gas, green hydrogen can replace use of coal by 30% in this case.

State Vision Scenario

Keeping a balanced approach towards maximizing the use of resources of the state green hydrogen takes a further leap of 10% in addition to Ambitious Scenario thereby reducing the gas based thermal use to 55%. This significantly reduces overall emissions of the industry 2040.

Aggressive Scenario

This scenario scopes the increasing use of Green Hydrogen by 2040 leading towards extensive reduction of emissions. It envisages promoting pathways that lead to Net-Zero. Potentially 45% of industrial thermal use can be met through green hydrogen. Energy Efficiency is scoped to improve by 5% in industries, thereby reducing the fuel demand.

Table 12 summarises the technology fuel mix shares under different scenarios used in this study.

Table 7: Industry sector targets scenario

Industry Fuel for Thermal use	**Fuel Mix**		
	Ambitious Scenario	**State Vision Scenario**	**Aggressive Scenario**
Share of Coal use for thermal use	0%	0%	0%
Share of Gas use for thermal use	65%	55%	55%
Share of Green Hydrogen use for thermal use	30%	45%	45%
Share of Oil use for thermal use	5%	0%	0%
Specific Energy Consumption Improvement	2%	3%	5%

5.1.4 Transport Sector

For the Transport sector, the major low carbon interventions are identified to be electrification and use of biofuels in various modes. Increasing share of electricity for public and private passenger transportation is the major means of decarbonization of the sector. The low carbon scenarios for the sector are therefore built based on increasing share of biofuel and electricity use.

Ambitious Scenario

Uttarakhand's Vision Document 2030 target sets the penetration of EV in the state to be 45% or more across all vehicle categories. Keeping this target in mind, it is assumed that share of total road-based passenger transport through electric vehicles in Uttarakhand will be 40% by 2040 in this scenario. This is also in line with the India's target of achieving 30% EV penetration by 20304. In freight transportation, it is assumed that the share of total freight transport running on electricity shall reach 15% by 2040. Since electric LCV are getting commercialized in the state, a gradual growth in electric LCV is assumed with an estimated share of 10% by 2040 along with a marginal presence of electric HCV (5%).

Biofuel blending of 20% by 2025 is considered as per the central government target[5] and has been kept constant till 2040.

State Vision Scenario

In this scenario, it has been assumed that the market for EVs for passenger transportation shall grow in the state and a draft EV policy shall be implemented, resulting in EVs becoming affordable. Therefore, a growing share of EV based passenger transportation has been considered in the road-based passenger transportation demand. Considering the economy of scale of the technology, the share of total road-based passenger transport through electric vehicles in Uttarakhand will reach 50% by 2040 in this scenario.

Similarly, with the implementation of EV Policy in Uttarakhand, LCV and HCV (electric) will also become affordable (given the incentive framework defined in the draft policy). It is also assumed that gradually diesel-based LCV will be phased out in the long run and therefore, LCV (EV) will be having a larger share in the road-based freight transportation. As such, a 30% share of road-based freight transport is estimated through electric vehicles under the state vision scenario (20% from electric LCV and 10% from electric HCV).

Biofuel blending of 20% by 2025 is considered as per the central government target and has been kept constant till 2040.

Aggressive Scenario

Here, it has been assumed that the market for EVs for passenger transportation shall grow in the state and draft EV policy shall be implemented, resulting in EVs becoming affordable. Therefore, a growing share of EV based passenger transportation has been considered in the road-based passenger transportation demand. Considering the economy of scale of the technology and taking the feedback from the stakeholder consultations in Uttarakhand, the share of total road-based passenger transport through electric vehicles in Uttarakhand is envisaged to reach 88% by 2040 in this scenario.

Similarly, with the implementation of EV Policy in Uttarakhand, LCV and HCV (electric) will also become affordable (given the incentive framework defined in the draft policy). It is also assumed that gradually diesel-based LCV will be phased out in the long run and therefore, LCV (EV) will be having a larger share in the road-based freight transportation. As such, a 66% share of road-based freight transport is estimated through electric vehicles under the ambitious scenario (26% from electric LCV and 40% from electric HCV).

Biofuel blending of 20% by 2025 is considered as per the central government target and has been kept constant till 2040.

Table 10: Transport sector targets

Passenger Car Modes	Fuel Share

[4] FullReport_Status_quo_analysis_of_various_segments_of_electric_mobility-compressed.pdf (niti.gov.in)

[5] https://www.niti.gov.in/sites/default/files/2021-06/EthanolBlendingInIndia_compressed.pdf

	Ambitious Scenario	State Vision Scenario	**Aggressive Scenario**
Car (20% BIODIESEL BLEND)	9%	10%	1%
Car (20% BIOETHANOL BLEND)	10%	5%	2%
Car (EV)	45%	60%	85%
Car (FCV)	1%	5%	10%
Car (CNG)	35%	20%	2%
2W (20% BIOETHANOL BLEND)	40%	25%	10%
2W (EV)	60%	75%	90%
3W (20% BIODIESEL BLEND)	30%	10%	5%
3W (EV)	40%	65%	85%
3W (CNG)	30%	25%	10%
Bus (20% BIODIESEL BLEND)	50%	35%	3%
Bus (EV)	30%	50%	80%
Bus (FCV)	5%	10%	15%
Bus (CNG)	15%	5%	2%
Taxi (20% BIODIESEL BLEND)	40%	35%	10%
Taxi (EV)	25%	50%	85%
Taxi (CNG)	35%	15%	5%
HEAVY DUTY VEHICLE(CNG)	15%	10%	10%
LIGHT DUTY VEHICLE(CNG)	20%	15%	10%
HEAVY DUTY VEHICLE(EV)	5%	10%	40%
LIGHT DUTY VEHICLE(EV)	10%	20%	26%
HEAVY DUTY VEHICLE (Oil)	45%	40%	12%
LIGHT DUTY VEHICLE (Oil)	5%	5%	2%

5.1.5 Agriculture Sector

Decarbonization of agricultural activities (irrigation pumps) in the State of Uttarakhand is envisaged to be done through solarization. Diesel and grid electricity are the two major sources of energy for irrigation pumping in the State. Under the low carbon scenarios increasing share of solar energy is considered.

Ambitious Scenario

This scenario scopes the use of electric pumps to meet at least 50% of the pumping demand by 2040. Further the efficiency improvement in technology is around 10% as covered under EESL[6] program which has been considered till 2040. The 10% target would be approximately around 2500 pumps for agriculture.

[6] https://ureda.uk.gov.in/dpages/agdsm

State Vision Scenario

Adding on to ambitious scenario the state vision scenario further extends the target for solar based pumping to be around 20% by 2040 which would be equivalent to distributing 5000 pumps. The electric based pumping will increase to 65% of share by 2040.

Aggressive Scenario

Complete electrification of agricultural pumping technologies has been scoped in this scenario with implementation of 80% of agricultural demand met using electric based pumping by 2040 and remaining using solar based pumps. This would eliminate the use of oil-based pumping in the agricultural sector of Uttarakhand leading to net-zero of the sector.

Table 11: Agriculture sector targets under ambitious scenario

Agriculture Pumps	Fuel Mix		
	Ambitious Scenario	State Vision Scenario	Aggressive Scenario
Electric	50%	65%	80%
Oil	40%	15%	0%
Solar	10%	20%	20%

5.2 Impacts of Low Carbon Scenarios

The following section describes the changes in energy consumption and corresponding impacts on GHG emissions under different LC scenarios described above in the State of UK. It is observed that under the State Vision and Aggressive LC scenario, the State requires 10% and 16% less energy consumption to meet the same energy demand due to various economic activities. Energy consumption growth rate reduces to 3.1% and 2.5% respectively under the State Vision and Aggressive LC scenarios compared to the 4% under the Baseline condition between 2020 and 2040. Figure …below shows the comparison of final energy consumption among different LC scenarios:

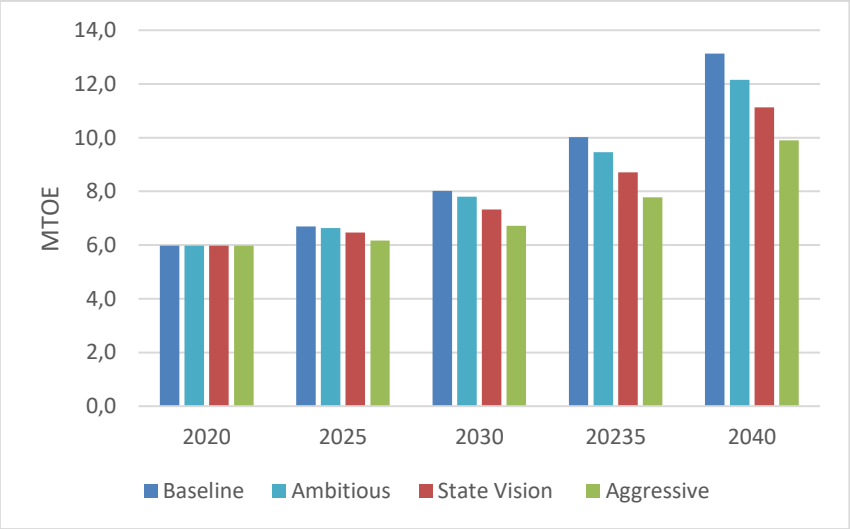


Figure 14: Comparison of final energy demand by scenario

Under different low carbon scenarios, it is observed that use of electricity as final energy source increased across the sectors of economic activities followed by reduction of use of pure liquid hydrocarbons like petrol and diesel, solid hydrocarbons like coal and biomass. It is assumed that across the scenarios including baseline and other LC scenarios, blending of biofuels by 20% is achieved. Therefore, consumption of unblended liquid

fuels was reduced across the scenarios in the State. Under the Aggressive Scenario, share of liquid fossil fuel could go down to 10% by 2040 compared to 58% in 2020. Due to significant push on Green Hydrogen program at the central level, following other states, Uttarakhand also envisaged to use green hydrogen to meet future energy demand especially in industry and transport sector. It is projected that under low carbon scenarios, hydrogen share in the total final energy mix could go up to 9% by 2040. Figure 14 below shows the comparison of share of different types of fuels under different scenarios by 2040.

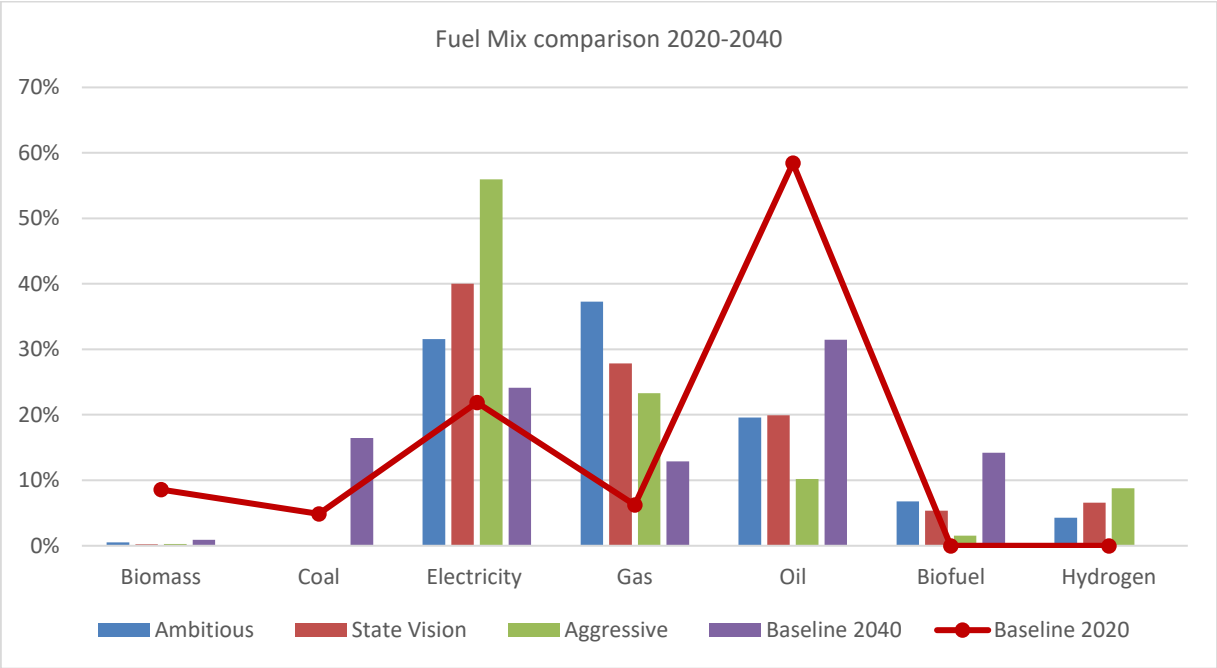
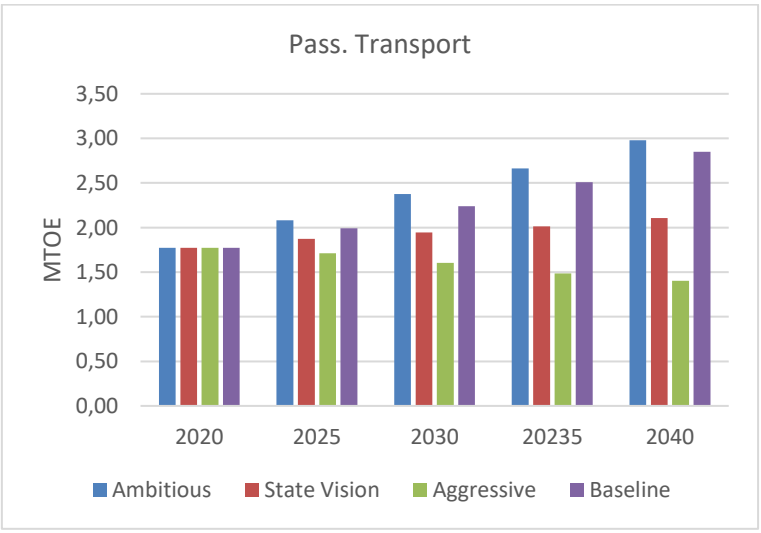


Figure 15: Comparison of fuel mix share under different LC scenarios

Under different LC scenarios of the State of UK, it has been observed that Industry, Transport and Cooking sectors are the majorly impacted sectors due to shift in fuel use and mode of operation. It is projected that under the Aggressive LC scenario the UK can reduce its emissions from the passenger transport segment by around 51% by 2040 compared to 2020 level. Similarly for the freight transport sector the emissions reduction potential is around 25% under the Aggressive Scenario by 2040 compared to 2020. Figure 15 shows the comparison of energy consumptions by transport sector under different scenarios. A major fuel shift in the transport sector is expected due to electrification. However, Gas and Hydrogen are two other fuels which could also play crucial role in the State. Due to hilly terrain, electric vehicle performances on the State roads are subject to further review.



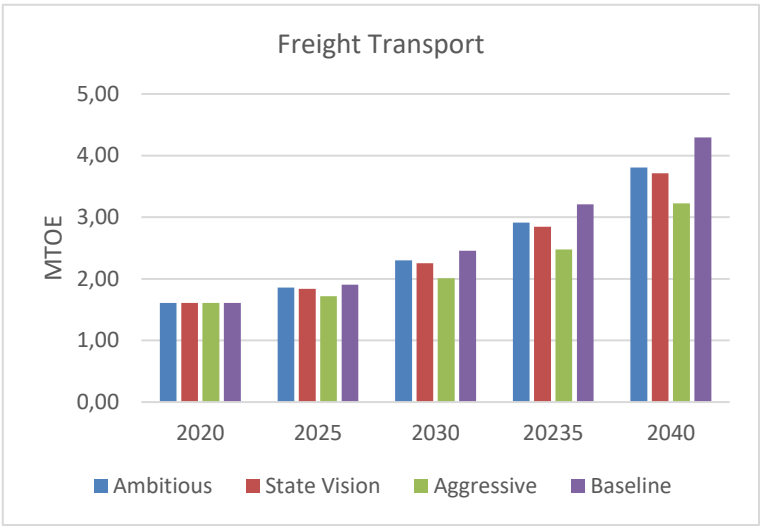


Figure 16: Comparison of energy consumption in transport sector

Industry is the second major sector to be impacted under the LC scenario. It is projected that the state has potential to supply industrial heat energy through biomass and green hydrogen using renewable energy in and outside of the State. State's biomass potential shall be utilized to replace the requirement of solid hydrocarbons like coal for heat energy requirement. Figure 16 shows the comparison of the industrial energy consumption under different low carbon scenarios:

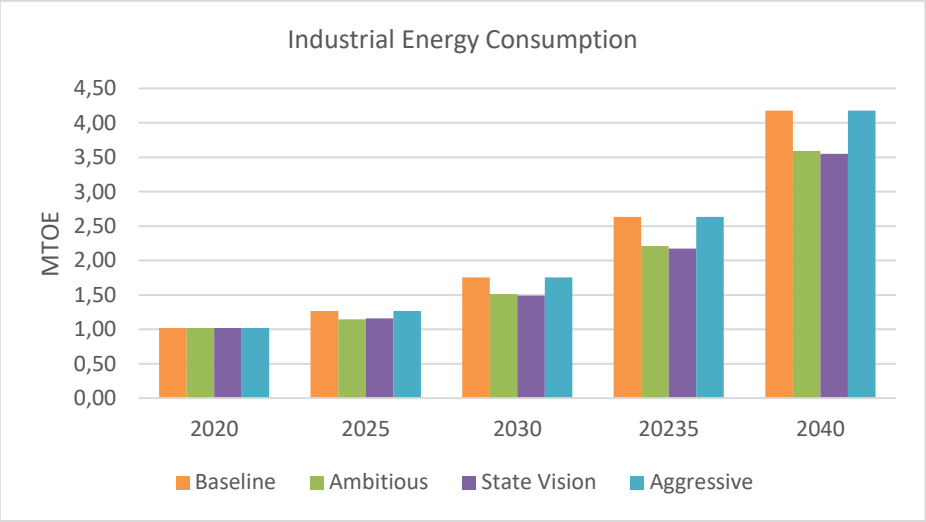


Figure 17: Comparison of industrial energy demand under LC scenarios

GHG Emissions

It is projected that under different LC scenarios GHG emissions are reduced significantly due to fuel shift. Under the aggressive LC scenario emissions reduction potential is around 60% compared to the base line condition in 2040. Industry, transport, and cooking sectors are the major sources of emissions reduction.

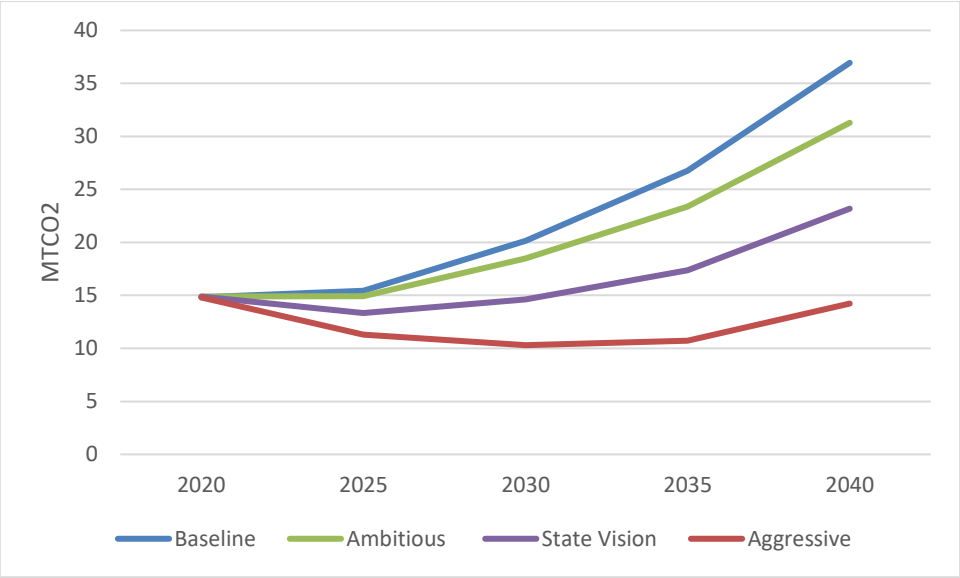


Figure 18: GHG emissions comparison

6.0 Action Plan for Energy Supply

The major source of power generation in the state includes large hydro, renewables (solar, mini/ micro hydro, biomass including CBG). For power generation, the primary data with respect to installed capacity of power plants and annual energy generation from conventional and non-conventional sources and other performance indicators viz. PLF/ APC/ Efficiency etc. has been collected from UPCL and UREDA.

The solar based power projects have been increased since 2015 (5 MW in 2015 to 305 MW in 2020) indicating a positive sign towards energy transition. e the generation through large hydro power plants still contributes more than 60% of the state's power requirements. The generation from Renewables has contributed significantly to the total generation mix in 2020. However, the energy generation through large hydro power in the state is 3.9GW in 2020.

6.1 Sectoral Vision

The following targets have been identified to drive the transformation of the energy supply sector of the state to achieve the Vision:

i. Power Generation – Renewable energy and energy efficiency

State has existing renewable-based power generation capacity which is yet to be fully utilized. There is a need to increase share of renewable energy in the total energy mix by focusing on the following thrust areas small hydel projects, biomass power projects, biomass cogeneration power projects, solar PV, solar water heating systems and solar streetlights, etc.

Vision: Promotion of renewable energy shall be prioritized. Rooftop Solar must be tapped in the State and subsidies should be introduced.

ii. Power Generation – Conventional

State has existing power generation capacity which is largely under-utilized and there is no immediate plan of introducing efficient power generation technologies. Also, generation potential from renewables in the state is yet to be fully utilized.

Vision: State will maximize the utilization of existing assets for power generation, reduction of losses, bringing in efficient power generation technologies in the future as much as possible.

iii. Power transmission and distribution

The distribution losses of the state are around 14-15% which has negative impact on the commercial condition of the DISCOM of the state. Revamping the power distribution systems can help address this issue.

Vision: State shall work towards reducing the T&D losses to the maximum extent possible

6.2 Existing initiatives

A. New and Renewable Sources of Energy (NRSE) Policy, 2013, renewed in 2022.

The policy aims to develop and promote new and renewable sources of energy-based technologies and energy conservation measures as well as providing financial & fiscal assistance, thereby addressing the problems arising from depletion of conventional sources of energy and environment pollution. This policy aims to achieve the following objectives:

- ✓ To maximize and improve the share of new and renewable sources of energy to 20% of the total installed power capacity in the state by 2022. NRSE sector wise details are mentioned separately.

- ✓ To promote renewable energy initiatives for meeting energy / lighting needs in rural areas and supplementing energy needs in urban, industrial, and commercial sectors.

B. Policy on net metering for Grid Interactive Roof-Top Solar Photo Voltaic Power Plants, 2017

Uttarakhand has also formulated a 'Policy on net metering for Grid Interactive Roof-Top Solar Photo Voltaic Power Plants' in 2017 which is applied to the distribution licensee and consumers of distribution licensee of the State of Uttarakhand. The eligible consumer may install the rooftop solar system under net metering arrangement. Notwithstanding the provisions of this Policy, relevant State authorities shall have the right to undertake rooftop solar projects up to 15 Kilo Watt Peak (MWp) capacity through alternative mechanisms.

C. Uttarakhand draft EV Policy, 2019

Uttarakhand EV policy has been developed with the following objectives, designed for direct and indirect impact on multiple UN Sustainable Development Goals (SDGs).

a) **Reducing Vehicular Emission**: To bring about reduction in vehicular emissions by end of policy[7]
b) **Adoption**: To drive adoption with an aim to have 25% of annual vehicle registrations as Electric Vehicles in the last year of policy
c) **Infrastructure:** To promote creation of public and private EV Charging Infrastructure in the state
d) **Manufacturing:** To establish Uttarakhand as a favoured destination for manufacturing electric vehicles, components, and batteries
e) **R&D**: To establish Uttarakhand as a R&D hub in electric vehicles led by a Centre of Excellence (CoE)

D. Improvement in power distribution system to reduce T&D losses.

The work being undertaken and planned to be undertaken by UPCL under various state and central level schemes to reduce transmission & distribution (T&D) losses.

6.3 Action Plans

A. Power Generation – Renewable

The state shall maximize the renewable energy resource utilization by promoting technologies and creating enabling environment for financial and regulatory support which can bring share of renewables to the level of 100% of total power generation in the state by 2040.

Activities

A.1: State shall conduct resource potential estimate for all categories of renewable sources within the state.

A.2: State shall explore the potential of developing decentralised solar PV especially agro PV and vertical solar PV on the farmlands.

A.3: State shall exploit the potential of biomass residue, and cattle waste as feedstock for power development.

A.4: State shall implement Draft NRSE Policy, 2013 which will provide the state's updated vision in renewable sector as well as the incentives to be provided for promoting renewables in the state including decentralised solar PV, biomass-based power, CBG.

A.5: Assessment of local level grid integration flexibility of LT network and creating digital grid map of the identified locations.

A.6: State shall ensure grid stability after integration of renewables in the power system.

B. Power Distribution

The state shall urgently focus on reducing the losses in the power system by adopting required technologies. By 2030 state shall reduce the distribution losses to 10% compared to 15% at the current level and by 2040 the state shall reduce the T&D losses to 7%.

[7] Policy valid for a period of 5 years from the date of notification

Activities:

B.1: State shall focus on strengthening distribution network by collecting and digitizing the line information and data (including assessment of substations and distribution transformers). State shall use modern technologies like GIS, SCADA, and pre-paid and smart meters for digitization of LT distribution network data.

B.2: State shall install infrastructure to prevent losses caused due to theft and damages due to natural disasters

B3: Creating a more robust and secure distribution infrastructure.

Table 13 below shows the summary of all activities and their corresponding sub-activities which are to be implemented over the period until 2040 to help achieve the targets in Uttarakhand Action Plan. The activities, which is further divided into sub-activities are derived from the State Vision statement. To achieve the objective of each sub-activity, multiple projects may need to be undertaken. Identification of these projects would be the next level of action required for implementation of the Energy Action Plan.

Table 12: Summary of action plans for energy supply side

S.No.	Sub-sector	Activity	Sub-activity	Scenario type	Time Period	Type of intervention	Implementing Agency
1.	**Power Generation-Renewable**	Utilization of renewable energy potential of state	Establishing the potential of renewable energy within the state	Aggressive; Ambitious	Short	Technical	URUREDA
2.			Incentivizing the development of Agro PV In Uttarakhand	Ambitious	Medium to Long	Financial	UREDA, UPCL, DoA
3.			Development of vertical PV on farmlands	Ambitious	Medium to Long	Technical	DoP, UREDA, UPCL, PWD
4.			Promoting development of biomass (including pine needle) power plants to increase share of renewables within state	Aggressive; Ambitious	Short to Long	Technical	DoP, UREDA, UPCL
5.			Promoting development of Waste-to-Energy plants in Uttarakhand	Aggressive; Ambitious	Short to Long	Technical	DoP, UREDA, UPCL
6.			Provide regulatory support to the private sector to increase penetration of solar rooftop enabling environment for increased penetration	Aggressive; Ambitious	Short	Regulatory/ Policy	DoP, UREDA
7.			Updating and Implementing Draft NRSE Policy, 2013	Aggressive; Ambitious	Short	Regulatory/ Policy	DoP, UREDA, UPCL
8.			Devising and implementing a state policy around biomass residue management	Aggressive; Ambitious	Short	Regulatory/ Policy	DoP, DoA, UREDA
9.			Supporting Research & Development of NRSE within Uttarakhand	Aggressive; Ambitious	Short to Medium	Market Development	DoP, UREDA
10.		Ensure grid stability due to integration of renewables	Undertake advanced load forecasting to ensure grid integration of renewables	Aggressive; Ambitious	Short	Technical	UREDA, UPCL, PTCUL
11.			Undertake capacity building of the DISCOM for managing RE integration	Aggressive; Ambitious	Short to Long	Technical	UREDA, UPCL
12.			Increasing penetration of power storage infrastructure and grid stabilization techniques	Aggressive; Ambitious	Medium to Long	Technical	DoP, UPCL
13.	**Power Transmission and**	Strengthening of transmission and	Modernize the power distribution system within the state	Aggressive; Ambitious	Short to Long	Technical	DoP, UPCL
14.			Introducing smart grid regulations in Uttarakhand	Aggressive; Ambitious	Short	Policy	DoP UERC

15.	**Distribution**	distribution network	Installation of infrastructure to prevent losses due to theft and damages due to natural disasters	Aggressive; Ambitious	Short to Long	Technical	UPCL
16.			Securing distribution infrastructure	Aggressive; Ambitious	Short to Long	Technical	DoP, UPCL

6.4 Scope of RE Supply Intervention in the State

The State of Uttarakhand is the endowed with plenty of natural resources including forest, wetlands & water bodies, sunshine. It is important for the State to explore all the possible sources of energy generation using these resources. Hydro is a common area of interest for the State as well as for the investors / promoters in order to fulfil the requirement of RPO. Nevertheless, hydro has its own pros and cons. Especially during winter due to water and silt generation is severely affected. This is an enough reason for the State to explore the alternatives when the State has a goal of becoming more decarbonized. Here the study highlights some of the important options for the State to explore.

A. Agro-PV

Integrating Solar with agricultural activities, the solar panels can be installed with higher ground clearance for letting the crop grow underneath. Additionally, unlike a typical solar farm where the solar panels are tightly installed to maximize land use, in agro PV, the solar panels can be installed with sufficient clearance for easy movement of the farmers and farm equipment. This shall also aid in water conservation on the farmland. Agro PV also offers to generate additional income for the farmer. A grid-tied solar panel enables farmers to sell the excessively generated electricity to utility companies. In India, a grid-tied solar panel of 100 MW installed on farmland of 6 acres in the Vidarbha region of Maharashtra generated an income of ~Rs. 21 Lakhs per annum (Mahto, et al. 2021).

B. Vertical PV

A variation in agro PV that can be of special interest to Uttarakhand is the use of bifacial panels arrayed in widely spaced rows, which in addition to the different generation properties, reduces dust accumulation. Vertical bifacial panel arrays have the property of generating maximum power in a morning and an afternoon peak, complementing the typical solar profile of midday peaking. One such layout is being trialled by India's National Institute of Solar Energy (NISE) as well as by Germany's Next2Sun GmbH.

C. Promoting use of biomass

Being a forest rich state, Uttarakhand has an immense potential of developing power from the use of biomass residue. According to Action Plan for Control of Burning of Crop Residue, Uttarakhand is producing around 15 million ton of residue produced every year (including pine needle). However, for biomass power plant developers setting up such plants only make sense when it is economically viable. The price of biomass should be the true reflection of what is the actual cost of pine needle and paddy straw at the boiler mouth to the biomass power plant developers. Uttarakhand has issued policies for promoting generation of electricity from biomass as part of its NRSE Policy 2018. However, there is a pressing need to formulate policies around strengthening the biomass supply chain. The 'Biofuel Policy of Rajasthan' is a good example in this regard.

D. Promoting Waste-to-Energy

In Uttarakhand, 2500MT per day of MSW is generated however, MSW had not been harnessed systematically on a significant scale for power generation. Further, only 10% of the MSW is collected in the state and rest is dumped in the open. It is important for the State to promote Waste to Energy facility to utilize the MSW and fulfil certain energy demand especially electricity and heating. The State being the tourist destination, it can develop the WTE policy linked to sustainable tourism policy as well. This can create an avenue for financial support to build and operate the plants.

E. Promoting solar roof top

The current grid connected solar installation of the state is around 320 MW (under four-year strategic action plan) with grid connected rooftop solar accounting for 4.9% of the total RE installed capacity (UREDA 2019). Since availability of large tracts of land in the state required for installing solar parks is limited (a solar PV installation of 1 MW requires 4 acre of land), promoting decentralised solar including rooftop solar (RTS) should be the recommended step to increase penetration of solar power in Uttarakhand.

F. Developing Technical Capacity of the State

Research & Development (R&D) is a priority focus area in the power sector. With a vision to provide sustainable and quality power to all in the state, it is not only necessary to ensure that, state-of-the-art technology is utilized but also that appropriate technology is developed keeping in view the social operating conditions in the state. The state government could look to allocate some budget to fund these R&D activities within the NRSE space in the state. The government could start by supporting the idea stage as part of its basic research efforts and to secure necessary patents.

G. Developing Power Storage Facility

Increasing share of renewable energy in the supply mix requires technology to store energy during power production (daytime with sunshine, time of higher wind speed etc.) which can be utilized during non-production time of the day. As a result, PLF of the RE power plants increases so as the system reliability.

6.4 Creating Jobs and Livelihoods while Energy Transition

The development of renewable energy projects within the state also present ample employment creation opportunities. These can be classified as direct and indirect jobs:

Table 13: Direct and indirect jobs are created through establishment of RE projects.

Category of job	Description of job
Equipment manufactures and distribution	R&D, Design (digesters, refineries, components, etc.), Quality assurance, Marketing and sales, Delivery
Project development	Design, Resource assessment, Environmental and social assessment, Financing, Land agreements, Permitting, Selection of supplier
Construction and installation	Plant construction, Pre-processing and upgrading, Processing, Quality assurance, Conversion (heat, power, or fuel)
Operation and maintenance	Operation and maintenance
Cross-cutting/enabling activities	Training, Management & Administration, Insurance, IT, Health and safety, Financing, Communication, power transmission, and distribution
Biomass Production	Cultivating, Harvesting, Transport

The labour-intensive nature of such projects can create employment for every MW of installed capacity.

Table 14: Job creation potential of RE projects (per MW)

Technology	Solar	Bioenergy	Waste to Energy
No. of Job / MW	7-10	15-18	23-25

6.5 Investment Requirement

The total investment required for implementing the activities mentioned in the Action Plan is provided in this section. The investment involves both capital investment in installing new infrastructure along with the operational cost for this infrastructure. Investment has been calculated based on current prices and empirical calculations for infrastructure development in each supply source. The table provides the total investment required in each of the 3-time frames i.e., short term (2022-25), medium term (2022-30) and long term (2022-40) in aggressive and decarbonisation scenarios:

Table 15: Investment requirement in energy supply sector in ambitious scenario (crores Rs.)

S.No.	Energy Supply Source	Short-Term (2022-25)	Medium-Term (2022-2030)	Long-Term (2022-40)
1.	Power – Conventional	-	-	-
2.	Power – Non-conventional	20,654	39,035	88,680
3.	Distribution	987	2,282	6,287

Table 16: Investment requirement in energy supply sector in aggressive scenario (Crores Rs.)

S.No.	Energy Supply Source	Short-Term (2022-25)	Medium-Term (2022-2030)	Long-Term (2022-40)
4.	Power – Conventional	-	-	-
5.	Power – Non-conventional	390,279	810,989	1,946,056
6.	Distribution	1,315	3,328	10,129

7.0 Action Plans for Energy Demand Sectors

7.1 Agriculture Sector

The state has 0.8 million ha of cultivated area constituting 14% of total geographical area. Over 55% of cultivated area is rainfed with frequent moisture stress to crops. The soils are low to medium in fertility status. The important crops are rice, wheat, finger millet and maize. Out of the total, about 89% are under small and sub marginal. As large number and area is under small and marginal holdings, scale of economies cannot be availed of, and so the input cost per unit of output is higher.

There are two types of agricultural practices i.e., the rainfed and the irrigated. Most of the agriculture in the state is rainfed. The net irrigated area of the state is around 3.38 lakh hectares (2009-2010). The net irrigated area to net sown area for the state is 45%. Being large area under hills, irrigation is available mostly in the plains and valleys. So there is a need to generate alternate sources of irrigation to increase the net irrigated area, which in turn shall also increase the cropping intensity of the state. These alternative sources can be rainwater harvesting, check dams, lift irrigation etc. Technologies like drip irrigation, sprinklers etc. can also be used for better water management.

In summary, the State's agriculture sector in reeling under multiple problems which are hindering the growth and economic output of the sector linked to the farmers' income and livelihood. Renewable energy is envisaged to play a crucial role in this context to address the productivity and income generation issues of the marginalized farmers with small land holdings. Where the fragmented lands are not economic for deployment of large size farm machines or irrigation system, RE based standalone systems can bring the revolution. Sectoral action plans identify the activities to be performed in a time bound manner so that the desired outcome is achieved.

Sectoral Vision

The 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.

Action Plan

a) Objective: State shall replace 80% of energy requirement for pumping from diesel to solar by 2040 and complete phasing out of diesel pumps by 2040

Activity:

A.1: State shall increase penetration of solar pumps by developing adequate financing mechanisms

A.2: State shall create market mechanisms as well as generate awareness to increase uptake of energy efficient pumps

A.3: State shall explore the potential of developing decentralised solar PV especially agro PV and vertical solar PV on the farmlands.

b) **Objective:** State shall improve energy efficiency and increase penetration of renewables in post-harvest activities

Activity:

B.1: State shall increase penetration of solar power micro cold storage

B.2: State shall increase private sector participation in establishing energy efficient post-harvest processes and infrastructure

B.3: State shall facilitate availability of e-tractors

Table 17: Summary of action plans for agriculture sector

S.No.	Sub-sector	Activity	Sub-activity	Types of scenarios	Time Period	Type of intervention	Implementing Agency
1.	**Agriculture Sector**	Increase penetration of energy efficiency and solar power in value chain	Increasing productivity of farmers using renewable energy (including solar, CBG, etc.)	Aggressive; Ambitious	Short to Long	Technical	UREDA, Department of Agriculture
2.			Distribution of energy efficient pumps to replace existing inefficient electric pumps	Aggressive; Ambitious	Short to Medium	Technical	UREDA, UPCL
3.			Increase construction of energy efficient cold storage working on solar power	Aggressive; Ambitious	Short to Long	Technical	UREDA
4.			Develop co-operatives to provide financial support for procurement of solar pumps and energy efficient pumps by farmers	Aggressive; Ambitious	Short to Medium	Financial	DoP, Department of Agriculture
5.			Promote installations under PM KUSUM scheme in the state	Aggressive; Ambitious	Short	Capacity building / awareness generation	UREDA
6.			Facilitation of e-tractors for farmers	Ambitious	Short to Long	Technical	UREDA
7.			Promotion of Micro Irrigation to increase water use efficiency in irrigation	Aggressive; Ambitious	Short to Long	Awareness generation	Department of Agriculture
8.		Capacity building / Awareness creation	Undertake awareness Programme for disseminating benefits of energy efficient pumping and irrigation systems as well as solar powered pumps to farmers through co-operatives, gram panchayats etc.	Aggressive; Ambitious	Short to Medium	Awareness generation	UREDA, Department of Agriculture
9.			Continue promotion of crop diversification	Aggressive; Ambitious	Short to Long	Awareness generation	Department of Agriculture

7.2 Buildings Sector

In this document building types have been defined in line with the DISCOM definitions – residential and commercial buildings (including government buildings), which correspond to domestic and commercial consumer categories of distribution companies, both in rural and urban areas respectively. Energy consumption in buildings is due to usage of lighting, household appliances and commercial heating, ventilation, and air conditioning (HVAC) systems and primary source of energy is in the form of electricity with diesel being the other source of energy in this sector.

Within the building sector (including government buildings), domestic sector forms the bulk consumer and has been growing consistently. The domestic sector accounted for 9% and commercial sector accounted for nearly 5% of the total electricity consumption in the state in FY 2018-19. Air conditioners and refrigeration form the bulk of the electricity consumption in the sector followed by lights and ceiling fans. Since the state has achieved 100% household electrification in 2018, it is expected that share of rural consumption will grow further.

It is projected that electricity (main source of energy) consumption in building sector (residential and commercial) will keep increasing between now until 2040 due to expected economic growth, population and increasing tourists' footfalls in the State. the expected combined growth rate of power consumption in the building sector is around 6% per annum which is reasonably good for the power distribution companies to keep a good prospect of expansion and development of the network within the State. Managing the T&D losses which is still very high (around 16%) in the State is a major concern for the DISCOM.

There are multiple initiatives which are being undertaken in the energy sphere for building sector in the State which can provide necessary support for sustainable and low carbon development of the sector. The list of enablers in the State is as follows:

- ✓ Energy Conservation Building Code (ECBC) in Commercial buildings sector.
- ✓ Eco-Niwas Samhita (ENS) in residential buildings sector
- ✓ Net-Zero Energy Buildings (NZEB)
- ✓ Uttarakhand State Vision 2030 targets
- ✓ Notifications/ Demo projects
- ✓ Unnat Jyoti by Affordable LEDs for all (UJALA)

Sectoral Vision

Residential and commercial sector, combined, accounts for over 4% of the total energy consumption of the state in FY20 and is the third most energy intensive demand sector after transport and industry.

Therefore, *State shall achieve improvement in energy performance of residential (15%) and commercial buildings (25%) through focus on implementation of ECBC and increased use of renewables including solar roof-tops and water heaters.*

Action Plan

Residential Sector

a) **Objective:** State shall increase the penetration and ownership of BEE star labelled energy efficient appliances and solar water heaters in residential sector.

Activity:

A.1: State shall provide financial incentives to retail consumers for increasing uptake of BEE star labelled energy efficient household applications and solar water heaters.

A.2: State shall conduct feasibility studies, pilot projects and adopt technologies that include demand side management (DSM) and demand response (DR) measures.

b) **Objective:** State shall set the targets for mandatory implementation of energy conservation building code (ECBC) in residential buildings.

Activity:

B.1: State shall proactively implement ECBC for residential sector and provide adequate institutional, regulatory and infrastructural support to ensure stringent implementation.

B.2: State shall generate awareness and conduct capacity building programmes among relevant stakeholders and at various levels including skilled manpower for enabling green construction.

Commercial Sector

c) **Objective:** State shall increase the penetration and ownership of BEE star labelled energy efficient appliances and solar water heaters in commercial sector.

Activity:

C.1: State shall create mechanism/ plan and implement projects to increase the uptake of BEE star labelled energy efficient household applications and existing electric water heater arrangement with solar water heaters.

C.2: State shall undertake outreach programs for relevant stakeholders to increase awareness of benefits of energy efficient appliances and solar water heaters.

d) **Objective:** State shall set the targets for mandatory compliance of energy conservation building code (ECBC) in commercial buildings.

Activity:

D.1: The benchmarking exercise/ studies shall be taken up by the state for further revision over time in Uttarakhand ECBC code based upon the building topologies.

D.2: State shall proactively implement robust institutional and regulatory framework to ensure implementation of ECBC code in commercial buildings along with adequate market capacity.

D.3: State shall increase awareness of relevant stakeholders on the benefits of adopting ECBC as well as prevalent regulatory requirements for compliance to ECBC.

D.4: State shall incorporate the best practices from the three rating systems into a single comprehensive platform to create awareness among the stakeholders that addresses every aspect of energy efficiency in buildings

The following table provides the list of identified strategies in the form of action plan to improve energy efficiency in building sector, including sub-activity, timeline, type of intervention and responsible stakeholders in the state of Uttarakhand:

Table 18: Summary of action plans for building sector

Sr. No.	Sector	Activity	Sub Activity	Type of Scenario	Timeline	Type of Intervention	Stakeholder
1.	**Commercial Buildings**	Implementation of ECBC code	Model regulations for Uttarakhand ECBC Rules 2020 for its incorporation and implementation roadmap along with requisite supporting infrastructure in the state by various stakeholder departments	Aggressive; Ambitious	Short to Medium	Regulatory/ Notification/ Institutional	UREDA, , Dept. of Town & Country Planning
2.		Market development to facilitate the implementation of ECBC code	Undertake awareness programs on building energy conservation and efficiency as well as building labelling systems.	Aggressive; Ambitious	Short to Medium	Awareness	UREDA
3.			Provide support to businesses (institutional and regulatory) support to businesses providing ECBC compliant building material and building energy management system	Aggressive; Ambitious	Short to Medium	Market Development / Policy & regulatory	UREDA, Dept. of Town & Country Planning
4.			Creation of centres of excellence to promote green buildings and strengthening R&D activities in collaboration with academia, industry, technical institutions, etc.	Aggressive; Ambitious	Medium to Long	Market Development	UREDA, Technical institutions/ centres
5.			Undertake the energy conservation buildings awards to incentivize uptake of energy efficiency and energy conservation	Aggressive; Ambitious	Short to Long	Financial	UREDA
6.		Increase the uptake of renewable energy integration	Encouraging development of building integrated PV	Aggressive; Ambitious	Short to Long	Technical	UREDA, UPCL, Dept. of Town & Country Planning
7.		Increase the uptake of energy efficiency and energy conservation measures/ activities	Undertake replacement of inefficient electrical equipment/ appliances with BEE star labelled energy efficient appliances and solar water heaters	Aggressive; Ambitious	Medium to Long	Technical	UREDA
8.			Develop and undertake pilot projects for demand side management (DSM) and demand response (DR) programs	Aggressive; Ambitious	Medium to Long	Technical	UREDA, UPCL
9.	**Residential Buildings**	Increase the uptake of energy efficiency and energy	Develop and implement loyalty program for building efficiency	Ambitious	Short to Medium	Financial	UREDA, Dept. of Town & Country Planning.

10.		conservation measures	Develop awareness of retail buyers on the benefits of energy efficiency for buildings and building labelling program	Aggressive; Ambitious	Short to Medium	Awareness	UREDA
11.			Develop implementation roadmap for demand side management (DSM) and demand response (DR) programs	Ambitious	Medium to Long	Technical	UREDA, UPCL
12.			Develop implementation roadmap of ECBC code for residential buildings	Ambitious	Short to Long	Institutional	UREDA, Dept. of Town & Country Planning
13.			Provide financial incentives to increase uptake of solar water heaters	Aggressive; Ambitious	Short to Long	Financial	UREDA
14.			Develop awareness on various rating systems including BEE, IGBC and GRIHA rating system	Aggressive; Ambitious	Short to Medium	Awareness	UREDA

7.3 Cooking Sector

For the EAP study, cooking sector comprises the fuel used by the households for cooking purposes. The fuels used in the sector are solid hydrocarbons (biomass), liquid hydrocarbons (i.e., LPG and kerosene), gaseous hydrocarbons (i.e., PNG and biogas) and electricity. As per Uttarakhand Census 2001 and 2011, there are in total more than 14 lakh and 19 lakh households in the state respectively. In 2001, rural households have 65% of contribution and urban households constitute remaining 35% whereas, in 2011, contribution by rural households was 61% and the urban households contribute remaining 39%.

Cooking energy requirement in the state is expected to slow down at an average rate of around -1.8% from 2.08 Mtoe to 1.45 Mtoe between 2020 and 2040 mainly due to efficiency improvement and fuel shift towards liquid and gaseous hydrocarbon like LPG & PNG. Efficiency of cooking heat generation of these fuels are much higher than biomass-based cook stoves. Therefore, for same amount of cooking energy input fuel requirement will be less and thus the State will observe decline in overall cooking input. In the baseline scenario, the energy consumption from biomass accounts for 50% of total energy demand in the sector in 2020, which reduces to 1.1% in 2040. This is due to the growing importance of LPG, PNG and CBG which is reflected by the increase in its share of total energy – 39% and 1.1% in 2020 to 96% and 2% in 2040.

The initiatives of state and central government that are currently being undertaken w.r.t. cooking sector is given as under:

- ✓ **Pradhan Mantri Ujjwala Yojana (PMUY)**
- ✓ **Promotion of modern cooking**
- ✓ **Promotion of Electric Cooking**

Sectoral Vision

In the baseline scenario, cooking as a sector account for 6.5% of the total energy consumption of the state in 2020. This is primarily due to the widespread use of an inefficient form of fuel i.e., biomass (majorly firewood) (50%) and traditional chullahs (9%) for cooking purposes. More than 3 times more biomass is used to cook the same food as compared to LPG. While use of LPG is being promoted to reduce dependence on biomass, the uptake of CBG is also providing new avenues for the state to curb stubble burning issue. Also, use of electricity as a means of cooking is gradually being perceived by consumers as a reliable and affordable source as compared to gas-based cooking, especially in urban areas.

Vision

State shall increase the use of biogas/ CBG and electric cooking in urban and rural areas and move away from emission intensive cooking fuel and inefficient cooking practices.

Action Plan

Cooking (Rural)

a) Objective: State shall completely phase out the use of biomass in final energy demand in the sector by 2030 and shall replace it with the increased use of electricity and CBG.

Activity:

A.1: State shall provide requisite infrastructure support to increase the penetration of LPG, electricity and CBG.

A.2: State shall invest in R&D to improve the thermal efficiency of LPG gas stoves and promote innovation in bulk procurement of composite fibreglass LPG cylinders.

A.3: State shall increase awareness of rural consumers regarding benefits of using LPG and electricity over biomass for cooking.

Cooking (Urban)

b) Objective: State shall increase penetration of gas, CBG and electricity to increase their share in the final energy requirement for the state.

Activity:

B.1: State shall provide requisite technical and institutional support to increase uptake of LPG and piped CBG

B.2: State shall provide adequate financial support to increase penetration of CBG and electricity as cooking fuel.

The following table provides the list of identified strategies in the form of action plan to improve access to clean cooking energy in rural and urban areas by source of cooking, including sub-activity, timeline, type of intervention and responsible stakeholders in the state of Uttarakhand:

Sr. No.	Sector	Activity	Sub Activity	Type of Scenario	Timeline	Type of Intervention	Stakeholder
1.	**Rural**	Increase penetration of LPG	Develop LPG distribution mechanism at co-operative/panchayat level to facilitate refilling of LPG cylinders by consumers	Aggressive	Short to Medium	Market development	, UREDA
2.			Enable SHGs and other local outlets to become extension counters for rural distributors	Aggressive	Short to Long	Market development	RWD
3.			Provide low-interest loans to households for LPG refills through self-help groups (SHGs), to allow flexible payment plans and to promote the sustained use of LPG	Aggressive	Short to Medium	Financial	RWD
4.			Invest in R&D to improve the thermal efficiency of LPG stoves	Aggressive	Short to Long	Technical & Financial	DST
5.			Increase rural LPG coverage, and improve safety/security of warehousing and retailing by enhancing skilling support for entrepreneurs and workers interested in LPG distributorships	Aggressive	Short to Medium	Awareness	RWD
6.			Undertake awareness programmes for disseminating benefits of switching from biomass to LPG	Aggressive	Short to Medium	Awareness	RWDUREDA
7.		Increase penetration of biogas	Facilitate setting up of biogas plants through setting up co-operatives	Aggressive; Ambitious	Short to Medium	Financial	UREDA
8.			Undertake awareness programmes for disseminating benefits of switching to biogas as a cooking fuel	Aggressive; Ambitious	Short to Medium	Awareness	RWD
9.		Increase penetration of electricity	Assess power distribution infrastructure development required to support use of electricity in cooking and develop implementation roadmap	Aggressive; Ambitious	Medium to Long	Technical	UPCL, UREDA
10.	**Urban**	Increase penetration of electricity as fuel	Improve the quality of electricity access	Aggressive; Ambitious	Short to Medium	Technical	MoP, UPCL
11.			Improve the energy efficiency of induction cook stoves	Aggressive; Ambitious	Medium to Long	Technical & Financial	MoP, DST, Private entities,
12.			Provide financial support to end user to increase the penetration of electric cooking equipment	Aggressive; Ambitious	Short to Medium	Financial	MoPNG, MoP, UREDA
13.			Undertake stakeholder outreach programs through mass media channels to create awareness on benefits of using electricity for cooking	Aggressive; Ambitious	Short to Medium	Awareness	MoP, UREDA, UPCL

14.		Increase penetration of biogas	Undertake awareness programmes for disseminating benefits of switching to biogas	Aggressive; Ambitious	Short to Medium	Awareness	RWD
15.	**Rural and urban**	Increase penetration of natural gas	Increase penetration of piped natural gas in urban and rural areas	Aggressive	Short to Long	Technical	RD&P, OMCs, UREDA
16.		Integration of solar energy in cooking sector	Promoting solar energy for institutional cooking in Uttarakhand	Aggressive; Ambitious	Short to Long	Technical	RWDUREDA

7.4 Industry Sector

Uttarakhand has a strong base of industrial units clustered into key sectors namely- Auto Components, Agriculture Implements, Bicycle Parts, Hand Tools, Foundry, Forging, Brick Kilns, Steel Re-Rolling Mills etc. The sources of energy in the industries are electricity and various other hydrocarbon fuels namely, solid, liquid, and gaseous hydrocarbon.

Historically, the industrial sector played an important role in state's growth and development. Manufacturing sector in the state contributes almost 52% in 2019-20, which reduced to 49% in 2022-23, in the state's GDP (PRS legislative research 2022). The total final energy demand for industry under baseline condition would be around 0.2 Mtoe in 2020, 0.5 Mtoe in 2040 thereby growing at a CAGR of 5%. There are two different sources of energy in the sector:

i) Electricity for industrial process and operation of the manufacturing facilities (lighting, space cooling, heating, water supply etc.)
ii) Thermal energy use for process and manufacturing (boiler, furnace, process heat etc.)

Around 45% of the final energy consumption in 2020 was supplied from electricity and the remaining 55% was met through fossil fuels and biomass. The share of electricity remains constant through 2040. There are four different fuel sources which supply thermal energy: a) Electricity, b) Coal, c) Gas and d) Oil.

Considering the high emission from the sector, which is expected to grow in future, various national level efforts towards decarbonization in the industry sector have been implemented in the state. These efforts are primarily focused on enhancing energy efficiency measures in the sector which can lead to energy savings and lesser emissions. In addition to this, these programs are also pushing towards a transition to cleaner energy sources to minimize the emissions and achieve the commitment towards sustainable growth of the sector. A brief description of the existing initiatives in the industry sector are provided below:

1. Perform, Achieve, Trade (PAT)

PAT is an innovative market-based mechanism dedicated to the large industries to evaluate their performance on energy and emission parameters (Bureau of Energy Efficiency, Ministry of Power 2022). Since its inception in 2012, 6 rounds of PAT have been notified. Under each round of notification, the selected large scale industrial unit or Designated Consumers (DCs) have been notified and mandated to take energy efficiency measures to reduce the energy intensity of their products. So far, the scheme looked after 14 sectors which include manufacturing and services, and the ambit of the scheme is likely to extended to more sectors in future, which are growing or expected to grow rapidly. For the state of Uttarakhand, multiple designated consumers have been notified under various cycles of PAT. There are large energy intensive industries known as DCs covering chlor-alkali, pulp & paper, cement, fertilizer, thermal power plant, textile, petroleum refinery, railway, and electricity distribution company (DISCOM).

2. BEE – SME Program (National Program for EE in SMEs)

Considering high employment potential and less efficient energy practices in the MSME sector in the country, the BEE in 2009 has initiated SME programme. Under this program, cluster level initiative towards energy saving has been evaluated and implemented.

A knowledge management portal – Simplified Digital Hands-on Information on Energy Efficiency in MSMEs (SIDHIEE) – has been developed to share resources such as case studies, best practices, energy efficient technology availability, etc. Through this programme, BEE has institutionalized Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) to provide financial support to MSMEs.

Sectoral Vision

Industry sector is the second most energy intensive sector in the state. Being an energy intensive and emissive sector, it shall be of priority to excel the efforts towards decarbonization of the sector in the state. To achieve

decarbonization of the industry sector various measures are widely considered and promoted, which includes high penetration of energy efficient equipment, transition to clean energy sources, increasing use of surplus available biomass to meet thermal energy demand of the sector, clean electricity generation and electrification of the industrial process.

Vision:

- The state shall undertake de-carbonization of the state industrial sector by moving towards clean fuel use.
- Reduction of specific energy consumption of industrial sector by following PAT norms.
- The state shall consider MSME sector in the overall industrial energy efficiency improvement planning.

Action Plan

a) **Objective:** The State shall increase the penetration of energy efficiency to save 20% energy by 2040 through various energy efficiency measures in large scale industries and MSMEs.

Activity:

A.1: Develop energy benchmarking for the industrial subsector and MSME clusters

A.2: Technology transfer support for the MSME sector to ensure the availability of the best operating technologies.

A.3: Providing R&D support to develop innovative energy efficient technologies

A.4: State shall undertake stakeholder outreach to create awareness of benefits of energy efficiency

A.5: State shall incentivize adoption of energy efficient technologies and processes as well as development of energy efficiency services market

A.6: Promotion for adoption of industry 4.0 in Uttarakhand focusing on interconnectivity, automation, machine learning, and real-time data.

b) **Objective:** Developing models for implementation of emission mitigation measures

Activity:
B.1: Collaborating technology providers, technology distributor, R&D labs, technical institutions to provide relevant technical inputs to beneficiaries

B.2: Develop and demonstrate green hydrogen projects

c) **Objective:** To achieve further decarbonization, the state shall promote the transition from fossil-based energy sources to clean energy alternatives.

Activity:
C.1: Encouraging industries to set-up captive solar plants especially rooftop solar systems to meet their electricity demand

C.2: Providing fiscal incentives to industries to promote the use of CBG

C.3: Providing fiscal incentives to industries to promote the use of biomass residue

C.4: Providing technology support to the industries for transitioning to green hydrogen

C.5: Providing policy and regulatory support for production of green hydrogen in the state

d) C.6: Support the development of clean energy supply to Industries using renewable energy resources **Objective:** Ease of finance.

Activity:
D.1: Providing soft loans to the industry sectors for energy saving and emission mitigation measures

The following table provides the list of identified strategies in the form of action plan to improve energy efficiency in industry sector, including sub-activity, timeline, type of intervention and responsible stakeholders in the state of Uttarakhand:

Table 19: Summary of action plans for the industry sector

Sr. No.	Sector	Activity	Sub Activity	Type of Scenario	Timeline	Type of Intervention	Implementing Agency
1.	**Large Industries and MSMEs**	**Energy savings through energy efficiency measures**	Develop energy benchmarking for the industrial subsector and MSME clusters	Aggressive	Short to Medium	Technical	Dept of Industry and commerce
2.			Technology transfer support for the MSME sector to ensure the availability of the best operating technologies	Aggressive	Short to Medium	Technical	Dept of Industry and commerce
3.			Providing R&D support to develop innovative energy efficient technologies	Aggressive	Short to Long	Technical	Dept of Industry and commerce
4.			Implementation of ISO 50001 for energy management in MSMEs	Aggressive	Short to Medium	Technical	Dept of Industry and commerce
5.			Promotion for adoption of industry 4.0 in Uttarakhand focusing on interconnectivity, automation, machine learning, and real-time data.	Aggressive	Short to Medium	Market Development	Dept of Industry and commerce
6.			Mandatory energy audits for MSMEs to monitor their energy use	Aggressive	Short to Long	Technical	Dept of Industry and commerce
7.		**Developing models for implementation of emission mitigation measures**	Collaborating technology providers, technology distributor, R&D labs, technical institutions to provide relevant technical inputs to beneficiaries	Aggressive	Short to Medium	Market Development	Dept of Industry and commerce
8.			Develop and demonstrate green hydrogen projects	Aggressive; Ambitious	Short to Long	Market Development	Dept of Industry and commerce
9.		**Promoting clean energy use in industries**	Encouraging industries to set-up captive solar plants especially rooftop solar systems to meet their electricity demand	Aggressive	Short to Long	Policy and regulatory	Dept. of Power, UREDA, UPCL

10.			Providing fiscal incentives to industries to promote the use of CBG	Aggressive	Short to Medium	Financial	UREDA, Dept of Industry and commerce, Dept of Planning
11.			Providing fiscal incentives to industries to promote the use of biomass residue	Aggressive	Short to Medium	Financial	UREDA, Dept of Industry and commerce, Dept of Planning
12			Providing technology support to the industries for transitioning from fossil fuel based energy sources to green hydrogen	Aggressive; Ambitious	Medium to Long	Technical	Dept of Industry and commerce
13			Policy and regulatory support for production of green hydrogen in the state	Aggressive; Ambitious	Short to Long	Policy and Regulatory	UREDA, Dept of Industry and commerce
14			Support the development of clean energy supply to Industries using renewable energy resources	Aggressive; Ambitious	Short to Long	Policy and Regulatory	UREDA, Dept of Industry and commerce
15		**Ease of finance**	Providing soft loans to the industry sectors for energy saving and emission mitigation measures	Aggressive	Short to Medium	Financial	Dept of Industry and commerce, Dept of Planning

7.5 Transport Sector

The use of passenger transport is considerably prevalent in the state of Uttarakhand with 2-wheelers and cars being the vehicles primarily used by the passengers with respect to taxis, buses, and LMV-passenger. As per the data collected from department of transport, Uttarakhand, the modal penetration share of 2-W and cars is maximum with 83% and 16% followed by taxis (1%), buses (0.5%) and LMV-passenger (0.3%) in the year 2021.

Based on the data collected from the Department of Transport, Uttarakhand, the total no. of registered vehicles has witnessed 9% CAGR growth rate between 2006 to 2021 in the state of Uttarakhand with cars and taxis growing at a CAGR of 18% each and 2-W, buses and LMV-passenger growing at a CAGR of 8%, 7% and 0.04% between 2006 to 2021.

The fuel used in the transport-passenger sector is primarily petrol and diesel. Out of the total number of registered vehicles, 89% of the transport-passenger vehicles run on petrol, majority of these vehicles being 2-W and remaining running on diesel. Penetration of electric vehicles is minimal in 2021.

The sector's energy consumption is projected to grow at a CAGR of 18% between 2020 and 2040 under the baseline conditions. The total energy demand is expected to increase from 3.9 Mtoe in 2020 to 8.2 Mtoe in 2040. The sector is further divided into passenger and freight transport segment.

Under the freight transport segment, it has been observed that during 2020, close to 27% of the total freight transport demand (TKM) has been met by electricity. Under the BAU projection and considering existing policy landscape, it is estimated to reach 46% by 2040, this also includes the rail passenger transport.

Considering the high emission from the sector, which is expected to grow in future, various efforts towards decarbonization has been considered by the state as well as centre government. These efforts are focused on transition to less emitting fuel which includes bio-fuel blended petroleum fuels and Compressed Biogas to replace fossil fuels. In addition to this, electrification of transport sector has also been considered to reduce the sectoral emission and has an added advantage of reduction in petroleum oil import dependency. As such, various initiatives are being undertaken by the central as well as state government to incentivise the transition to clean energy.

Bio-fuel blending (Central Government), 2021

Indian government has achieved an 8.5% ethanol blending in 2021[8]. This is targeted to further increase to 10% by 2022. Further, the Government of India has targeted to achieve 20% ethanol blending in petrol by 2025. Uttarakhand has four ethanol plants attached with distilleries (Hindustan Times 2021). With high biomass potential, the state became a preferred destination for the ethanol plant developers to set-up production units.

Compressed Biogas (CBG) – SATAT (Central Government), 2018

Central government scheme aims to support the development of large-scale bio-gas plants and promote the Oil Marketing Companies (OMCs) to offtake CBG and supply it as a transport and industrial fuel. With the surplus biomass availability, the state is envisaging large uptake of the scheme. So far, Uttarakhand has already setup its first Bio-CNG plant and 23 similar plants are in pipeline, to be completed by 2023-24 (Times of India 2021)

FAME – II (Central Government), 2019

The central government is pushing the uptake of electric vehicle under the FAME-II policy by providing financial incentives to the end consumers and support the development of infrastructure required for the same.

[8] https://www.pib.gov.in/PressRelese.

Draft Electric Vehicle (EV) Policy (State of Uttarakhand), 2019

The draft policy document has targeted to incentivise various EV stakeholders to increase the electrification of the transport sector in the state. This will be on the top of applicable schemes from the central government. Apparently, the policy remains in the draft stage since 2019.

Uttarakhand Government is placing a significant thrust on increasing the share of e-2W, e-autos, e-buses, and e-tractors. This draft policy offers various fiscal and financial incentives which can act as catalysts for EV adoption in the state. Some of these incentives of the potential customers include:

Considering the growing concerns of the GHG emission and transport sector being the most energy intensive sector in the state, currently operating mainly on the petroleum fuels, multiple low carbon pathways have been developed. The key interventions under the sector include electrification of the transport sector, biofuel blending in the petroleum fuels, oil to natural gas transition in the sector along with promoting CBG production and consumption in the sector. Description of the aggressive and decarbonisation scenarios is provided below.

Sectoral Vision

To improve the fiscal position of the state and reduce GHG emission in the state, decarbonization of the transport sector is of utmost importance. To achieve decarbonization of the transport sector various measures are widely considered and promoted, which includes electrification of transport sector, biofuel lending in the petroleum fuels, replacement of CNG with clean CBG, and developing market for hydrogen-based fuel cell vehicles.

Vision:

- The state shall undertake de-carbonization of the transport sector by introducing fuel shift towards electricity-based and gas-based transportation including CBG.
- The state shall increase energy efficiency of the transport sector by introducing stricter fuel efficiency norms, higher biofuel blending share and electric mobility.

Action Plan

Passenger Transport

a) **Objective:** The State shall increase the penetration of electric vehicles to a minimum of 50% for passenger transport by 2040

Activity:

A.1: State shall develop and implement Electric Vehicle Promotion policy along with the existing EV Manufacturing Promotion Policy 2018 to provide adequate and effective fiscal and financial incentives to motivate consumers to buy EVs.

A.2: Market development for End-of Life/Recycler for existing vehicle and batteries

A.3: Confluence of EV policy and vehicle scrappage policy in Uttarakhand

A.4: Create adequate charging infrastructure (both public and private based)

A.5: Skill development required for the development and up keeping of EV

b) **Objective:** The State shall promote uptake of CBG-based vehicles

Activity:

B.1: Market development for CBG

Freight Transport

c) **Objective:** The State shall increase the penetration of electric vehicles in road freight transport by a minimum of 15% by 2040.

Activity:
C.1: Develop awareness among the commercial fleet operators on the benefits of EVs adoption

C.2: Real time digital information system for charging infrastructure

d) **Objective:** The State shall promote green hydrogen-based fuel cell vehicles in the State

Activity:
D.1: Developing adequate infrastructure for handling freight-vehicle green hydrogen requirement

D.2: Market development activities to generate awareness in commercial transportation space for up taking green hydrogen-based vehicle

The following table provides the list of identified strategies in the form of action plan to improve energy efficiency in transport sector, including sub-activity, timeline, type of intervention and responsible stakeholders in the state of Uttarakhand:

Table 20: Summary of action plans for the transport sector

Sr. No.	Sector	Activity	Sub Activity	Type of Scenario	Timeline	Type of Intervention	Implementing Agency
1.	**Passenger Transport**	**Regulatory support**	Develop and Implementation State EV policy integrated with Ropeway Development	Aggressive	Short	Regulatory/ Policy	Dept. of Transport
2.		**Promote uptake of Electric Vehicles (EV) & Other Non-Emissive Transport System**	Market development for End-of Life/Recycler for existing vehicle and batteries	Aggressive;	Short to Medium	Market Development	Dept. of Local Govt, Dept of Industry and commerce
3.			Confluence of EV policy and vehicle scrappage policy in Uttarakhand	Aggressive;	Short to Medium	Regulatory/ Policy	Dept. of Transport, Dept of Industry and commerce
4.			Create adequate charging infrastructure (both public and private based)	Aggressive;	Short to Medium	Technical	Dept. of Transport, UPCL
5.			Skill development required for the development and up keeping of EV	Aggressive;	Short to Medium	Financial	UREDA, Dept. of Transport
6.		**CBG Production**	Market development for CBG	Aggressive;	Short to Long	Technical	UREDA, Dept. of Local Govt.
7.	**Freight Transport**	**Promote uptake of Electric Vehicles (EV)**	Develop awareness among the commercial fleet operators on the benefits of EVs adoption	Aggressive;	Short to Long	Technical	Dept. of Transport, UPCL
8.			Real time digital information system for charging infrastructure	Aggressive;	Short to Medium	Technical	Dept. of Transport
9.		**Promote hydrogen-based fuel cell vehicle**	Developing adequate infrastructure for handling freight-vehicle green hydrogen requirement	Ambitious	Medium to Long	Market Development	UREDA, Dept. of Local Govt.
10.			Market development activities to generate awareness in commercial transportation space for up taking green hydrogen-based vehicle	Ambitious	Short to Long	Market Development	UREDA, Dept. of Transport

Description of Sub-Activities

1. Developing and implementing State EV policy integrated to Ropeway Development Plan

Uttarakhand is currently having State EV Manufacturing policy which is incentivizing the vehicle manufacturers to produce EVs within the State. However, there is a need to push for usage of EVs in the State. However, given the hilly terrain of the State, use of EV is typical in the case of Uttarakhand which needs to be considered while developing the policy. The major thrust for EV use could be for the vehicles used for tourism purposes for in and out bound tourist travel.

However, the State of Uttarakhand has huge potential of alternative energy efficiency / non-emissive transportation system like Ropeways/ Cable Cars. Given the hilly terrain of the State, efficiency of the EVs will be lower compared to plane land performances. As a result, blanket deployment of EVs across the State (including high altitude areas) could be challenging. The State is also having an existing plan on developing six different ropeway routes[9] covering various tourist and pilgrimage destinations. Integrating the ropeway development plan to EV policies could be an effective way to support the alternative low carbon transport system in the State.

2. Create adequate charging infrastructure (both public and private based)

Alongside promotion of private individual charging infrastructure in the state (as part of the draft EV policy of Uttarakhand), Uttarakhand should also look at installing public charging stations for EVs to cater to high EV volume and their rapid charging needs. This is required to expand the EV transition portfolio in the state and provide accessible and affordable charging infrastructure on a wider scale. To bring the facility at the nearest place, the charging stations can be set up in public parking lots, fuel stations and along the state highways. Further, the facility should be such that two-wheelers, three-wheelers and fourth wheelers can be charged at the same charging station. The infrastructure can be gradually improved to encourage the sale of electric vehicles in the state. A pre-requisite for this would be developing a plan for a network of chargers that are conveniently located and well-distributed across the city or region. 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.

To begin with, the installation of EV charging stations can take place in the smart cities of Uttarakhand. For example, providing e-mobility experience to tourist-heavy smart cities like Dehradun will provide enhanced visibility to benefits of EV adoption to citizens across the state. Further, introduction of EV in the city of Dehradun shall align well with the Smart City vision / goals, specific thematic focus and envisaged investments in the city in the areas of traffic and transportation.

3. Skill development required for the development and up keeping of EV.

High uptake of EVs and development of supporting infrastructure comes with a larger challenge of good upkeep and efficient operation of the technologies. There is significant variation in the EV technology compared to the existing internal combustion engines. Implementation of the envisaged transition requires advancing the skills and capabilities of the workforce supporting the existing operations of the transport sector in the state, primarily automobile engineers, technicians, mechanics, etc. As such, significant capacity building is required to be undertaken to skill the workforce engaged in the EV sector.

The initiatives that can be undertaken with regards to capacity development in the state are as follows:

i. Introduction of curricula and courses suited to the EV industry in professional institutes, polytechnics, vocational education institutes.
ii. Formulating certified courses for skilled and semi-skilled repair and maintenance personnel by technical education department in collaboration with Transport Department

[9] For further detail:
https://investuttarakhand.uk.gov.in/themes/backend/investible/IP_UK_Development%20of%20Ropeways%20in%20Uttarakhand.pdf

iii. Mandating the vehicle manufacturers to up-skill their skilled and semi-skilled workforce in EV system design and operations
iv. Vocational trainings towards installation and maintenance of EV charging infrastructure

7.6 Cross-Sectoral Initiatives

To implement the core activities provided under the Action Plan there are a number of supporting activities/initiatives that need to be undertaken which are cross-sectoral in nature. This section provides a brief description of such activities/initiatives.

1. Raising awareness & capacity building of demand sectors in energy efficiency/conservation

While a wide range of energy conservation and energy efficiency initiatives are possible with compelling outcomes and impacts, the critical factor in all these initiatives is the participation of the beneficiaries. Even though some options provide considerable financial benefits, apart from environmental and socio-economic benefits, these options are not actively taken up by the end-users viz. uptake of solar pumps in agriculture, development of agro PV on farmland, energy efficiency methods in MSME, uptake of energy efficient appliances, etc. In each case, there are unique issues which prevent the mainstreaming of renewable energy, energy efficient and energy conservation initiatives.

To understand the issues of the beneficiaries and to address these issues adequate awareness and capacity building measures need to be designed and implemented. Such measures have been elaborated under the sub-activities of each specific sector.

2. Prepare 'Green Procurement Guidelines' to promote procurement of technology / equipment / components that lead to energy efficiency.

Green procurement is a spending and investment process through which organizations meet their needs for goods, services, utilities and works not exclusively on a cost-benefit analysis but with a view of maximizing long term financial and economic benefits. Green products are often found to be costlier (initial/ upfront cost) than other products. Hence, any organization has to incorporate extrinsic cost considerations into decisions alongside the conventional procurement criteria of price and quality. The public sector is continually procuring various goods for sustaining its operations. Since a substantial amount of money is spent on these items, adoption of energy efficient/cleaner alternatives can help to reduce total cost of ownership of these items over a period. An effective method of reducing operational cost can be switching to purchase and increased usage of energy efficient items. Hence, looking at life cycle cost or total cost of ownership (TCO) and selecting energy efficient products can bring down the GHG emission as well as reduce energy consumption. Hence, the State Government can adopt Green Procurement Guidelines which will, on one hand, reduce the carbon footprint of government entities and bring about energy savings, on the other hand, it will help to stimulate the market for green or environment friendly products in the state.

The procurement guidelines shall contain the following aspects:

- Setting the 'green procurement' criteria – subject matter of the proposed PO/ Contract.
- Technical specification of the product or works.
- Selection criteria for bidders
- Contract award criteria
- Any other contract performance clauses

Establishing a state-wide 'Green Procurement Guidelines' across all departments of the State government would require consultations with sector experts as well as extensive consultations with individual departments to ensure formulation of comprehensive guidelines, relevant to all concerned stakeholders.

3. Developing a biomass trading platform

To mitigate the effects of biomass residue burning on the environment and to establish a streamlined price mechanism for biomass procurement, there is a pressing need to set up a trading platform / marketplace for biomass trading in Uttarakhand. Thus, the main scope for intervention here includes collection and mobilization of the raw material to the plant / industry which could be facilitated by a biomass trading platform. GIZ is already working in the space to develop a framework for biomass trading platform at the national level. Synergies could draw with GIZ to develop something similar at the state level.

On the supply-side, development of a biomass platform to collect and process biomass has the potential to generate additional employment opportunities in rural areas and increase the source of income for farmers supplying the biomass. On the demand side, a trading platform shall mean regular and consistent biomass supply for industries. In the absence of formal trading platform / exchange, ensuring high levels of transparency and clear regulatory frameworks is necessary to reduce uncertainly for economic agents and build trust between them, which often becomes difficult. This can incentivise the development of the biomass sector.

4. Integrating Renewable Energy in Healthcare Sector in Uttarakhand

Uttarakhand can look at integrating RE in its healthcare system. One way to do this is to solarize the health centres. Chhattisgarh is an Indian state that solarized most of its health centres. However, to successfully replicate Chhattisgarh's policies in Uttarakhand, it must formalize cooperation between health department, UREDA and UPCL to identify health centres in need of solarization. It will create a sustainable health system in the state with access to reliable electricity, especially in rural communities. The RE options that can be availed by health centres could include off-grid solar rooftop systems for serving electricity load in the centre, solar water heaters for serving the hot water needs at the facility, standalone solar cold storages / solar deep freezers for storing vaccines, etc. Further, green hydrogen fuel cells could also be used at the health facilities for supply of electricity, heat, and oxygen to the facility. Hydrogen production, compression and storage components of the project could be installed at the premises. The electricity, heat and oxygen supply component could be connected to the 11kV feeder at the health centres. SECI has taken out a tender for a similar technology for a hospital in Leh, Ladakh (SECI 2022). Synergies could be drawn with this project. Collaboration could also be explored with SECI for similar initiatives in Uttarakhand.

5. Developing a Clean Energy Fund

There is multiple schemes of the State and Central government which are aimed to promote clean technologies across some sectors as per departmental targets. However, a consolidated fund for financing clean technologies and related technical services across all energy demand sectors and the energy supply sector will help to create a focus on increased penetration of such technologies**.**

The fund could initially target small to medium scale projects with a value of INR 1 lakh to INR 1 crore and could have an initial fund scope of INR 50 crore. This is expected to help mainstream the uptake of clean technology by the end users i.e., retail, industrial and institutional consumers as well as stimulate the growth of the energy services industry in the state. The fund can be scaled up in the future to fund projects with investment requirement of above INR 1 crore, based on the availability of funds and the utilization of the initial fund allocation.

The fund can focus on projects/initiatives implemented in agriculture, residential and commercial buildings, transport, SMEs etc. The fund could have a three-tier structure, wherein the Steering Committee could have over-arching jurisdiction on the fund functions and could be assisted by the Management Committee, which could undertake the overall management and utilization of the Fund. The Management Committee could be supported by the Technical Committee on technical aspects of the proposals put forward for funding by the beneficiaries. The Secretariat could conduct preliminary screening of the proposals and other requisite back-end activities required for functioning of the Fund. Empanelled banks could be the agents for receiving the applications from beneficiaries and based on the decision provided by the Steering Committee, disburse the funds/communicate the rejection of application to beneficiaries.

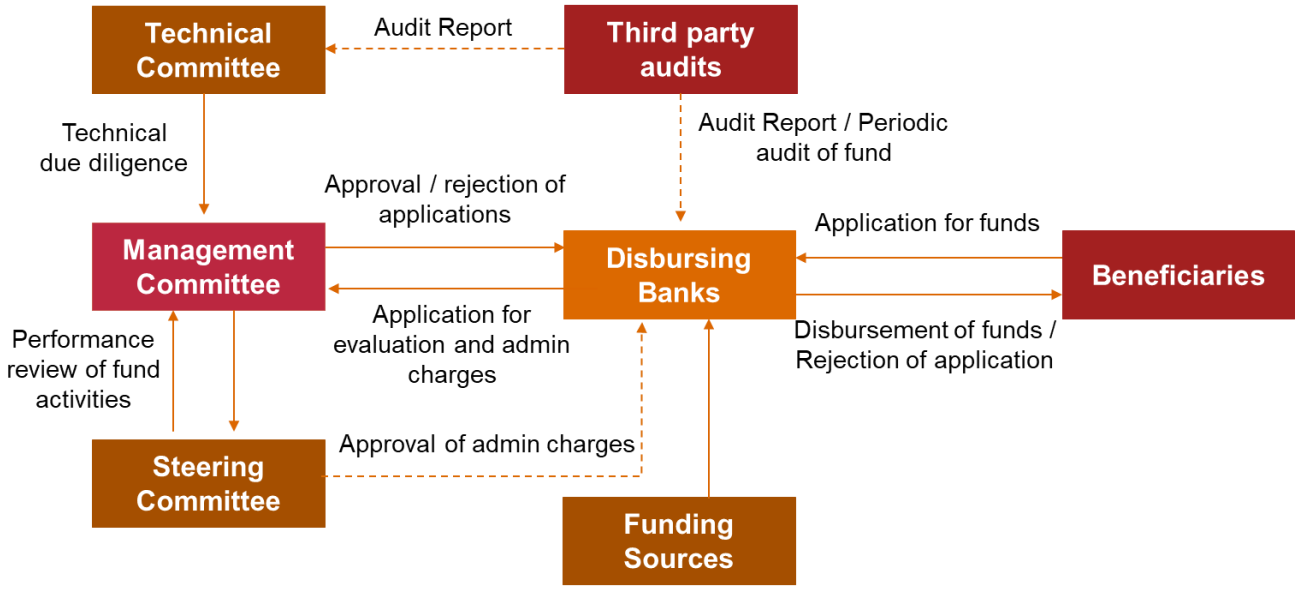


Figure 19:Proposed structure of Clean Energy Fund

In the short term, the source of fund could be through state budgetary allocation, proceeds from a proposed pollution tax, central government funding schemes or CSR spend of public/private entities. In the long term, the fund can provide allocation from state government, state government owned entities (e.g.: UREDA, UPCL), development / financing agencies and private sector entities to provide seed funding for start-ups from Uttarakhand, operating in manufacturing activities or providing services related to the focus areas stated above. Based on the prospects, the participants can further convert their seed funds into equity in the start-ups. This can help to increase private sector participation and aid in the development of clean energy market in the state.

Appendix – Assumptions

Annexure-1

Transport Sector Data

Registered Passenger Vehicles			
Mode	**Fuel Type**	**Unit**	**2020**
Bus	Diesel	No.	13427
	LPG/CNG	No.	41
	Electric	No.	10
	FCV	No.	0
Omnibus	Diesel	No.	6154
	CNG	No.	12
Car	Petrol	No.	449742
	Diesel	No.	237279
	CNG/LPG	No.	7732
	Electric	No.	50
	FCV	No.	0
2W	Petrol	No.	2464652
	Electric	No.	100
3W	CNG/LPG	No.	1999
	Diesel	No.	34390
	Electric	No.	200
Taxi	CNG	No.	1895
	Diesel	No.	70586
	Electric	No.	0

Average Annual Utilization						
Vehicle	**Fuel**	**Total kilometres travelled per year**				
		2020	2025	2030	2035	2040
BUS	DIESEL	98391	99978	101565	103152	104739
BUS	CNG	98391	99978	101565	103152	104739
BUS	ELECTRIC	98391	99978	101565	103152	104739
BUS	FCV	98391	99978	101565	103152	104739

ONMI-BUS	DIESEL	38246	39039	39833	40626	41420
	CNG	38246	39039	39833	40626	41420
CAR	PETROL	13924	14779	15633	16487	17341
CAR	DIESEL	13924	14779	15633	16487	17341
CAR	CNG	13924	14779	15633	16487	17341
CAR	LPG	13924	14779	15633	16487	17341
CAR	ELECTRIC	13924	14779	15633	16487	17341
CAR	FCV	13924	14779	15633	16487	17341
2W	PETROL	6427	6030	5634	5237	4840
2W	PETROL	6864	6665	6467	6268	6070
2W	PETROL	1825	1825	1825	1825	1825
2W	ELECTRIC	2261	2460	2658	2857	3055
3W	CNG	35405	35405	35405	35405	35405
	LPG	35405	35405	35405	35405	35405
	PETROL	35405	35405	35405	35405	35405
	DIESEL	35405	35405	35405	35405	35405
	ELECTRIC	35405	35405	35405	35405	35405
TAXI	CNG	37373	37770	38166	38563	38960
	LPG	37373	37770	38166	38563	38960
	DIESEL	37373	37770	38166	38563	38960
	ELECTRIC	37373	37770	38166	38563	38960

Freight Transport

Total Number of Registered Freight Vehicle	Sub type	Unit	2020
HCV (Heavy Carrier Vehicle)	DIESEL	No.	54310
	LNG	No.	325
	ELECTRIC	No.	0
LCV (Light Carrier Vehicle)	DIESEL	No.	84669
	CNG	No.	11605
	ELECTRIC	No.	0

Fuel Mix in Freight Transport (TWh)	Unit	2020	2025	2030	2035	2040
Oil	TWh	17.82805898	20.11993965	25.05463	31.79504	41.58095
Gas	TWh	0.371343575	1.031615772	2.024594	3.488996	5.766141
Electricity	TWh	0.504098744	1.035614011	1.466251	2.001998	2.605271
Total	TWh	18.7035013	22.18716943	28.54547	37.28603	49.95237

Energy Use by Fuel (Mtoe)	Unit	2020	2025	2030	2035	2040
Road						
HCV	Diesel	1.12097829	1.243793882	1.43996	1.675876	1.99797
	LNG	0	0.023702746	0.059197	0.112209	0.195196
	Electric	0	0	0	0	0
LCV	Diesel	0.322710788	0.461073156	0.655566	0.929789	1.346001
	CNG	0.0319298	0.065000244	0.114887	0.187791	0.300602
	Electric	0	0.003632969	0.009096	0.017285	0.030145
Rail	Diesel	0.081882784	0	0	0	0
	Electric	0.04334469	0.085413808	0.116979	0.154856	0.193868
Air	Air	0.007365281	0.02513637	0.058784	0.128216	0.231348
Shipping	Diesel	0	0	0	0	0

Annexure-II

Power Sector

Large Hydro Projects (capacity above 25 MW) Operational in Uttarakhand			
Sr. No.	**Agency**	**Installed Capacity**	**Remarks**
1	UJVNL	1372.15	
2	IPPs	829	
3	CPSUs	1800	Only 12 % free power received from all the hydro projects allotted to CPSUs
Total		4001.15 MW	

Small Hydro Projects Operational in Uttarakhand		
Sr. No.	**Agency**	**Installed Capacity**
1	UJVNL	48.45
2	IPPs	138.45
3	CPSUs	0
Total		186.90 MW

Type of Power Plant	Installed Capacity (GW) by 2019-20	Plant Load Factor	Generation (Million Units)
Hydro	3.881	65%	22098
SHP	0.210	32%	589
Solar PV	0.295	14%	362

Annexure-III

Industry Sector Energy Use

Sub Sectors	Unit	Coal	Electricity	Petroleum Products	Total
Textiles	Toe	2105	22305	1984	26393
Paper & Pulp	Toe	191526	63276	14040	268842
Petrochemicals	Toe	0	607	5	612
Chemicals and Fertilizer	Toe	22310	193606	59653	275569
Iron & Steel	Toe	61036	87468	12926	161430
Others	Toe	6735	187361	60840	254937
Total	Toe	283711	554623	149448	987782

Annexure-IV

Cooking Sector Energy Demand

Fuel Demand (TWh)	Fuel type	2020	2025	2030	2035	2040
	LPG	3.38	4.29	5.04	5.62	6.23
	Electricity	0.05	0.06	0.07	0.07	0.08
	PNG	0.00	0.00	0.00	0.00	0.00
	Biomass (Improved)	5.00	3.34	2.09	0.99	0.06
	Coal	0.01	0.01	0.01	0.00	0.00
	Kerosene	0.10	0.07	0.05	0.02	0.00
	Biogas	0.10	0.10	0.10	0.10	0.10
	Biomass (Traditional)	0.88	0.45	0.00	0.00	0.00
	Total	9.54	8.33	7.35	6.80	6.47
Fuel Demand (Mtoe)	**Fuel type**	2020	2025	2030	2035	2040
	LPG	0.29	0.37	0.43	0.48	0.54
	Electricity	0.00	0.01	0.01	0.01	0.01
	PNG	0.00	0.00	0.00	0.00	0.00
	Biomass (Improved)	0.43	0.29	0.18	0.08	0.01
	Coal	0.00	0.00	0.00	0.00	0.00
	Kerosene	0.01	0.01	0.00	0.00	0.00
	Biogas	0.01	0.01	0.01	0.01	0.01
	Biomass (Traditional)	0.08	0.04	0.00	0.00	0.00
	Total	0.82	0.72	0.63	0.58	0.56

Annexure-V

Buildings Sector

Residential

Total Cooling Demand (Mtoe)	2020	2025	2030	2035	2040
Cooling Demand (Urban + Rural)	0.450693242	0.573484213	0.708633	0.833364	0.959612
Internal Heat Gain through Occupants (Mtoe)	0.362365192	0.381583712	0.398912	0.413647	0.433504
Cooling Demand (Mtoe)	0.813058434	0.955067924	1.107546	1.247011	1.393117

Appliances	No of Appliances	2020	2025	2030	2035	2040
Lighting	4	7194050.482	7690038.78	8165020	8548391	9259691
Televisions	1	1798512.62	1922509.695	2041255	2137098	2314923
Refrigerators	1	1798512.62	1922509.695	2041255	2137098	2314923

Commercial

Own Account (HVAC)		2020	2025	2030	2035	2040
Wholesale trade	Mtoe/ Mha	6.846	6.846	6.846	6.846	6.846
Retail trade	Mtoe/ Mha	8.7787	8.7787	8.7787	8.7787	8.7787
Restaurants & Hotels	Mtoe/ Mha	12.5706	12.5706	12.5706	12.5706	12.5706
Transport & Storage	Mtoe/ Mha	7.6412	7.6412	7.6412	7.6412	7.6412
Post & Telecom	Mtoe/ Mha	6.125	6.125	6.125	6.125	6.125
Financial Intermediation	Mtoe/ Mha	6.125	6.125	6.125	6.125	6.125
Real estate, renting, business services	Mtoe/ Mha	10.6743	10.6743	10.6743	10.6743	10.6743
Public adm. & defense; compulsory social security	Mtoe/ Mha	4.9875	4.9875	4.9875	4.9875	4.9875
Education	Mtoe/ Mha	4.9875	4.9875	4.9875	4.9875	4.9875
Health and Social Work	Mtoe/ Mha	8.7787	8.7787	8.7787	8.7787	8.7787

Other community, social & personal services	Mtoe/ Mha	8.7787	8.7787	8.7787	8.7787	8.7787
Other	Mtoe/ Mha	8.0206	8.0206	8.0206	8.0206	8.0206

Commercial Energy	Units	2020	2025	2030	2035	2040
Lighting	Mtoe	0.005226	0.015591	0.026846	0.038774	0.052097
HVAC	Mtoe	0.096422	0.143877	0.180495	0.217215	0.257925
Others	Mtoe	0.004154	0.012395	0.021342	0.030825	0.041416
Hot Water	Mtoe	0.004612	0.009387	0.016202	0.025179	0.037022
Fuel Mix in Commercial Buildings		2020	2025	2030	2035	2040
Grid	Mtoe	0.104893	0.174	0.237539	0.304193	0.376807
Diesel	Mtoe	0.004417	0.004531	0.002449	0	0
Solar	Mtoe	0.001104	0.002719	0.004898	0.0078	0.011654
Total Electricity Demand	Mtoe	0.110413	0.18125	0.244886	0.311993	0.388461
Total with hot water demand	Mtoe	0.110545	0.181551	0.245445	0.312913	0.389881
Hot water demand met by Solar Water heaters	Mtoe	0.000132	0.000301	0.000559	0.00092	0.00142

Annexure-VI

Agriculture Sector

Tractors values updated in 2020 and projected using historic CAGR	2020	2025	2030	2035	2040
Total number of tractors	44100	43571	43047	42531	42020
Percentage of tractors in use	0.95	0.95	0.95	0.95	0.95
Hours of usage per tractor	1199	1199	1199	1199	1199
Fuel consumption of tractors per hour (Mtoe/h)	3.35E-09	3.35E-09	3.35E-09	3.35E-09	3.35E-09
Fuel consumption of tractors per hour (lit/h)	4	4	4	4	4
Demand from tractors (Mtoe)	0.168398	0.166376	0.164378	0.162405	0.160455

Demand for pumping (POWER in GW)	2020	2025	2030	2035	2040
Total Diesel pump capacity GW	0.51	0.50	0.50	0.49	0.48
Total Electric pump capacity GW	0.08	0.08	0.08	0.07	0.07
Total Solar Pump capacity GW	0.03	0.03	0.03	0.03	0.03
Number of pumps derived from Agricultural Land use	2020	2025	2030	2035	2040
Diesel Pumps	69742	68904	68077	67260	66452
Electric Pumps	10629	10502	10376	10251	10128
Solar Pumps	4230	4179	4129	4080	4031
Total Pumps	84601	83585	82582	81590	80611
Net Cropped Area (Ha)	1099000	1085806.068	1072771	1059891	1047167
Pump Density (Pumps/5Ha)	0.384900143	0.384900143	0.3849	0.3849	0.3849

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