Final Report
on

# "Energy Efficiency in Eco Cities"

(A Case Study of Residential Sector in Dehradun City, Uttaranchal)


**Study Team**

***Prof. K.K. Pandey***
***Dr. Sachin Chowdhry***
***Dr. Sujit Kumar Pruseth***



**Sponsored by**

**Human Settlement Management Institute**
**Housing & Urban Development Corporation**

**Centre for Urban Studies**
**Indian Institute of Public Administration**
Indraprastha Estate, Ring Road, New Delhi-110002

**February, 2018**

# ACKNOWLEDGEMENTS

We are thankful to Human Settlement Management Institute of HUDCO for assigning this study to Indian Institute of Public Administration, New Delhi. The theme of the study is very timely and appropriate in the context of Government of India's commitment for Energy Efficiency and UNSDGs (United Nations Sustainable Development Goals). Being an innovative area and availability of limited work on the subject, the task of researching was very challenging. The data and information related to the topic is also fairly diverse and emerging slowly. Therefore, this is one of the initial studies to develop a frame-work for further consolidation and expansion on energy efficiency among cities and towns. The study presents a set of assumptions on carbon emissions from different sectors and potential actions thereon. Dr. Shaleen Singhal, TERI, provided expert comments and guidance on frame-work of the study. Dr. Akshay Kumar Sen, Fellow, HSMI, Ms. Simrandeep Kaur, Fellow, HSMI and Ms. Preeti Sing, JGM (P) HSMI also provided useful guidance at different stages of the study.

Our thanks are particularly due to Dr. M. Ravi Kanth, Chairman & Managing Director HUDCO, Shri N.L. Manjoka, Director (Corporation Planning) HUDCO and Shri Rakesh Kumar Arora, Director (Finance) for their kind support for the study. We are specially thankful to Dr. D. Subrahmanyam, Sr. Executive Director (Training/HR/ Corporate Planning/Core Infrastructure & Smart City) in HUDCO for his guidance on the final report. Our thanks are also due to Shri A.N. Krishnamurty and Dr. H.S. Gill, former Executive Director, HSMI for their valuable comments on earlier drafts of this study.

The study would not have been completed without the support of officials in various government departments, Regional Office, HUDCO, Uttarakhand, Municipal Corporation Dehradun, Mussoorie Dehradun Development Authority and other stakeholder organizations and the respondents of sample households. We are deeply grateful to them.

During the course of the study the team received a pointed support and guidance from Director, IIPA, Dr. T. Chatterjee (former Secretary, Environment and Forest, Govt. of India) who despite a busy schedule spared his valuable time to provide guidance on specific issues. We are also thankful to Mr. Anand Singh Patwal, Ms. Neelam Handa and Ms. Niharika for helping in the preparation of this report.

Sachin Chowdhry

**(Dr. Sachin Chowdhry)**

Sujit Kumar Pruseth

**(Dr. Sujit Kumar Pruseth)**

# ABBREVIATIONS

| | | |
|---|---|---|
| **ALT** | : | Alternative |
| **AMRUT** | : | Atal Mission for Rejuvenation and Urban Transformation |
| **ASEM** | : | Advisory Companies with Environment Management |
| **BAU** | : | Business-as-usual |
| **BEE** | : | Bureau of Energy Efficiency |
| **BHK** | : | One Bedroom, Hall and Kitchen |
| **BPL** | : | Below Poverty Line |
| **BUR** | : | Biennial Update Report |
| **CDIAC** | : | Carbon Dioxide Information Analysis Center |
| **CDP** | : | City Development Plan |
| **CEA** | : | Central Electricity Authority |
| **CFL** | : | compact fluorescent lamp |
| **CGD** | : | City Gas Distribution |
| **CGE** | : | computable general equilibrium |
| **CNG** | : | compressed natural gas |
| **COP** | : | Conference of Parties |
| **CPCB** | : | Central Pollution Control Board |
| **CPHEEO** | : | Central Public Health and Environmental Engineering Organisation |
| **CSIR** | : | Council of Scientific & Industrial Research |
| **CSR** | : | Corporate Social Responsibility |
| **DNN** | : | Dehradun Nagar Nigam |
| **DVWM** | : | Doon Valley Waste Management |
| **ECBC** | : | Energy Conservation Building Code |
| **ECEEE** | : | European Council for an Energy Efficient Economy |
| **ED** | : | Executive Director |
| **EIA** | : | U.S. Energy Information Administration |
| **GAIL** | : | Gas Authority of India Limited |
| **GBPN** | : | Global Buildings Performance Network |
| **GDP** | : | Gross Domestic Product |
| **GHG** | : | Green House Gas |
| **GPS** | : | Global Positioning System |
| **HCFC** | : | Hydrochlorofluorocarbons |
| **HIG** | : | Higher Income Group |
| **HSMI** | : | Human Settlement Management Institute |
| **HUDCO** | : | Housing and Urban Development Corporation |
| **IEA** | : | International Energy Agency |
| **IIPA** | : | Indian Institute of Public Administration |
| **IIT** | : | Indian Institute of Technology |
| **IPPU** | : | Industrial Processes and Product Use |
| **IRADe** | : | Integrated Research and Action for Development |

| | | |
|---|---|---|
| **IREDA** | : | Indian Renewable Energy Development Agency |
| **ISBT** | : | Inter-state bus terminus |
| **IT** | : | Information Technology |
| **KABP** | : | Knowledge, Attitude, Behavior and Practices |
| **LED** | : | Light-emitting diode |
| **LIG** | : | Low Income Group |
| **LPG** | : | Liquefied Petroleum Gas |
| **LULUCF** | : | Land-use Change and Forestry |
| **MARKAL** | : | MARKet ALlocation |
| **MDDA** | : | Mussoorie Dehradun Development Authority |
| **MIG** | : | Middle Income Group |
| **MLD** | : | Metachromatic Leukodystrophy |
| **MNRE** | : | Ministry of New and Renewable Energy |
| **MoEF** | : | Ministry of Environment and Forest |
| **MoSPI** | : | Ministry of Statistics and Programme Implementation |
| **MSME** | : | Ministry of Micro, Small & Medium Enterprises |
| **NAPCC** | : | National Action Plan on Climate Change |
| **NCAER** | : | National Council of Applied Economic Research |
| **OECD** | : | Organisation for Economic Co-operation and Development |
| **PNG** | : | piped natural gas |
| **PPP** | : | public–private partnership |
| **PWD** | : | Public Works Department |
| **REC** | : | residential electricity consumption |
| **RGGVY** | : | Rajeev Gandhi Grameen Vidhyutikaran Yojna |
| **RWA** | : | Resident Welfare Association |
| **SIDCUL** | : | State Industrial Development Corporation of Uttarakhand |
| **SPV** | : | Special Purpose Vehicle |
| **UEPPCB** | : | Uttarakhand Environment Protection and Pollution Control Board |
| **UK** | : | United Kingdom |
| **UNFCCC** | : | United Nations Framework Convention on Climate Change |
| **UP** | : | Uttar Pradesh |
| **UPCL** | : | Uttarakhand Power Corporation Limited |
| **UPSIDC** | : | Uttar Pradesh State Industrial Development Corporation |
| **UREDA** | : | Uttarakhand Renewable Energy Development Agency |
| **USA** | : | United State of America |
| **VGF** | : | Viability Gap Funding |
| **VKT** | : | Vehicle-Kilometers-Travelled |

# TABLE OF CONTENTS

# List of Tables

# List of Figures

# CHAPTER 1- INTRODUCTION

Ideals of sustainable development demand adoption of environment friendly measures in the development process. It becomes even more important in view of increased depletion of natural resources. The speed and scale of urbanization and increasing contribution of urban areas to the GDP have conclusively proven that cities are engines of growth and therefore it is in everybody's interest that cities and activities therein are planned appropriately (Kenworthy, 2006; Keirstead et al., 2012). The development process entails among other things, continuously increasing use of energy. Therefore, achieving energy efficiency in all the processes has become a focal point for all the countries. For a country like India, it is even more challenging because of the exponential growth in its population and economy both. "Cities are the future, they invariably need to demonstrate strong leadership in emission-reduction process as outcomes.' This line represents the Herculean task of reduction of greenhouse gases by cities in India, including Dehradun.

The measures differ from sector to sector and country to country. However, there are certain areas around which there is consensus. One of such themes is `Eco-cities'. The concept as such is not new but has assumed focus in recent times and has seen several activities by various stakeholders across the globe. It is in this context that Richard Register first coined the term `Eco-city' in his book – "*Eco-city: Building Cities for a Healthy Future*" way back in 1987 (Roseland, 1997). The concept as such was discussed initially in 1970s as a part of sustainable urban development agenda.

The urbanization and increasing awareness of this concept initiated the scholars to find a new way of building and developing eco-cities which are sustainable for the future (Keirstead et al., 2012). China talked of building `Eco-communities' in its `Agenda 21' in 1994 and came up in 1996 with policy document Guidelines for the Building of Eco-communities (1996-2050).

The conservation of resources for the benefit of future generations and the protection of a healthy and livable environment are key objectives for sustainable urban development (Song, 2011). All areas of planning need to be evaluated for their impact on the environment prior to execution. The recent years have seen the strategic take up of the eco-city concept and an accelerated translation of the ideas and visions are now taking place in many initiatives. Eco-cities are characterized by solar, wind and recycling technologies, in green buildings and green businesses and in urban environmental restoration projects. In simple terms, an eco-city is ecologically healthy and eco-friendly established city. Experts and builders believe that developing or converting existing cities into what are known as eco-cities is the only solution.

## 1.1 Defining an Eco City

An Eco City could be defined as an ecologically healthy human settlement modeled on the self-sustaining resilient structure and function of natural ecosystems, which implies healthy living to its inhabitants without consuming more (renewable) resources than it produces, without producing more waste than it can assimilate, and without being toxic to itself or neighboring ecosystems. Eco-city was a proposal for building the city like a living system with a land use pattern that will support the healthy environment of the whole city, improve biodiversity, and make the city's features resonate with the patterns of development and sustainability (Cheng and Hu, 2010; Yu, 2014). The word 'eco-city' stayed mainly a compilation of various thoughts about sustainable urban planning, transportation, housing, energy, water, wastes, as well as the protection of the environment.

Subsequently eco-cities were planned in Dongton near Shanghai, Tianjin in northern China and Huangbaiyu in north-east China. Japan also planned six eco-cities starting 1997- Yokohama, Kitakyushu, Toyama City, Obihiro, Shimokawa and Minamata.

Roseland suggested that an accumulation of obviously disconnected ideas about urban planning, transportation, health, housing, energy, financial development, natural habitats, community involvement, and social justice all comprise a single framework, the eco city. Analysis of various plans of eco-cities throws some common parameters, which may be said to be integral part of any eco-city, which are:

i. Environmentally sound technologies to reduce carbon emission implying minimal energy consumption,
ii. Resources needed are found/produced locally.
iii. Energy production is carbon-neutral or renewable in nature.

From the energy efficiency point of view, some more parameters which can be considered for assessing an Eco city are as below:

1. Efficient public transport system, minimizing use of private vehicles.
2. A city lay out which promotes cycling and walking.
3. A waste management system leading to zero-waste city implying recycle and reuse of entire waste generated in the city.
4. Restoration and conservation of damaged urban areas, public spaces and urban forests.

## 1.2 The Vision of Eco- City

The overall Eco-City objectives give a first indication of the issues that need to be considered in different planning sectors (Wu et al., 2005; Anderson et al., 2015). However, they are still relatively abstract. To develop a common image of the sort of settlement that eco-city planning should lead to, it is necessary to agree on a common vision.

The idea of creating an eco-city is very complex to realise even in the developed world. It is worthwhile examining the experiences and appreciating the differences in eco-city initiatives in western countries compared to the Indian situation. A closer look at such western initiatives usually reflects priorities. In a country like India, which is predominantly defined by vastness and diversity, an eco-city vision should reflect an awareness of history and society, relate the human, built, and natural environments, and respect the cultural and social use of space.

In India, a meteoric growth of megacities has brought with it huge environmental and social problems. For the first time since independence, the absolute increase in population is more in urban areas that in rural areas. The population living in urban areas is increasing rapidly. As per Census of India, the urban population has increased from 28% in 2001 to 31% in 2011. It is not only the total population but the growth rate of urban population is also higher than the country's average. The average annual growth in population of India was recorded as 1.64% during 2001 and 2011 whereas during the same period, the urban population has increased by 2.8%.

A major consequence of the rapidly urbanizing population is on the micro environment (i.e. within the city). Rapid urbanization in India has many consequences like; cities are expanding in a non-planned manner, public transport is not sufficient and accessible, energy conservation gets little attention, localization of resources etc. which is defeating the concept of eco-cities and hence making long term damage to the ecology and micro-environment in urban areas.

Thus, there are several challenges in developing eco-cities. For example, Dongstan was conceived as a city on the outskirts of a super-cityand which would attempt to have zero emissions, even if it meant banning cars, and use various renewable energy systems. The land was acquired and the city was expected to be ready and functioning by the year 2010. However, The project was stalled in Sept. 2006. Some pertinent issues have been raised by Julie Sze in her book `Fantasy Islands'. She attributes the failure of the effort to

(i) corruption by officials in land acquisition,
(ii) focus on technological and ecological sophistication in green-building structures, and
(iii) Less concern with behavioural aspects of population, amplified by displacement of entire original population expecting to bring-in the spill-over population from Shanghai to Dongton.

Sze suggests that the role of individual citizens is equally important.

## 1.3 ECO-CITY Project in INDIA

The Eco-city Project was initiated by the Central Pollution Control Board (CPCB) in the year 2002 with the grants-in-aid from the Ministry of Environment and Forest (MoEF), Government of India in partnership with the German Specialized Co-operation beneath India-German Atmosphere Plan about "Advisory Companies with Environment Management" (ASEM) as part of the 10 Strategy activities. In 2001, as part of 10th 5-Year Plan (2002-2007). The MoEF selected 6 towns-**Kottayam, Puri, Thanjavour,Tirupati, Ujjain and Vrindavan.** Kottayam was the first eco-city of six pilot eco-city initiatives, which started to make various retro-fit adaptations.

All six MOEF eco-city initiatives had almost similar objectives, which incorporated: improving sanitation in public spaces; making public transport more resourceful and environmentally sustainable; improving urban management; and improving amenities and situation for tourists. Overall, comparatively little improvement appears to have been made in the MOEF eco-city programme, with a lot of recommendations in each city not getting beyond the planning stage. India has seen numerous other eco-city initiatives sponsored by government ministries, which are not linked to the Ministry of Environment and Forest's pilot initiative. The particular eco-city program throughout India directed to ameliorate the existing environment, addressing generally to these elements that are producing the environmental destruction. The particular concentration from the program ended up being to manage pollution, boost environmental management, through environmental methods like waterways and also waters, sanitary issues, improve necessary infrastructure and to create aesthetic environs inside the selected neighborhoods. This specific challenge was supposed to pave means intended for altering the particular determined planned Cities/towns that are clear, well-kept and also environment friendly.

In 2008, the Ministry of New and Renewable Energy (MNRE) announced development of solar cities initiative, to be implemented during the 11$^{th}$5-year plan (2007-2012). This agreed to provide financial support to 60 cities to work towards plummeting conventional energy demand by at least 10%, through the implementation of solar and other renewable energy sources, along with energy and water management. The project had been developed with input from the US Department of Energy, among others. In 2010 the Japanese government showed interest in collaborating on one city. As of 2017, MNRE had given "in principle" conformity for 48 solar city programs[1] to go ahead. In addition, the Indian Ministry of Urban Development worked with the US Department of Energy and US-based Brookhaven National Laboratory to make eight "Near-Zero Energy Satellite Towns". Rajarhat, a fast growing new township near Kolkata, was preferred in 2010 to be the first of these.

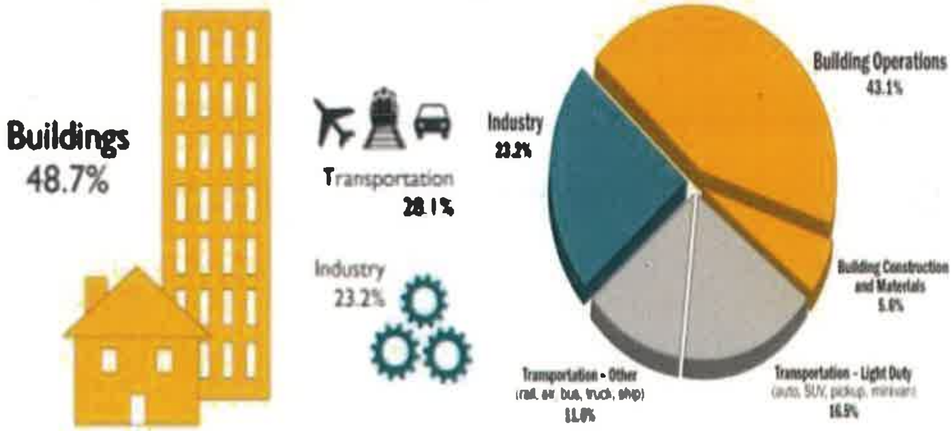
As per the Census of India, the total number of urban units in 2001 stood at 5,161 Towns (Statutory Towns – 3,799 and Census Towns – 1,362) which has increased to 7,935 Towns (Statutory Towns – 4,041 and Census Towns – 3,894) in 2011 i.e. an overall increase of 2,774 Towns (Statutory Towns – 242 and Census Towns – 2,532) in the ten year duration.

Thus a focused approach is needed to assess in detail requirements and the policy level interventions required for making the urban areas more eco-friendly (Kenworthy, 2006; Cheng and Hu, 2010). A calculation of the carbon footprint of the present energy consumption in urban areas is expected to provide prioritization of parameters which can be tackled firsthand to maximize the environmental benefits. Globally, it is a general understanding that energy consumption is highest in transportation i.e. petrol, diesel and coal. But as per the

[1]*MoNRE, 2017. Solar/Green Cities. [Online], Available at: http://mnre.gov.in/schemes/decentralized-systems/solar-cities/ [Accessed 27 December 2017].*

records of US Information Administration (2011)[2], most of the energy in urban areas are consumed in Buildings. The figure below further illustrates the consumption of electricity in various sectors:

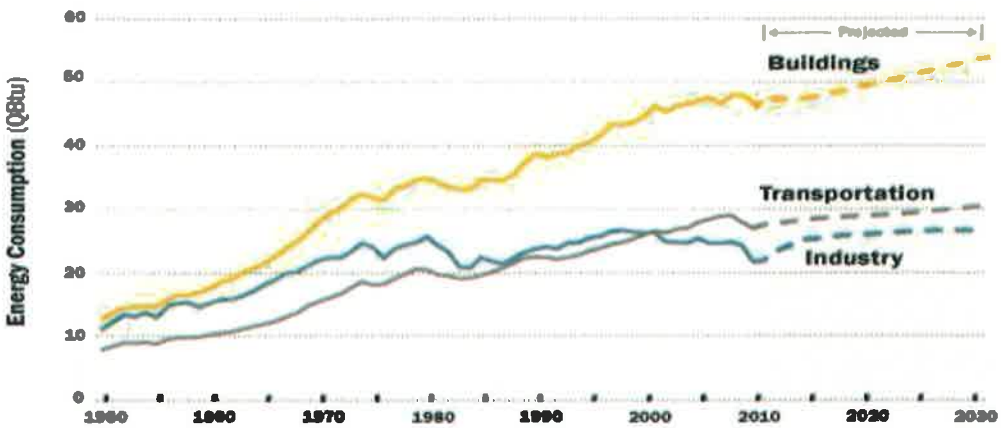
**Figure 1-1: Sector wise Energy Consumption in urban areas**




***Source:*** *U.S. Energy Information Administration, AnnualEnergyReview2011*

As evident from the above figures, nearly half of the total energy produced in US is consumed in building operations and building construction & materials. The same agency has also projected the split of energy consumption for future years and is presented in the figure below:

**Figure 1-2: Projected distribution of energy among various sectors in Urban Areas**




***Source:*** *U.S. Energy Information Administration, AnnualEnergyReview2011*

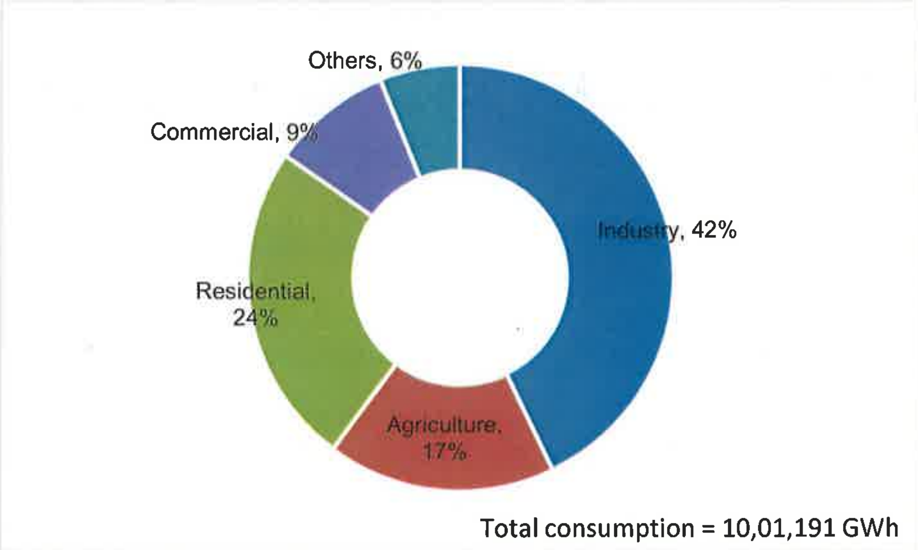
The above figure illustrates that by 2030, energy consumption in buildings will be equivalent to the energy consumed in transportation and industries together. Though, no such figures and energy consumption data is available for Indian cities but the scenario is not

---

[2] *AnnualEnergyReview2011, Independent Statistics & Analysis, U.S. Energy Information Administration, DOE/EIA-0384(2011)| September2012*

expected to have a large margin of difference. Energy statistics published by MOSPI (Figure 1.3) shows the electricity consumption by different sectors in India during 2015-16. The households accounted for 24% of the total 1001 billion units consumed in India as shown in Figure 1.3.

**Figure 1-3: Consumption of electricity by different sectors in India during 2015-16**




Therefore, it is imperative to undertake study to find out share of residential sector in energy consumption and also to assess major sources of such consumption and how they can be minimized to make a move towards more eco-friendly cities. In this study, an attempt has been made in learning the energy consumption pattern in the residential sector of Indian cities. It is the endeavor of this study to evaluate the carbon footprint created by the residential sector in the city on the basis of which measures have been recommended. Another key objective of the study was to provide policy inputs that may be enforced by the governing bodies in any new and upcoming residential development projects.

Moreover, various ways have been studied exploring various interventions that could be taken to minimize the energy demand and use more environment friendly ways in day to day life and thus maintain the ecological balance within the city. As the cities grapple for checking the emissions, a new framework has been devised by a joint efforts between GHG Protocol at World Resource Institute, C40 Cities Climate Leadership Group [C40] and Local Government for Sustainability. The new framework is called the Global Protocol for Community- scale green House Gas Emission Inventories [GPS][3] This framework [GPS] allows a fair amount of flexibility for city government to choose the most suitable methodology depending on their requirements, objectives and availability of data.

[3] *Terragreen, August 2017, Page 28*

## 1.4 GHG Emission Studies in India

India has been critically looking into issue of its Greenhouse Gas (GHG) emissions over the previous many years. One of the earliest studies on the issue of Greenhouse Gas (GHG) emissions has been the *Report of the Expert Committee on India's Integrated Energy Policy* in 2006, which estimated the carbon dioxide generation profile of India's energy sector up to 2031-32 under 11 different scenarios of fuel mix. Subsequently, the report entitled 'India's GHG emissions profile, Results of Five Climate Modelling Studies' comes across as the guiding light towards preparing the pragmatic policy options. The report highlights about the broad convergence across the five studies in the estimates of India's aggregate GHG emissions and per capita GHG emission over the next two decades.

This *Government of India, Ministry of Environment and Forests, (2009)'India's GHG emissions profile, Results of Five Climate Modelling Studies'* report summarizes the initial results of five studies. These studies are as follow:

1. NCAER-CGE study: This study was carried out by India's National Council of Applied Economic Research (NCAER) using computable general equilibrium (CGE) model. The model covered 37 sectors including Government and is top-down, non-linear general equilibrium model, which basically simulates the activities of Indian economy in which producers and consumers maximize profits and utility respectively, as per standard economic behavioural assumptions.
2. TERI-MoEF study: A MARKet ALlocation (MARKAL) model study by The Energy & Resources Institute (TERI). This model comprise of 35 energy consuming subsectors and a set of primary energy sources (conventional and non-conventional). It is a Linear Programming MARKAL Model set up with an objective function of cost-minimization of the overall energy system over a 30 year modelling timeframe extending from 2001-2031.
3. IRADe-AA study: The study was carried out by the Integrated Research and Action for Development (IRADe). It is also a linear programming model, which uses the activity analysis framework to model the linkages between the national economy and environment. The model is multi-sectoral and inter-temporal and maximizes an objective function, which is the discounted sum of total consumption streams given the resources available to the economy and the various technological possibilities for using them.
4. TERI-Poznan study: This study used the framework of MARKAL model as used in TERI-MoEF study to forecast the GHG emissions at of India in 2031 and the results were presented at the 14th Conference of Parties (COP) on Climate Change at Poznan. The model differ from TERI-MoEF study in its assumptions related to GDP growth rate, energy prices and improvements in energy efficiency considered on the basis of experts' judgement.
5. McKinsey study: This study provides an estimation of GHG emissions from 10 large sectors by the year 2030 carried out by McKinsey and Company. The study followed a bottom-up analysis based on certain assumptions of growth and energy patterns in these sectors for estimating the GHG emissions.

Overall, these five modelling studies have used a range of methodologies to model the factors of production across industry sectors and consumers' behavioural pattern. The studies give estimates of India's per capita GHG emissions in 2030-31 ranging from 2.77 tonnes to 5.00 tonnes of $CO_2$ eq.

The five models describe the possible scenario. The report says that key drivers of the range of these estimates are the assumptions on GDP growth rates, penetration of clean energy, assumed energy efficiency improvements etc. Significantly, the report argues that there are also justifiable differences in model assumptions, model structure and data, and scenario definitions. The opinion of the report is note-worthy. It states 'it is therefore neither feasible nor advisable to define a single "baseline" or "business-as-usual" trajectory for a country's GHG emissions.'[4]

Here it may be noted that most of the estimations are represented as range and all are illustrative scenarios; not best- or worst-case scenarios. Since all the model-specific assumptions and factors included are illustrating the Indian conditions in 2031 on a wider scale, it was perceived that these studies cannot be brought into application for achieving the objectives of the present study. Further, all of them have assumed a level of technology adoption and improvement in energy efficiencies over time which does not reflect the scenario specific to Dehradun city. The present study attempted to explore the technological interventions specific to Dehradun city.

The standard guidelines are also available which suggest ways for reducing GHG emissions.

### Table 1-1: Ways for reducing GHG emissions from the Residential Sector in the City

| Ways for reducing GHG emissions from the Residential Sector in the city | | |
|---|---|---|
| **Type** | **How Emissions are reduced** | **Examples** |
| **Homes and Commercial Buildings** | Reducing energy use through energy efficiency | Homes and Commercial buildings use large amounts of energy for heating, cooling, lighting and other functions. "Green buildings" techniques and retrofits can allow new and existing buildings to use less energy to accomplish the same functions, leading to fewer greenhouse gas emissions. Techniques to improve buildings energy efficiency include better insulation ; more energy-efficient heating, cooling, ventilation and refrigeration systems; efficient fluorescent lighting; passive heating and lighting to take advantage of sunlight and the purchase of energy-efficient appliances and electronics |

[4] Government of India, Ministry of Environment and Forests, (2009)'India's GHG emissions profile, Results of Five Climate Modelling Studies', page 7

| | | |
|---|---|---|
| **Refrigeration** | Reducing leakage from refrigeration equipment. Using refrigerants with lower GWPs. | Commonly used refrigerants include ozone-depleting hydro chlorofluorocarbon (HCFC) refrigerants, often HCFC -22 and blends consisting entirely or primarily of HCFC, both of which are potent greenhouse gases. In recent years there have been several advancements in refrigeration technology that can help food retailers to reduce both refrigerant charges and refrigerant emissions. |
| **Wastewater Treatment** | Making Water and wastewater system more energy efficient | Drinking water and wastewater systems account for approximately 3-4 % of energy use in the united states. Studies estimate potential saving of 15-30% that are readily achievable in water and wastewater plants. |
| **Waste Management** | Reducing Solid waste sent to landfills. Capturing and using methane produced in current landfills | Landfill gas is the natural by-product of the decomposition of solid waste in landfills. It primarily consists of Co2 and CH4. Well established, low-cost methods to reduce greenhouse gases from consumer waste exist, including recycling programs, waste reduction programs, and landfill methane capture programs. |

***Source:*** *EPA, 2017. Climate Change.*

## 1.5 Awareness about Environmental Concerns

There is more awareness among citizens about the environmental concerns and private initiatives are also being taken in this direction. Dehradun itself has seen such an initiative. Energy efficient buildings make small yet significant contribution towards reduction of energy demand and carbon emission. The SOS Tibetan Children's Village, Dehradun, located in Rajpur in Mussoorie foothills, is one of the best examples of energy saving building in India.5 The remarkable feature has been that it is built by taking advantage of the climatic conditions of Dehradun region, simple construction techniques, innovative use of solar techniques, appropriate material selection and intelligent planning. Going by the physical infrastructure data, the site of SOS measures 14,300 sq.m. comprising of 15 family cottages, small nursery school, dispensary, community house, residences for the director and co-

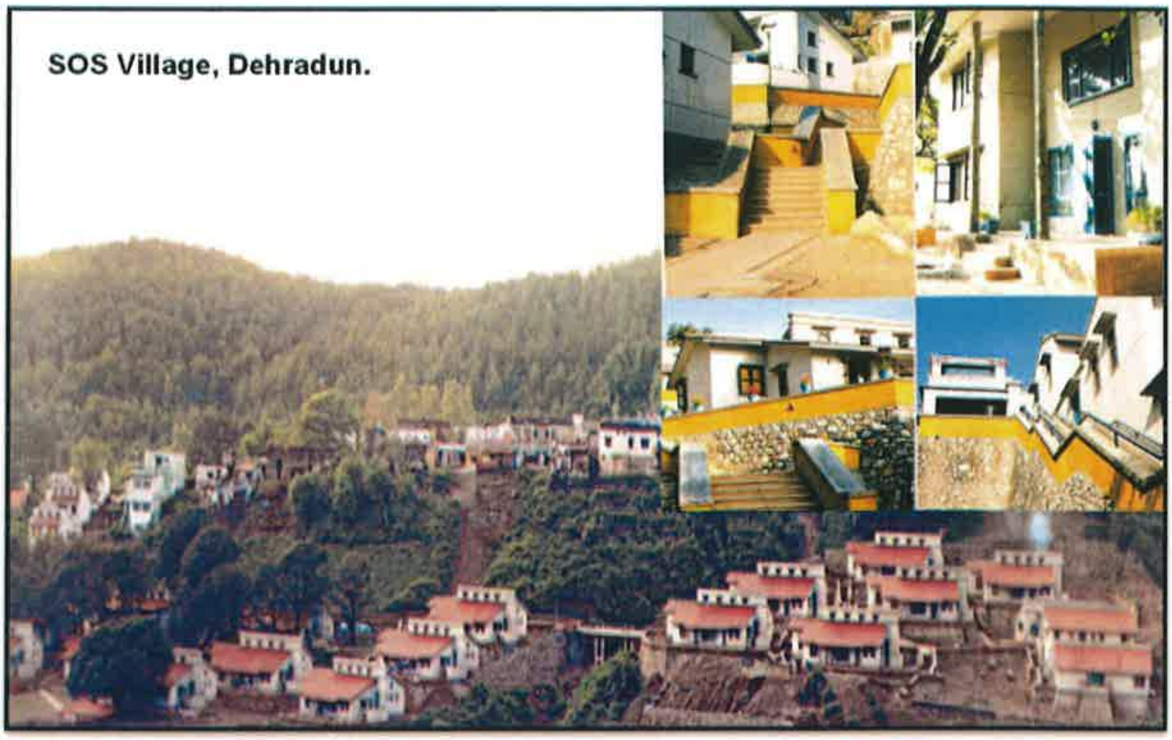
[5] Agarwal Bindu, Dhenesh Raj, Energy saving in Buildings case study: SoS Children's village, Dehradun, *Journal of Civil Engineering and Environmental Technology* Volume 1, Number 1; August, 2014 pp. 10-16

workers, recreation room and place of worship. It has been functioning since 4th of October, 1999.

**Some of the key features are as follow:**

1) The Architecture of the SOS Village responds to composite climate of Dehradun and its traditional building material.
2) the architectural energy efficient design
3) The concept of design is based on simple low-cost, low – maintenance construction, environment friendly techniques, design taking the advantage of climatic condition, recycling of water ( use of rain water), use of natural forests, air and carefully designed out building envelop.
4) The primary strategy is to provide protection from harsh winds from the north-east and to provide solar access.
5) Orientation of building is such that maximizes solar access in the winters and ventilation in the summer.
6) Light grey color stone aggregate plaster is used on external faces of walls.
7) Windows with double rebate double shutters in houses are provided to reduce infiltrations.
8) Bedrooms have solid timber board shutters on inner side for insulation.
9) It adopts a careful landscape planning. Landscape planning has been carefully done to provide shelter from cold winter winds and access to winter sun. The planning and plantation schemes are combined.
10) Terracotta tiles are used at roofs for insulation

The city administration of Dehradun may utilize the features of SoS village which will help in enhancing the energy efficiency.



## 1.6 Achieving Energy Efficiency through Behavioural Change

Though there is greater awareness among people today about environment, a lot of efforts are still required for behavioral change in people to reduce energy consumption and strive for greater energy efficiencies in their use of resources. There have been several studies which indicate towards the efficacy of such an approach.

A study was conducted about understanding the behavioral aspects of consumer on making an energy efficient household using smart technologies.[6] A household survey was carried out in March-April 2013 in Latvian. A study has been analysed and tested in three stages i.e. 480 households are taken in 1st round and 8 target group households were taken in 2rd and 3rd rounds and re-interviews. Socio-demographic, building physical parameters, user behavioral factors, electric appliances and climatic aspects were taken in as influencing factors.

After first stage study telephonic survey was conducted and apart from these questions, their attitude, awareness, level of knowledge on energy efficiency, habit of appliance usage and behavior had been analyzed. It was found that time, appliance and income have significant impact on the electricity consumption rate. Face to face interviews were carried out in the 2nd round and was structured into two parts i.e. to how exactly electricity has been used in households and factors that affected the patterns of use in similar households.; and secondly, to estimate participants' behavioral, motivation and attitude in the context of consumption reduction. In the 3rd round, replacement of appliances were done and re-surveyed and it was found that users are willing to reduce consumption, use energy efficient technologies like smart meters, renewable sources of energy only if economic benefits are given or they were made to think 'greener'. They are not willing to invest in new technologies.

Lastly, it was concluded that the motivational factors for households can be related to save money, competition, awareness of real examples of save energy and promoting energy efficiency through smart meters.

I. Khan* and P. K. Halder[7] conducted a study to assess achievement of the electrical energy conservation for residential consumers through behavior change, in Jessore, Bangladesh. The study was conducted at the end of summer (July-August) and in the beginning of winter (November-December 2013). KABP (Knowledge, Attitude, Behavior and

---

[6] Poznaka, L. et al., 2014. *Analysis of electricity user behavior: case study based on results from extended household survey.* Latvia, Elsevier Ltd. .

[7] Khan, I. & Halder, P. K., 2016. Electrical Energy Conservation through Human Behavior Change: Perspective in Bangladesh. *International Journal of Renewable Energy Research*, 6(1), pp. 43-52

Practices) Model had been adopted to bring behavioral change through knowledge, attitude, behavior and practices. As electricity consumption in Bangladesh is increasing steadily, it is very essential to assure optimum utilization of the energy. Considering the barriers like efficiency measures can be relatively expensive, lack of energy efficient technology, lack of knowledge and understanding of energy saving behavior and efficiency measures available, hassle factor of installing efficiency measures, aesthetics, social norms influence people's behavior, etc. three approaches were adopted for behavioral change programme- real time feedback generating in home devices and displays, customized-regular feedback delivered to consumers and dynamic pricing and rate design program.

It was found that people are yet to realize the benefits of energy efficiency and energy conservation and not aware about energy use behavior. Therefore, it has been suggested that for increasing public awareness through various initiatives like advertisement, billboard, seminar, fairs, campaigns for the benefit of the consumers and the country.

A study on models of behavior change[8] is based on the relationship between energy use, behavioral determinants and effective strategies to promote more efficient behavior specifically in residential users with a believe that changing people's behavior can significantly reduce energy consumption, and it appears that conditions are now mature for integration of social science into energy research. Energy behavior has been classified into investment behavior and habitual behavior.

After the study of approaches of various behavior model like Reasoned Action Theory, Ajzen's theory of planned behavior, norm–activation model (NAM), etc, economical, psychological and sociological approach has been found. Energy behavior research and behavioral change efficiency programme and intervention shows that a focus only on the instrument of an intervention, without an analysis of energy-related targeted behaviors and their behavioral antecedents masks the real potential of energy savings and fail to rigorously assess the true impact of the instrument in question.

A comparative study was conducted in 2014[9] to analyze research related to energy saving through changing people's behavior. The document provides the research related to energy saving potential of changing the behaviour of the population of few foreign countries such as Switzerland, Germany, UK, Netherlands and USA.

The study found that people's changing behaviour in relation to energy consumption affects a number of macro level and personal factors. Receiving a regular and effective feedback on energy consumption behaviour allows individuals to change the behaviour. In

---

[8] Karatasou, S., Laskari, M. & Santamouris, M., *2013. Models of behavior change and residentialenergy use: a review of research directions and findings for behavior-based energy efficiency. In: Advances in Building Energy Research. s.l.:*Taylor & Francis Group.

[9] Simanaviciene, Z. et al., 2015. *Research Review Of Energy Savings Changing People's Behavior: A Case Of Foreign Country.* s.l., Elsevier Ltd..

order to improve the policy to make an impact on household and consumer environmental behaviour, a project BEHAVE 2007 was carried out. The user behaviour was found to be dependent on information, motivation and responsibilities. These factors determine certain important financial and potential saving instruments. The project BEHAVE 2007 provides an overview of studies conducted in household results of 100 cases in eleven countries. Energy consumption metering devices were found to be useful in encouraging people to save, buy energy efficient appliances and turn them off when not in use. It was advised that Government's energy saving policies should not be directed only to households, but also to supply.

Another study W. Poortinga and others draws attention to the direct and indirect energy consumption. Indirect energy devoted to manufacture, transportation, sales of services and goods etc. can achieve a significant energy savings. Netherlands greenhouse project provided Greenhouse gas reduction opportunities in areas such as nutrition, clothing, household activities etc. The J HWang study showed smart metering with which consumers can save 3.5% to 22% of energy.

The European Union adopted the Energy Efficiency Directive on 2012 to reduce primary energy consumption by 20% by 2020, which requires change in consumer behavior and energy consumption practices. The report however does not include a discussion on the socio-economic implications of these structural changes. The report by EEA also argues that a whole range of changes need to take place in the way energy markets function and are regulated in order to enable the consumer to actively engage with these markets. Some measures were taken targeting behavior and justifies their implication on behavior change towards energy consumption, which includes Feedback- combining direct and indirect feedback. Direct Feedback includes information received via consumer's computer through smart meters and indirect feedback includes more informative and frequent bills; Energy Audit to provide the information needed to implement energy efficiency measures in a specific environment; Community-based initiatives to bring long-term behavior change to introduce a new, pro-environment social norms; Structural Factors could include linking dynamic pricing schemes with smart meter; Rebound Effect to increase the energy efficiency measures through initial savings.[10]

It can be concluded that changing the behaviour of individuals, regular and effective feedback, identifying bad habits can help significantly in the energy savings.

---

[10] EEA, 2013. *Achieving energy efficiency through behaviour change: what does it take?*, Denmark: European Environment Agency.

# CHAPTER 2- THE STUDY

## 2.1 Aim of the Study

"To study carbon footprint of energy consumption in the residential sector of Dehradun, Uttarakhand". This will enable city like Dehradun and other important cities to align themselves with the national agendas and transform into livable and sustainable cities. In other words, city like Dehradun will have a fair amount of reliable database which will enable it to frame suitable city-wide policies.

## 2.2 Objectives of the Study

The study aims at analyzing energy efficiency aspects in the context of eco cities, which include the following:

1 Macro analysis of energy consumption in the city.

2 Micro level analysis of selected category of houses within the city to understand their energy consumption pattern.

3 Calculation of carbon footprints in the existing scenario in the selected case study areas.

4 Exploring available technological interventions to ensure reduction of the carbon footprint and to check its adaptability and suggest/provide policy inputs to increase energy efficiency.

## 2.3 Methodology

Dehradun has not been identified as an 'Eco-city' under any scheme, however, two factors led to selection of the city for the study – first that it is undergoing transformation after becoming capital city and has seen a lot of growth in economic activities and second it is covered under various schemes of the government which have implication for the energy consumption. It was chosen for the collection of empirical data in consultation with HUDCO officials. Besides the above-mentioned reasons the city is a hilly area and well-endowed with green spaces, but after becoming the state capital it saw increased commercial and construction activities which have implications for carbon footprint. Several government offices moved to the city and the city population registered growth. It gave an opportunity to understand the increase in energy consumption and also to see whether sustainability concerns received due attention of the policy makers and other stakeholders.

The study aims to assess major sources of energy consumption in the residential sector and their carbon footprint. For the macro level analyses, the study focuses on Energy, Water and Sewage Management and Transport. For residential sector the study was conducted at two levels- assessment has been made about the share of residential sector in the overall energy consumption by various sectors and then secondly the assessment was made of the various sources of energy consumption at the household level.

This study further investigates the patterns of energy consumption in Dehradun city and documents the energy saving potentials that can be achieved with focused policy efforts. Furthermore, the study investigates the potential saving of greenhouse gas (GHG) emissions for different scenarios developed for the interventions related to electricity consumption, water supply and losses, wastewater treatment. Description of scenarios generated and projections for saving potential (electricity and GHG emissions) under each has been provided in the concerned chapter.

Both the primary and secondary data sources were used for the study. The household data was collected through canvassing the questionnaires among the households. For the purpose, six localities were identified- two having one bedroom, two having two bedrooms and other two having three or more bedrooms. 500 households having one bedroom were covered in an earlier survey in October, 2013, while 500 more were covered in the second round in February, 2014. Forty households in each of the other four localities having HIG and MIG households were covered under the survey in the third round conducted in May, 2017. Questionnaires were designed to assess the pattern of energy consumption through uses of electrical appliances, uses of alternative sources of energy and uses of water and sanitation services including that of Solid Waste Management. Besides the household surveys, discussions were held with all the other stakeholders including Dehradun office of HUDCO which has funded many projects in the city.

The other stakeholders included, municipal officials, town planning officials, development authority, PWD, Uttarakhand Power Corporation Ltd., Indian Institute of Remote Sensing and Uttarakhand Renewable Energy Development Authority. The macro level data was collected from these city and state level agencies. Focused Group Discussion method was also resorted to in the selected residential areas. The required estimations and projections have been made on the basis of methods which are widely prevalent and accepted. A number of reports and plans have been perused for getting data and information.

Finally, the data has been projected to build two scenarios – Business-as-usual (BAU) and Alternative (ALT). The BAU scenario refers to a situation where the energy consumption and GHG emissions would grow without any management strategy or policy intervention and ALT scenario refers to the case of interventions by various concerned agencies and implementation of reforms as per different schemes specific to Dehradun city, e.g. Solar City Mission, SMART city project etc..

## 2.4 Scope of the Study

The study is limited to the energy consumption pattern of Residential sector in Dehradun so that best possible solutions to maximize the environmental benefits could be identified. The study has also taken up issues which have linkages with the households like public transport or green building code etc. and suggests an integrating approach of policy framework and recommendations to be taken by the multiple stakeholders including government.

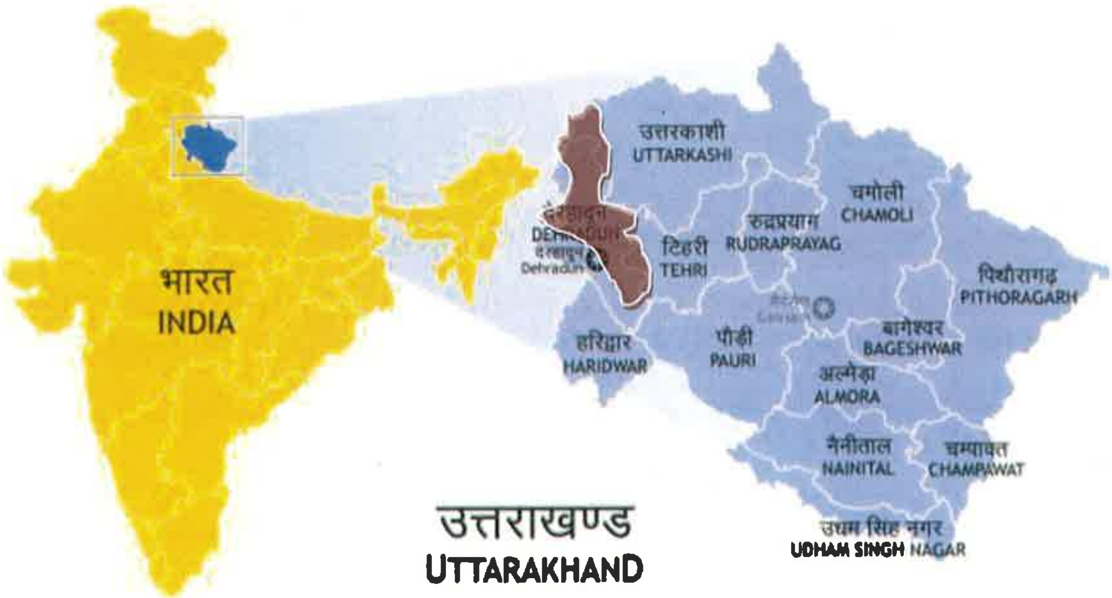
## 2.5 Limitations of the Study

The study is limited to three areas which are affected by the household consumption- Energy, Water and Sewage management and Transport. Lack of availability of data required for the assessment of energy distribution losses is another key limitation for this study. Further, the study was restricted to few select areas for household surveys, which may not be representative of the entire city. However, it brings out the necessary comparisons between the three categories of houses.

# CHAPTER 3- THE STUDY AREA

Uttarakhand, formerly Uttaranchal state of India is located in the northwestern part of the country. Starting from the foothills in the south it extends to the snow clad mountains in the north. The state is rich in natural resources especially water and forests and has many glaciers, rivers and dense forests. It has almost all major climatic zones, making it amenable to a variety of commercial opportunities in horticulture, floriculture and agriculture. It has a vast tourism potential in adventure, leisure, and eco-tourism.

**Figure 3-1: Location of Dehradun in Uttarakhand**




***Source:*** PHD Research Bureau, Chamber of Commerce and Industry, June 2011

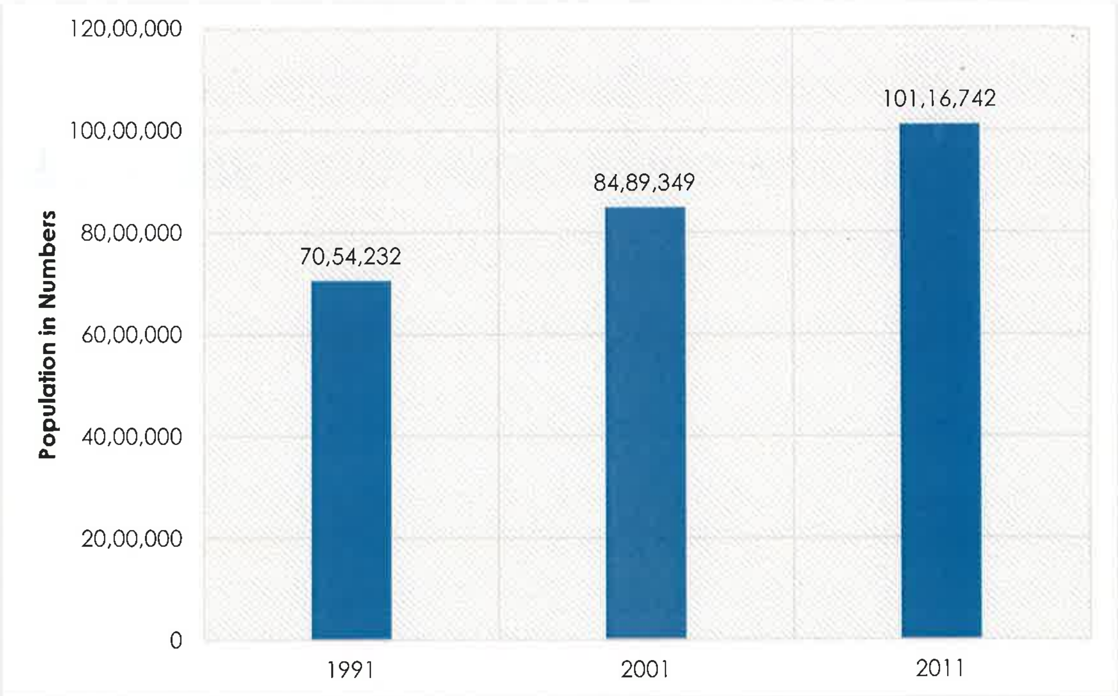
## 3.1 Demographic Profile

The population of Uttarakhand is about 0.84% of the total national population. As per Census of India 2011, the total population of Uttarakhand State was recorded as 10,116,752 which has experienced decadal increase of 19.7% since the past Census conducted in 2001.

The population of the districts in Uttarakhand varies considerably. Four of the 13 districts, namely Dehradun, Haridwar, Udham Singh Nagar and Nainital account for 61.5% of the state's total population. On adding Tehri Garhwal, Pauri Garhwal and Almora, this accounts for nearly 81% of the total state's population. This clearly shows that the concentration of population is quite high in the mid and foothills as compared to the remaining six districts of high hills.

Increment from the past population shows a linear trend in decadal growth which accounts from 70, 54,232 in Census 1991 to 1,01,16,752 in Census 2011at an average decadal growth rate of 19.17%.

**Figure 3-2- Past Population Trend of Uttarakhand**




***Source:*** Census of India 2011

## 3.2 Economic Base of the State

The Uttarakhand economy has been growing at very high rates in the last few years. Trends in sectoral and sub-sectoral growth in the Uttarakhand economy between 1993-2004 show two distinctly different kinds of growth dynamics. There are four sub-sectors that exhibit steady and unchanging growth dynamics for the whole period. These are (i) Agriculture, (ii) Mining, (iii) Industrial, and (iv) Tourism.

Uttarakhand economy heavily relies on tourism industry. Uttarakhand being situated on the foothills of Himalayas comprises of numerous hill stations which attracts tourists from all across the globe thereby bringing money to the state. Apart from the hill stations, the wildlife has also been a major attraction for tourism as tourists come to visit the wildlife sanctuaries such as Corbett National Park, the famous Tiger Reserve. The total number of tourists to Uttarakhand in year 2011 was nearly 2.5 crore.[11]

[11] *ToI, 2013. Recipe for disaster in Uttarakhand: 1 crore population, 2.5 crore tourists. [Online] Available at: https://timesofindia.indiatimes.com/india/Recipe-for-disaster-in-Uttarakhand-1-crore-population-2-5-crore-tourists/articleshow/20721226.cms [Accessed 27 December 2017]*

Industries in the perspective of today's world plays a large role in consolidating the socio-economic rubric of a state. Previously, agriculture used to be the basis of the economic set up, but its share to economy has come down. Industries of Uttarakhand form the basis of the economic set up of Uttarakhand. The State Industrial Corporation of Uttarakhand has developed seven industrial estates; and thus it is helping the industries of Uttarakhand to develop further. Majorly the industrial sector of Uttarakhand involves: - Sugar Mills, Cloth Mills, Paper Mills, and Pharmaceuticals etc.

### 3.2.1 Agriculture

Agricultural activity takes place in the river valleys of Uttarakhand (a meager 10-15% of the total land area). The Uttarakhand farmers have also developed advanced manure, crop rotation and inter cropping practices. Due to the hilly terrain most part of the land in Uttarakhand remains non-irrigated.

Fishing is also an important part of the economy of Uttarakhand. Many regions of Uttarakhand have ample number of lakes that largely contribute towards the fishing activity.

### 3.2.2 Mining

Mineral resources of Uttarakhand play a significant role in the economy of Uttarakhand. Although, the mineral resources of Uttarakhand are not as varied as that of Bihar or Odisha; yet mineral resources at Uttarakhand contribute significantly towards the economic well-being of the state. The Chamoli district of Uttarakhand is especially famous for housing a number of mineral resources in Uttarakhand. The northern division of the district consists entirely of medium to high grade metamorphic rocks, which also contains bands of volcanic rocks in some regions. placer gold, copper and iron ores have been extracted/mined in this part of Himalayan terrain on a very small scale over hundred years ago. The mineral resources contain rocks such as quartzite, marble, and various types of schist and gneiss.

## 3.3 Regional Settings and Importance of Dehradun

Dehradun district is bounded by Uttarkashi district on the north, Tehri Garhwal and Pauri Garhwal districts on the east and Saharanpur district (UP) on the south. Its western boundary adjoins Sirmour district of Himachal Pradesh separated by Tons River and Yamuna River. The total area of Dehradun district is 3088 Sq km.

## Figure 3-3: Regional Connectivity of Dehradun


Dehradun city is the administrative centre and the capital of the state of Uttarakhand. It is situated at the Himalayan foothills in the fertile Doon Valley. It is due to this reason Dehradun has been one of the favorite residential cities in the state.

## 3.4 Demographic Profile- Dehradun

It is clearly indicated from the figures shown below, that in 1981, the decadal growth rate of Dehradun was 27.1% whereas in 1991 it was 28%. Because of the fact that during this decade Uttarakhand was separated from the Uttar Pradesh and became a new separate state with Dehradun as a capital city, there was a sudden increase in decadal growth rate of 65.9%[12]. As far as population of census 2011 is concerned; it accounts for a 29% decadal growth rate since the past decadal year 2001i.e.an increase of 2.9% annually.

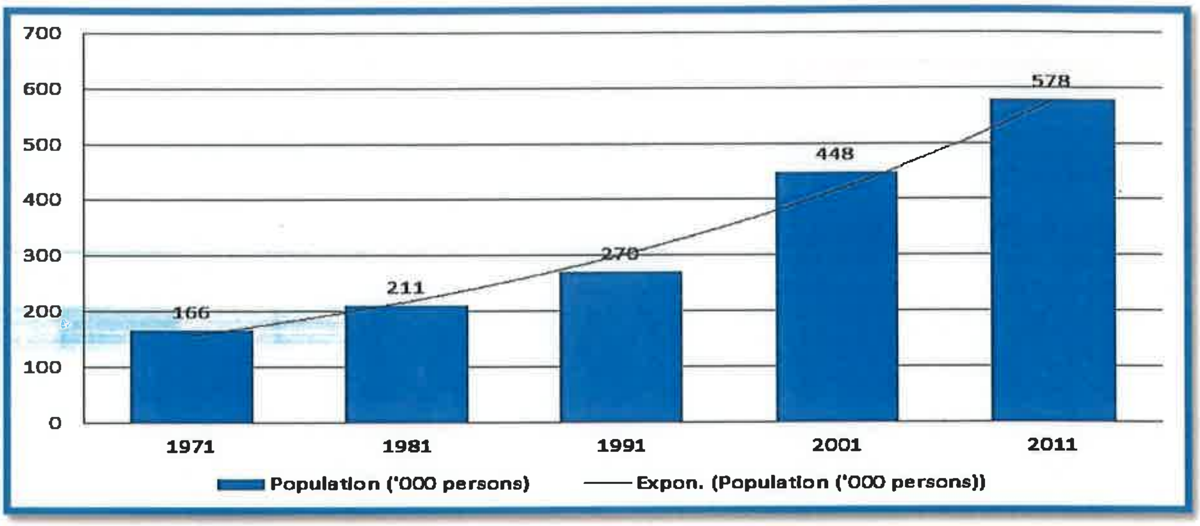
### Table 3-1: Dehradun city Population and Decadal Growth Rate

| Year | Population ('000 persons) | Decadal Growth Rate (%) |
|---|---|---|
| **1971** | 166 | |
| **1981** | 211 | 27.1 |
| **1991** | 270 | 28.0 |
| **2001** | 448 | 65.9 |
| **2011** | 578 | 29.0 |

***Source:*** *Census of India, 2011*

[12]*Directorate of Economics and Statistics, Government of Uttarakhand, Statistical Diary, Uttarakhand,2004-05, page 9, Table 1*

## Figure 3-4: Past Population Trend of Dehradun City

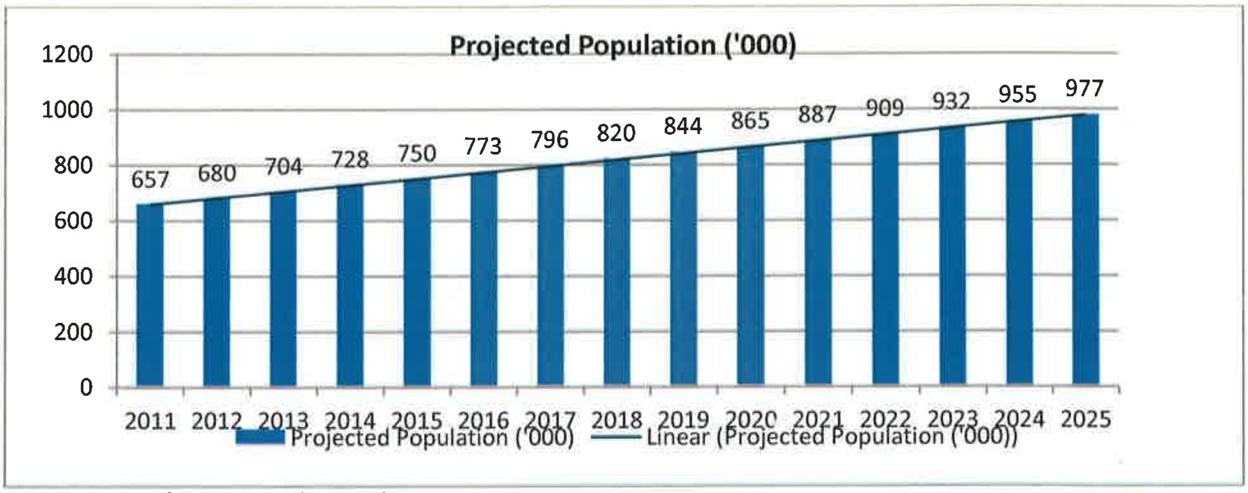



***Source:*** Census of India, 2001

### 3.5 Projected Population as per the Master Plan 2025 and Census of India

As per Draft Master Plan 2025, Dehradun started with a low population base of 4.48 lakhs in (2001), It was assumed that the population of Dehradun would grow at the rate of 4% per annum for 5 years following 2009, 3.5% from 2010to 2014, and 3.0 % from 2015 to 2019. As the base (population) expands, the rate of growth in terms of percentage gradually slows down although in absolute numbers population keeps increasing. It is presumed that population growth rate would stabilize at 2.5 to 2.0% per annum for the next few decades.[13]

## Figure 3-5: Projected Population of Dehradun as per Draft Master Plan 2025




***Source:*** Draft Master Plan 2025

[13] *Content Source – Draft Master Plan of Dehradun 2025*

## 3.6 Literacy Rate

Literacy indicates a major aspect of social development of City/town or a country that is directly correlated with participation in labor force and has an effect on demographic variables. According to Census of India 2011, the average literacy rate of Dehradun is 84.25% compared to 78.98% in 2001. Male literacy rates in Dehradun district of Uttarakhand is 89.40% and as far as female literacy rate is concerned it is about 78.54%. Total Male literates in Dehradun district are 702,216 whereas female literates in Dehradun district are 557,290.

**Table 3-2: Literacy Status of Dehradun District**

| Town | Male | Female | Total |
|---|---|---|---|
| | Literate | Literate | literate |
| **Dehradun** | 702216 | 557290 | 1259506 |

***Source:*** Census of India, 2011

## 3.7 Ground Water Resources

There are six development blocks in District Dehradun. Two blocks (Chakrata and Kalsi) fall in mountainous terrain where the slopes are high and water resources are not estimated for these blocks. The block areas are divided into command and non-command. The stage of groundwater development, for command area, ranges from 53.78 to 78.34% while it ranges from 19.23 to 51.23% for non-command areas. All the blocks are categorized as Safe.[14]

## 3.8 Spatial Urban Development Pattern

Dehradun has seen an unprecedented growth in physical expansion in the post-independence period. There was no serious initiative taken by the government to control the haphazard growth of the city till the seventies. In order to control the haphazard growth of Dehradun the state government declared it as a regulated area in 1963 under UP regulation of Building and Building Operation Act 1958 but the desired objectives could not be achieved as it performed only regulatory functions.

For the balanced and controlled development of the Dehradun city, MDDA (Mussoorie Dehradun Development Authority) has prepared two Master Plans till now. First master plan for 1982-2001 came into effect in 1982 and continues to be the legal document and the second Master Plan is conceived for 2025 but still in its draft form.

**As per Dehradun Master Plan 1982-2001**

- The Total area of the Urban Agglomeration was 6,423 ha.

---

[14]*CGWB, 2011. Groundwater brochure Dehradun, Uttarakhand.*

- It consisted of Dehradun Municipal area, Forest Research Institute, Adhoiwala outgrowth, Dehradun Cantonment Clement Town Cantonment and Rajpur town.
- The Total area within Municipal limits was 3,108 ha out of which 2,398 ha (77%) was developed area.
- About 655 ha (21%) was undeveloped in the form of streams, forests, agricultural land, vacant land, etc.
- About 55 ha (2 %) was under undefined use.
- The limits of the development area coincide with Dehradun District boundary in the north, forest areas in the south and west and the river Song in the east.

**Table 3-3: Land use Deviation of Dehradun as given in different Master Plans (1982, 2001)**

| Land Use | Master Plan 1982 | | Master Plan 2001 | | % change in land use from 1982 to 2001 |
|---|---|---|---|---|---|
| | Area in Ha | % age to Total | Area in Ha | % age to Total | |
| **Residential** | 1588.80 | 41.78 | 3001.77 | 42.60 | + 0.82 |
| **Commercial** | 81.00 | 2.14 | 290.00 | 4.12 | + 1.98 |
| **Industrial** | 113.36 | 2.98 | 350.00 | 4.97 | + 1.99 |
| **Govt. and Semi govt.** | 267.20 | 7.00 | 313.52 | 4.45 | - 2.25 |
| **Facilities and Services** | 802.22 | 21.06 | 833.21 | 11.82 | - 9.24 |
| **Orchards and Gardens** | 205.65 | 5.40 | 250.65 | 3.55 | - 1.9 |
| **Open spaces, parks** | 156.00 | 4.10 | 226.00 | 3.22 | - 0.88 |
| **Circulation** | 203.03 | 5.35 | 400.09 | 5.68 | + 0.33 |
| **Rivers and Nalas** | 331.50 | 8.74 | 1295.98 | 18.39 | + 9.65 |
| **Undefined Land use** | 55.00 | 1.45 | 84.01 | 1.20 | - 0.25 |
| **Total** | **3802.75** | **100** | **7045.13** | **100** | |

***Source:*** Dehradun Master Plan1982-2001and Draft Master Plan of Dehradun 2025.

(+) sign indicates the increase in land use and (–) sign indicates the decrease in land use

Following land use encountered decrease in percentage of land use from1982 to 2001:-

- Government and Semi-government (- 2.25)
- Facilities and services (-9.24)
- Orchards and gardens (-1.9)
- Open spaces and Parks (-0.88)
- Undefined Land use (-0.25)

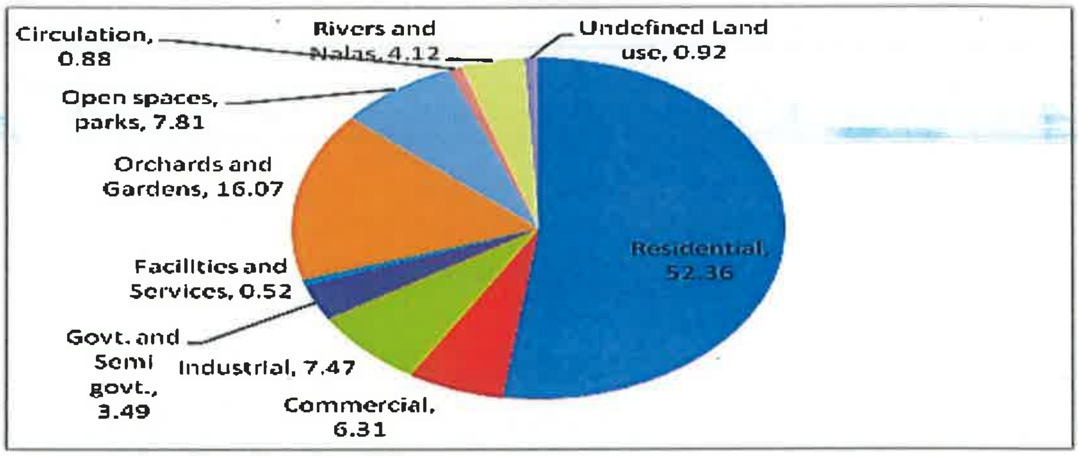
**Master Plan 2005-2025 (Draft) of Dehradun**

- The second master plan prepared for 2025 is still in its draft form.
- Total planning area covered by the plan is approximately 35,867.20 ha which includes Dehradun Urban Agglomeration Area (9,698.97 ha), undefined area (3,058.82 ha) and

172 rural villages (26,163.33 ha). The draft Master plan (2025) projected a population of 15.30 lakhs by 2025.

- The Draft Master Plan 2025 identifies areas where deviations in land uses against 2001 Master Plan have taken place.

**Figure 3-6: Land use deviations as per Draft Master Plan 2025 of Dehradun**




***Source:*** Draft Master Plan 2025 of Dehradun

## 3.9 Future Urban Development Proposed in Master Plan

- Urban development is one kind of emergent phenomenon of urban system, which is very complex and hard to measure.
- The Future growth has been proposed based on the existing growth pattern.
- In the past two decades, it has been observed that the city has been expanding towards Haridwar road, Saharanpur road and Chakrata road where terrain is relatively plain and accessibility is easier.
- MDDA (Mussoorie Dehradun Development Authority) has proposed a scheme of "Greater Doon" measuring about 450 ha for urban development around the Haridwar Bye Pass, out of which 88 ha has already been acquired, which clearly indicates the future direction of growth of Dehradun city.
- Around 28 acres of land has been developed for the Transport Nagar on the Saharanpur Road by MDDA (Mussoorie Dehradun Development Authority).
- About 22 acres is yet to be developed which includes about 8 acres for ISBT workshops.
- Draft Master Plan 2025 indicates that the existing trend of physical development of the city will expand mainly towards south, south-west and south-east mainly from Sahastradhara Bye Pass junction towards Sahastradhara.

## 3.10 City Economy

Among three economic sectors in Dehradun, the dominant sector is Tertiary sector. It involves activities like: storage, transport, trade, real estate etc. Establishment of industries based mainly on limestone and forests have attracted ancillary industrial units and other industries. Development of industries in the city is likely to play a vital role in building a sound economic base of the city. There was an absence of large scale industrial units in Dehradun city. There are 28 small enterprises, 76 micro enterprises and 1 medium enterprise employing

8278 workers. These industrial units are not set up within the city area but have a strong impact on Tertiary sector of the economy of Dehradun city.

### 3.10.1 Institutional/Service

Dehradun is the place of work for large number of state and central government employees. Most of the major banks, public and private sector financial institutions and different service providers have their one or more branches in Dehradun. Institutes such as Forest Research Institute, Indian Institute of Remote Sensing, Indian Military Academy and University of Petroleum and Energy Studies etc. are located in Dehradun.

## 3.11 Forest Resources

Topography of the city is such that forest area plays a dominating role to assess the impact of urban development on Environment. The land-cover changes are equally important elements of the larger problem of global and regional environmental changes. The increasing urban population pressure is putting tremendous pressure on the land use and forest cover of Doon valley. The decline in the Forest area is a matter of concern in order to assess the impact of expansion of urban sprawl.

The Doon Valley is a longitudinal topographic depression situated in the foothills of Lesser Himalaya of Uttarakhand. Doon Valley covers 85.7% area of Dehradun Tehsil of Dehradun district. The valley is believed to have been formed due to folding of Siwalik sediments of Upper Tertiary age. Doon Valley has a rich vegetation cover. Although the major portion of Doon is occupied by the Sal (shorearobusta) but miscellaneous other species are also found here. The hydro-geological and meteorological conditions (231.5 cm annual average rainfalls) of the valley are responsible for the condition for the different types of forest cover.

**Table 3-4: Forest Cover Area of Dehradun (2000-2009)**

| 2000 | | 2009 | | Characteristics Features |
|---|---|---|---|---|
| **Forest Area ($km^2$)** | **Forest Area %** | **Forest Area ($km^2$)** | **Forest Area %** | |
| **1071.56** | 57.98 | 1032.07 | 55.85 | Forest – Farm Fringe |

***Source:*** *Tiwari and Khanduri, 2011*

It is clearly evident from the above figures given in Table 3-4, that there is a decrease in forest cover area from 57.98 % in year 2000 to 55.85 % in year 2009 in Doon Valley which is a matter of concern to assess the impact of urban development on environment.

#### *3.11.1.1 Industries in Dehradun*

In Dehradun district a number of areas are under the industrial land use and the detail of same is as provided in the table 3-5 below. These units are not located within the Dehradun city area.

**Table 3-5: Large and Medium Scale Industrial Areas in Dehradun District and No. of Workers**

| Sl. No. | Name of Ind. Area | Land Acquired (in hectrare) | No. of Units established | Capital Investment (in Lacs) | Employment |
|---|---|---|---|---|---|
| 1 | Govt. Industrial Estate, Patel Nagar, Dehradun | 10 | 13 | 447.51 | 160 |
| 2 | Govt. Indstrial Estate, Vikasnagar, Dehradun | 4 | 6 | 171.04 | 77 |
| 3 | Govt. Mini Industrial Estate, Ranipokhari, Dehradun | 3 | 2 | 47.46 | 15 |
| 4 | Govt. Mini Industrial Estate, Langha Road, Dehradun | 3 | 2 | 82.00 | 26 |
| 5 | Industrial Area, Langha Road, Chabra, Dehradun | 79 | 44 | 10119.91 | 1853 |
| 6 | Industrial Area, Camp Road, Selakui Dehradun | - | 50 | 11573.16 | 2357 |
| 7 | Industrial Area, Centra hope town, Selakui Dehradun | - | 59 | 15937.16 | 2382 |
| 8 | Industrial Area, UPSIDC, Selakui Dehradun | 257 | 156 | 19072.65 | 5472 |
| 9 | Industrial Area, Mohobewala, Dehradun | 51 | 35 | 6656.29 | 1435 |
| 10 | Industrial Area Laltappar, Dehradun | 40 | 28 | 8179.67 | 1681 |
| 11 | Industrial Area Kuanwala, Dehradun | - | 10 | 1558.95 | 316 |
| 12 | Sara Industrial Estate, Shankarpur, Dehradun | 60 | 22 | 8507.62 | 984 |
| 13 | SIDCUL Pharmacity, Selaqui, Dehradun | 50 | 24 | 12059.62 | 1245 |
| 14 | SIDCUL Pharmacity, Sahastradhara Road, Dehradun | 50 | 9 | 851.34 | 246 |
| 15 | Other Industrial Area (thrust Sector), Dehradun | - | 57 | 8263.03 | 1688 |

***Source:*** *MSME Uttarakhand, 2014*

## 3.12 Municipal Solid Waste

### 3.12.1 Municipal Solid Waste Generation in the City

Dehradun city on an average generates about 200 MT of MSW per day. This figure is calculated on the basis of per capita per day generation of waste @ 0.4 kg (CDP, 2007). The CPCB's report on status of municipal solid waste generation states 220 MT of MSW per day in Dehradun (CPCB, 2011). Besides domestic, other major sources of MSW generation of the city are shops and commercial establishments, hotels and restaurants and fruit and vegetables markets. Area of Land fill site in Dehradun is 4.50 ha, new site for landfill is also proposed in Dehradun (Rawat and Ramanathan, 2011). In Dehradun city, the organizational in charge of Municipal solid waste management scenario is Senior Health officer. Partial system of house to house collection of waste is carried out in Dehradun city which results in an unaccounted system of quantifying solid waste generation in the city.

## Figure 3-7: Status of Dehradun city in implementation of Municipal Solid Waste (Management and Handling Rules), 2000

| Name of City | Waste Qty. (TPD) | MSW Management | | | Collection | | | Transportation of MSW | | | | Processing of MSW | | | | Disposal of MSW – Situation Analysis at Landfill Site | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Organization in charge | Penalty Clause | Manual Handling | Community bin system | House to house collection | Segregation by rag pickers at | Municipal vehicles | Private vehicles | Provision of tarpaulin/good | Transfer station facility | Composting (TPD) | Vermicomposting (TPD) | Pelletisation & waste to energy | Biomethanation & any other | Uncontrolled dumping | Sanitary landfill site | Earth cover | Compaction of SW | Leachate collection & | Biogas recovery facility | Remaining useful life of landfill (yr) |
| Kohima | 13 | AO | × | × | ✓ | No | × | ✓ | × | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |
| Bhuveneshwar | 234 | HO | × | ✓ | ✓ | Partially | × | ✓ | | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |
| Agartala | 77 | CEO | × | ✓ | ✓ | Partially | × | ✓ | × | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |
| Dehradun | 131 | SHO | × | ✓ | ✓ | Partially | ✓ | ✓ | × | × | × | × | × | × | × | ✓ | × | ✓ | ✓ | × | × | N |
| Pondicherry | 130 | HO | × | ✓ | ✓ | Partially | ✓ | ✓ | × | ✓ | × | × | 5 | × | × | ✓ | × | × | × | × | × | N |
| Itanagar | 12 | DC | × | ✓ | ✓ | No | × | ✓ | × | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |
| Gangtok | 13 | JS | ✓ | × | × | Fully | × | ✓ | × | ✓ | × | 50 | × | × | × | ✓ | × | × | ✓ | × | × | N |
| Kavaratti | 3 | CP | × | ✓ | ✓ | Partially | × | × | ✓ | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |
| Daman | 15 | ME | × | ✓ | ✓ | No | × | ✓ | × | × | × | × | × | × | × | ✓ | × | × | ✓ | × | × | N |
| Jammu | 215 | HO | × | ✓ | ✓ | Partially | × | ✓ | × | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |
| Silvassa | 16 | CMO | × | ✓ | ✓ | No | × | ✓ | × | × | × | × | × | × | × | ✓ | × | × | × | × | × | N |

**DC**: Dy. Commissioner, **JS**: Joint Secretary, **CP**: Chairperson (Village Panchayat), **CMO**: Chief Medical Officer, **SHO**: Senior Health Officer
**Source**: CPCB, 2012

### 3.12.2 Composition of Municipal Solid Waste

It is interesting to note that outside expert agencies are being engaged by the city government. Andhra Pradesh Technology Development and Promotion Centre helped Dehradun Nagar Nigam in carrying out MSW composition and characteristics analysis for the city. Analysis Results suggested the following composition of the city MSW.

## Table 3-6: Composition of MSW in Dehradun

| Constituent | Composition (%) |
|---|---|
| **Organic Matter/Bio-Mass** | 65.0 |
| **Paper** | 3.5 |
| **Rags/Textiles** | 6.0 |
| **Plastics** | 7.0 |
| **Glass** | 1.5 |
| **Rubber/Leather** | 1.5 |
| **Metal** | 0.5 |
| **Stones** | 8.0 |
| **Sand/Earth** | 7.0 |

***Source:*** City Development Plan, 2007

Analysis was done on dry weight basis. The above figures suggest that the city has a high percentage of organic Matter/Bio gas (65%). Recyclable waste contributes about 20% including 7% plastics; Composition of inert substance is 15%.

### 3.12.3 Segmentation Techniques being followed

Existing solid waste collection system mainly comprises of (i) Collection from the doorstep by means of hand-carts/cycle-rickshaw and (ii) Collection through community bins/containers. Municipal Corporation sweepers and sanitary workers engaged by the *Mohalla Swachhata Samitis* collect solid wastes from the streets. They accumulate the collected waste into small heaps and subsequently load manually or mechanically on to the solid waste transportation vehicles for onward transportation to the disposal site. The present collection and transportation system involves multiple handling of solid waste. About 300 open handcrafts and 50 cycle-rickshaws are used for collection of waste including wastes generated from street sweeping and cleaning of drains.

As far as segmentation technique is concerned in Dehradun, there is no segmentation technique being followed by the Municipal Corporation. There is no major waste generating industry in the city. At present, there is no segregation of waste at source being done.

### 3.12.4 Current Status of Recycling Waste in Dehradun

In Dehradun, the Recyclable waste contributes about 20% of the total waste generated in the city including 7% plastics. There are no recycling activities being organized by the Dehradun Nagar Nigam (DNN). There is no organized approach to recycling and combusting in Dehradun city. Recycling occurs informally at landfills, uncontrolled dumps and on streets. Waste pickers often collect materials for reuse or sale without any organization, supervision or regulation. There is lack of adequate planning for waste recycling which creates hazardous waste in the city.

### 3.12.5 E-Waste management in Dehradun

At present, there is no separate collection system of e-waste existing in Dehradun, due to which there is no clear data available on the quantity generated and disposed of each year. At the national level the preferred practice to get rid of obsolete electronic items is to get them in exchange from retailers when purchasing a new item. Obsolete computers from the business sector are sold through auctions.

## 3.13 Institutional Set Up for Energy in Dehradun

Three major organizations are engaged in energy conservation and generation as outlined below:

1. Uttarakhand Renewable Energy Developemnt Agency (UREDA)
2. Uttaranchal Power Corporation Ltd.
3. Uttarakhand Environment Protection and Control Board

## 3.14 Uttarakhand Renewable Energy Development Agency (UREDA)

UREDA has taken a leading role in the development of the renewable energy sector in Uttarakhand in line with the directions of Ministry of New and Renewable Energy and establishing platform for the promotion of energy conservation.

UREDA handles operation and execution of various schemes based on non-conventional energy resources through local Panchayats, voluntary organizations and district administration. Since 2008 UREDA is also spearheading the activities of Energy Conservation as a state nodal agency of BEE (Bureau of Energy Efficiency)

### 3.14.1 Functions of UREDA

UREDA functions under the administrative control of Department of Renewable Energy, Govt. of Uttarakhand and basically implements the following programmes in the State:-

1 Renewable Energy Programmes including generation of Power from Renewable Energy Sources.
2 Implementation of Energy Conservation Act, 2001.
3 Demand side management.
4 Accreditation of RE Projects under REC (Renewable Energy Certificate) mechanism.
5 Frame a procedure consistent with the procedure framed by Central Agency to meet the requirement of these regulations.
6 Accreditation of eligible entities at the state level and recommending them to Central Agency for registration at the central level.
7 Maintaining and setting accounts in respect of certificates.
8 Repository of transactions in certificates.

## 3.15 Uttaranchal Power Corporation Ltd. (UPCL)

Uttaranchal Power Corporation Ltd. was created on the 1st April 2001 after the bifurcation from UPPCL (erstwhile UPSEB) catering to the Transmission & Distribution infrastructure in the newly formed state of Uttaranchal. Since then UPCL is engaged in improving the power supply of the State with the following aims & objectives:

- To achieve 100% Rural Electrification Infrastructure for electrification of villages & hamlets.
- To provide 24x7 reliable, quality and un-interrupted supply to its consumers.

- To provide POWER TO ALL on demand.
- To strengthen the existing power network based on latest advanced technology with an objective to reduce T&D losses.
- To provide power system network with minimal environmental impact.
- To develop a professionally managed organization.
- To generate additional revenue for the Corporation and State by developing a strong, adequate, reliable and cohesive power network based on most techno-economic aspects to contribute towards the development and prosperity of the State.
- To improve social status of the people.
- To provide employment in the rural parts of state by providing reliable supply.
- To establish Consumer Care Centre, Centralized Service Centre etc. to provide quality service to the Consumers.
- Implementation of IT based consumer services
- To provide on-line payment facility to consumers
- To contribute to the formation of a developed & progressive Uttarakhand State.

## 3.16 Uttarakhand Environment Protection and Pollution Control Board

The Uttarakhand Environment Protection and Pollution Control Board (UEPPCB) is a statuary organization constituted under the section 4 of Water (Prevention and Control of Pollution) Act, 1974 to implement environmental laws and rules within the jurisdiction of Uttarakhand.

The UEPPCB came into existence on 1st May 2002 and functions through its Head Office at Dehradun along with its 4 Regional Offices - Dehradun, Roorkee, Haldwani and Kashipur. It has endeavored to strike a rational balance between economic growth and environmental conservation. The Board has been entrusted with the powers and functions provided in the Act. Subsequently the implementation of Water (Prevention and Control of Pollution) Cess Act, 1977; Air (Prevention and Control Of Pollution) Act, 1981; Environment Protection Act (1986) and the Public Liability Insurance Act, 1991 were also entrusted to the State Board.

### 3.16.1 Functions and Responsibilities of UEPPCB

- To plan a comprehensive programme for prevention, control or abatement of pollution in respect of air, streams, rivers and wells in the State and to secure the execution thereof;
- To advise the State Government on any matter concerning the prevention, control or abatement of water and air pollution;
- To collect and disseminate information related to water and air pollution and prevention, control or abatement thereof;
- To encourage, conduct and participate in investigations and research relating to problems of water/air pollution and organize mass education programme relating thereto;
- To collaborate with the Central Board in organizing the training for persons engaged or to be engaged in programme relating to prevention, control or abatement of pollution and to organize mass programme relating thereto;

- Lay down and modify effluent and air standards for various environmental pollutants;
- To evolve economical and reliable methods of treatment technologies for abatement of environment;
- To lay down standards of treatment of sewage or trade effluents to be discharged into any particular streams taking into account the minimum fair weather dilution amiable in those streams and the tolerant limits of pollution permissible in the water of the stream, after the discharge of such effluents;
- To advice the state government with respect to the location of any industry the carrying on of which is likely to pollute a stream or well;
- Implementation of various provisions of environmental laws;
- Carry out inspections of industries, local bodies, hospitals for compliance of conditions of consent and authorization granted under various Rules;

Since inception of UEPPCB in 2002 the pollution control measures in industries and monitoring of effluent and stack emission along with monitoring network of ambient air, river quality monitoring have been strengthened in due course of period. Over the year, UEPPCB has taken stride for prevention of environmental pollution through introduction of cleaner technologies.

# CHAPTER 4: INITIATIVES FOR DEVELOPING SUSTAINABLE/ ECO FRIENDLY CITY

## 4.1 Solar Cities Programme

The Ministry of New and Renewable Energy (MNRE) had launched a program on "Development of Solar Cities" in February 2008 (MNRE, 2014).It had been modified /revised vide no. 5/4/2013-14/SC dated 17th January 2014 for implementation during the 12th Five Year Plan. The Solar City Programme aims at minimum 10% reduction in projected demand of conventional energy at the end of five years, which can be achieved through a combination of energy efficiency measures and enhancing supply from renewable energy sources in the City.

A total of 60 cities/towns were proposed to be supported for development as "Solar/ Green Cities". It was envisaged that the targets would be achieved by providing support for preparation of a Master Plan for their city; setting up of a 'Solar City Cell' in the Council/Administration, organizing training programmes / workshops / business meets for various stakeholders such as elected representatives of the municipal bodies, municipal officials, architects/engineers, builders and developers, financial institutions, NGOs, technical institutions, manufactures and suppliers, RWAs etc. and by creating public awareness.

### 4.1.1 The Solar City Plan Dehradun

The goal of the programme is to promote the use of Renewable Energy in Urban Areas by providing support to the Dehradun Municipal Corporation for preparation and implementation of a Road Map to develop Dehradun as a Solar City. The objectives of the programme are given below:

- To enable / empower the local body to address energy challenges at city - level.
- To provide a framework and support to prepare a Master Plan including assessment of current energy situation, future demand and action plans
- To build capacity in the local body and create awareness among all sections of civil society.
- To involve various stakeholders in the planning process.
- To oversee the implementation of sustainable energy options through public - private partnerships.

### 4.1.2 Present Status of the Project

As per the guidelines of the Ministry of New & Renewable Energy, the Dehradun Nagar Nigam is under the process of implementing first Solar City Plan in Uttrakhand. A Draft Master Plan has been prepared and is under finalisation and further improvement. The Dehradun Nagar Nigam has also formed a Solar City Cell in the office and will be soon organizing a stakeholder meeting regarding the implementation.

The Nigam in co-ordination with the Mussoorie Dehradun Development Authority, has installed the Solar Energy Traffic Signals based on PPP model. The work for installing more Solar Energy Traffic Signals is underway. A brief overview of the various lights installed by the Dehradun Nagar Nigam is provided below:

**Table 4-1: Details of various types of lights installed by Dehradun Nagar Nigam**

| Total Lights | CFL | TL | LED (90w) | LED (120w) | Main Switch |
|---|---|---|---|---|---|
| 34321 | 1573 | 399 | 211 | 255 | 154 |

***Source:*** Dehradun Nagar Nigam

The Bureau of Energy Efficiency, Govt. of India has partially funded the project which also includes maintenance cost for five years.

## 4.2 Jawaharlal Nehru National Solar Mission

The National Solar Mission is a major initiative of the Government of India and with state governments to promote ecologically sustainable growth while addressing India's energy security challenge. The mission was launched on 11 January, 2010 by the former Prime Minister of India, Dr. Manmohan Singh.

### 4.2.1 Aim

The aim of the mission is to focus on setting up an enabling environment for solar technology penetration in the country both at centralized and decentralized level.

### 4.2.2 Objective

The objective of the National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.

### 4.2.3 National Solar Mission Targets:

- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To create favourable conditions for solar manufacturing capability for indigenous production and market leadership.
- To promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million sq. metres by 2022.
- To deploy 20 million solar lighting system for rural areas by 2022.

### 4.2.4 Major characteristics of the Mission associated with Energy Efficiency and Conservation

1. Creation of enabling policy framework to attract the industry and project developers to invest in research, domestic manufacturing and development of solar power generation.
2. Promotion of off grid solar applications.
3. In order to create a sustained interest within the banking community, it proposed to provide a soft re-finance facility through Indian Renewable Energy Development Agency (IREDA).
4. Creating a policy and regulatory environment which provides a predictable incentive structure that enables rapid and large-scale capital investment in solar energy applications and encourage technical innovation and lowering of costs.
5. Set up a Committee to formulate a policy for promotion of solar thermal manufacture in the country.

## 4.3 Scheme on "Energy Efficient Solar/ Green Buildings"

The Ministry of New and Renewable Energy (MNRE) had launched a modified Scheme on "Energy Efficient Solar/ Green Buildings" for implementation during 2013-14 and rest of the 12th Plan.

### 4.3.1 Objective

The main objective of the scheme is to promote the widespread construction of energy efficient solar/ green buildings in the country through a combination of financial and promotional incentives, and other support measures so as to save a substantial amount of electricity and other fossil fuels apart from having peak load shavings in cities and towns.

The objectives are to achieved by providing promotional incentives for the construction of green buildings creating awareness by organizing workshops, seminars and trainings for engineers, planners, builders, architects, consultants, housing financing organizations and potential users and besides, for development of literature, compilation and publishing of documents related to solar/ green buildings and installation of renewable energy projects/systems in the green buildings.

### 4.3.2 Budgetary Allocation

The total budget of Rs.10.00 crore had been allocated for implementation of the scheme during the year 2013-14 and rest of the 12th Plan period. This also included meeting the pending liabilities.

### 4.3.3 Implementation Arrangement

The scheme proposed to be implemented through State Nodal Agencies/ Municipal Corporations/ Govt. Bodies / reputed NGOs, technical institutions, professionals, consultants etc.

## 4.4 The New and Renewable Energy Policy 2005

New and Renewable energy policy is an integral component of a national energy policy. Recognizing the changes that are likely to occur in the global energy fuel-mix, production, transmission, distribution, applications and consumption levels apart from the requirement to meet future energy needs, the core drivers of development and deployment of new and renewable energy technologies, products and services are as under:-

1. Lesser dependence on energy imports through a device and sustainable fuel-mix in furtherance of the aim of National Energy Security.
2. Expand cost-effective energy supply for achieving per capita energy consumption level at par with global average through increasing share of new and renewable energy in the fuel mix in furtherance of the aim of Equity.
3. Fuel Switching through new and renewable energy system/device deployment in furtherance of the aim of conventional energy conservation.
4. Augment energy supply to remote and deficient areas to provide normative consumption levels to all sections of the population across the country through new and renewable energy sources in furtherance of the aim of accessibility.

## 4.5 National Mission on Sustainable Habitat

The National Mission on Sustainable Habitat has been approved by the Prime Minister. It is one of the eight missions under National Climate Change Action Plan and aims to make cities sustainable through improvements in energy efficiency in buildings, management of solid waste and shift to public transport. The National Mission includes a major R&D programme, focusing on bio-chemical conversion, waste water use, sewage utilization and recycling options wherever possible.

The National Mission for Sustainable Habitat is a component of the National Action Plan for Climate Change and broadly covers the following aspects:-

- **Extension of the energy conservation building code** – Address the design of new and large commercial buildings and townships to optimize their energy demand.
- **Better urban planning and modal shift to public transport** – make long term transport plans to facilitate the growth of medium and small cities in such a way that ensures efficient and convenient public transport.
- **Recycling of material and urban waste management** – A special areas of focus is development of technology for producing power from waste.

### 4.5.1 Objectives

- To exploit the potential for mitigating climate change through reduction in demand for energy in the residential and commercial sector by adopting various energy efficiency and conservation measures.
- To adopt a comprehensive approach in the management of water, municipal solid waste with a view to realize their full potential for energy generation, recycling and reuse and composting.
- To facilitate adoption of technologies, research and development leading to energy efficiency and reduction in emissions.
- To promote patterns of urban growth and sustainable urban development that help and secure the fullest possible use of sustainable transport for moving freight, public transport and encourage cycling and walking.
- To reorient urban planning with a view to address climate with respect to mitigation as well as adaption and improve the responsiveness to disasters by strengthening community based disaster management.
- To encourage community involvement in ensuring more sustainable patterns of development.

### 4.5.2 Major findings associated with Energy Efficiency and Green Features given under National Mission on Sustainable Habitat

The following energy efficiency measures have been incorporated in the building code to reduce annual energy consumption of the building. This has been achieved in the following ways:-

1. Architectural design optimized as per the climate of city, sun path analysis, predominant wind direction and existing vegetation.
2. Efficient window design by selecting efficient glazing (high performance glazing), external shading to reduce solar heat gain but at the same time achieve glare free natural daylight inside all the laboratory space of the building.
3. Roof shaded by bamboo and green cover to reduce external solar heat gains from the roof.
4. Common circulation areas are naturally day lit and naturally ventilated through integration of skylights and ventilators.
5. Water cooled chiller selected that complies with the efficiency recommended by the ECBC (Energy Conservation Building Code).
6. Variable Frequency Drive installed in the Air Handling Units (AHUs)
7. Low energy strategies such as replacement of water cooler by the water body to cool the condenser water loop, integration of thermal energy storage and earth air tunnels to enable reduction in chiller capacity.
8. Integration of Energy efficient lighting design that complies with the recommendation of ECBC (Energy Conservation Building Code).
9. Integration of daylight with artificial lighting.

## 4.6 National Mission on Enhanced Energy Efficiency

National Mission on Enhanced Energy Efficiency is a Government of India initiative proposed to address national problems of inefficient energy use. It is one of the eight proposals taken up under India's National Action Plan for Climate Change and is based on the Energy Conservation Act of 2001.

The initiative outlines several actions needed, including:

- Perform, achieve and trade
- Market transformation for energy efficiency
- Financing of energy efficiency
- Power sector technology strategy
- Strengthening of state designed agencies
- Strengthening of Bureau of Energy Efficiency
- Awareness programs

Recommendations include specific energy consumption decreases in large energy consuming industries as well as a system for companies to trade energy savings certificates.

## 4.7 Existing Energy Demand and Supply Scenario

Uttarakhand State is richly endowed with natural renewable energy sources. These sources can be helpful for generating electricity. Most of this could be harnessed through environmentally clean Micro/Mini/Small Hydro Power Projects capacity up to 25 MW. In addition to this, the state has significant renewable energy sources that include Biomass/Agro residue, wind power, solar energy, cogeneration, Geothermal and Municipal Waste etc. There were 15761 inhabited villages as per 2001 census, out of which 15593 (98.9%) had been electrified under the RGGVY (Rajeev Gandhi Grameen Vidhyutikaran Yojna) till 30 June 2012. Energy demand modeling with special reference to housing is a process which involves the assessment of energy distribution losses of the city by using population density, assessment of energy demand and gap analysis.

It is evident from the table given below that there is gap of 170 MW of electricity supply in Uttarakhand. This is because of the acute shortage of peak supply of 1430 MW for the peak demand of 1600 MW.

**Table 4-2: Peak Demand and Supply of Electrical Energy in Uttarakhand (2011-2012)**

| **Particulars** | **Position** |
|---|---|
| **Peak Demand of the State** | 1600 MW |
| **Peak Supply** | 1430 MW |
| **Annual Demand for the Electrical Energy** | 10480 MU |
| **Supply** | 8363 MU |

***Source:*** UPCL & CEA, URED

It is clearly observed from the above table that there is a gap of 2117 MU of electricity supply; this is because of the supply of 8363 MU for the demand of 10480 MU in Uttarakhand.

### 4.7.1 Sources of Power Generation and their Capacity

Power generation is the responsibility of the Uttarakhand Jal Vidyut Nigam Ltd, power transmission that of Power Transmission Corporation Ltd and power distribution of Uttarakhand Power Corporation Ltd. According to the stats of Power Ministry, the total installed capacity in Uttarakhand as on 31st March 2015 is 2361.08 MW as detailed in table below (4-3). Hydro based capacity constitutes about 76% of total capacity followed by thermal (coal based) 17%, gas based 3%, nuclear 1% and balance about 3% cogeneration plus solar. Transmission losses for the year 2014 were 18% (Indiastat, 2014).

**Table 4-3:** Installed Capacity of Uttarakhand Power Utility

| Total Installed Capacity | Thermal (coal and gas based) | Nuclear | Hydro | RES (cogeneration and solar) |
|---|---|---|---|---|
| 2361.08 | 472.31 | 23.61 | 1818.03 | 70.83 |

***Source:*** *Power Generation Capacity – Installed, Indiastat, 2014*

Therefore, the city of Dehradun has a couple of initiatives under various schemes and programmes aiming at sustainable and eco-friendly city. These include Solar City Programme, JNN Solar Mission, Energy Efficiency and Solar Green Buildings. At the same time, city government gives due cognizance to National Mission on Sustainable Habitat. These have widened the vision of city government to initiate corrective measures towards energy efficiency.

# CHAPTER 5: ENERGY CONSUMPTIONS AND GHG ESTIMATIONS

The rapid growth in India's population and concomitant increase in urbanization, and change in life styles and energy use patterns have contributed in huge increase in the energy consumption accounted by the residential sector (Prayas, 2016). This leads to a lot of emissions of GHG.

Greenhouse gases trap heat and make the planet warmer. Human activities are responsible to a great extent for almost all of the increase in Greenhouse gases in the atmosphere over the last 150 years. The largest source of greenhouse gas emissions from human activities is from burning fossil fuels for electricity, heat and transportation. Primarily these gases include Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfur Hexafluoride (SF6) and five categories, namely- energy, industrial processes and product use (IPPU), agriculture, waste and Land-use, Land-use Change and Forestry (LULUCF).

A large number of gases contribute to climate change but the Kyoto Protocol has a commitment to limit emissions of the six gases which are majorly accountable for the global warming. Of these, the three most effective are carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), at present accounting for nearly 98% of the GHG emissions. Electricity consumption generates the largest share of greenhouse gas emissions. Over 70% of our electricity comes from burning fossil fuels, mostly coal and natural gas. It is to also highlight that the Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains and planes. Over 90% of the fuel used for transportation is petroleum based, which includes gasoline and diesel. Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials. Similarly, the Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases and the handling of waste. It has also been proved that land areas can act as a sink (absorbing Carbon dioxide from the atmosphere) or a source of greenhouse gas emissions. The agricultural practices also are a major cause of Greenhouse gas emissions. Mainly GHG in agriculture practices come from livestock such as cows, agricultural soils and rice production.

While global CO2 emissions decreased in 2009 – by 1.5%, trends varied depending on the country context: developing countries (non-Annex I, see Section 3.3) emissions continued to grow by 3%, led by China and India, while emissions from developed countries fell sharply – by 6.5% (IEA, 2011a). Most CO2 emissions come from energy production, with fossil fuel combustion representing two-thirds of global CO2 emissions.

**Figure 5-1: Carbon dioxide emissions (CO2), metric tons of CO2 per capita (CDIAC)-2011**

| Country | Carbon emissions per capita (in tonnes of CO2) |
|---|---|
| Luxembourg | 20.9787 |
| United States | 16.8478 |
| Sourth Africa | 9.1867 |
| United Kingdom | 7.1802 |
| China | 6.5911 |
| Sweden | 5.5186 |
| France | 5.3286 |
| Singapore | 4.3131 |
| India | 1.6987 |
| Afghanistan | 0.4209 |
| Nepal | 0.1596 |

***Source:*** Millennium Development Goals Indicators

## 5.1 Climate change and cities

The growing residential, commercial, industrial, and transportation activities in cities, have led to a rapid growth in consumption of fossil fuels, contributing to GHG emissions. Thus, cities are attributed as key contributors to these emissions. In the context of concerns about climate change impacts due to increasing GHG emission levels, cities across the globe have started to take concrete initiatives. They will also experience tangible local benefits, including healthier habitats and communities with lower water and energy usage (leading to lower costs). Globally, many interventions are already being undertaken by the city governments to curb carbon emissions. In order to understand the impact of these interventions in terms of their ability to reduce carbon emissions, it is important to estimate the current levels of emissions and create a baseline.

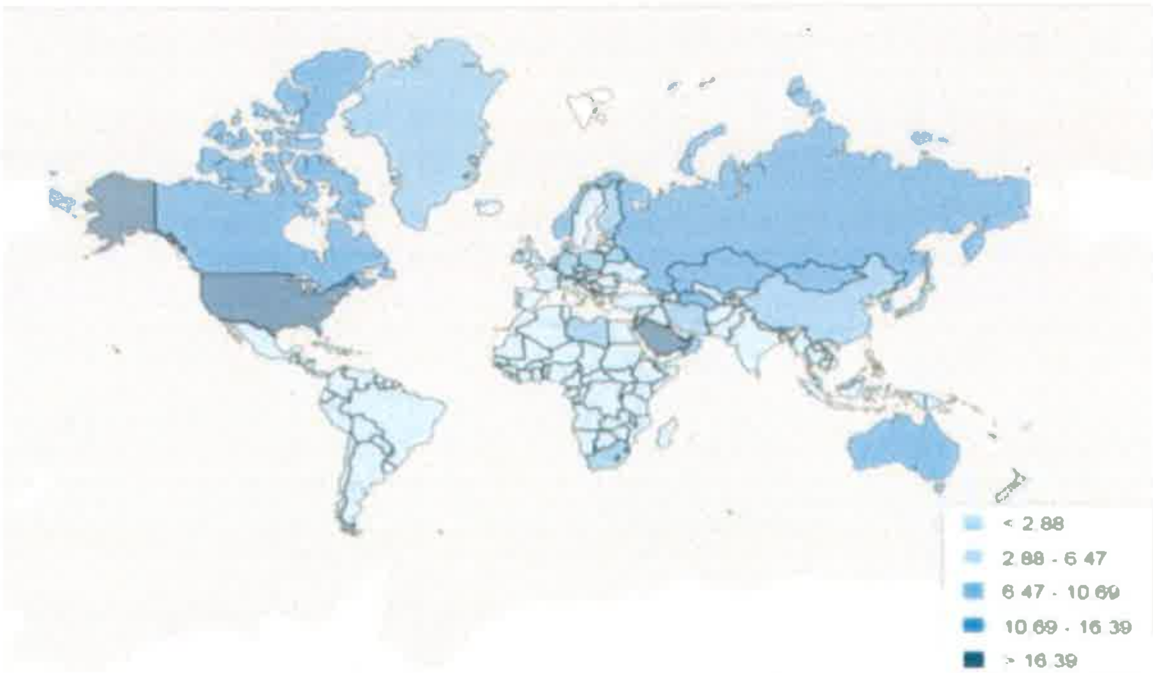
## 5.2 Climate change and India

National Action Plan on Climate Change (NAPCC) was released in June 2008 which emphasized on climate change and eight missions in the context of India. It identifies measures for promoting development objectives while yielding co-benefits for addressing climate change effectively. In August 2009, the Hon'ble Prime Minister of India urged each state government to create its own state-level action plan consistent with strategies in the national plan. In the light of this initiative, a nodal agency under Ministry of Environment and Forests (MoEF) for climate change cooperation and global negotiations was appointed as the Climate Change Division of MoEF. It functions as a nodal unit for coordinating the NAPCC.

According to the first Biennial Update Report (BUR) submitted by India to the United Nations Framework Convention on Climate Change (UNFCCC), for the year 2010, prepared in accordance with the guidelines of Intergovernmental Panel on Climate Change (IPCC), India's per capita GHG emission in 2010 was 1.56 tCO2 equivalent, which is less than one-third of the world's per capita emissions and far below than many developed and developing countries.

As per BUR, India emitted 2,136.84 million tonnes of $CO_2$ equivalent greenhouse gases in 2010. Energy sector was the prime contributor to emissions with 71% of total emissions in 2010. Energy sector includes - electricity production, fuel combustion in industries, transport and fugitive emissions. Industrial processes and product use contributed 8%; agriculture and waste sectors contributed 18% and 3% respectively to the national GHG inventory. About 12% of emissions were offset by carbon sink action of forests and croplands, considering which the national GHG emissions are arrived at a total of 1,884.31 million tonnes of $CO_2$ equivalent.

India faces the challenge of providing massive infrastructure to its growing population while adopting a low carbon growth. It is estimated that the current level of per capita carbon dioxide equivalent emissions ($CO_2e$) in the country, i.e., 1.6- 2.0 tonne per capita will increase to about 3 to 5 tonne by 2030[15]. The figure below shows the variations of the global $CO_2$ emissions per capita/ year for the year 2013.




***Source:*** World Bank, 2013

It is quite evident from the above figure that the Carbon emissions of per capita Indian is much below from the average emissions of the various developed economies globally. The present study focuses on to understand the current pattern of carbon emissions in Dehradun city, in order to plan specific strategies/interventions to reduce the same.

[15]*MoEF(2010) National Workshop on India: Greenhouse Gas Change Emissions 2007*

## 5.3 Identification of the appropriate data sources

### 5.3.1 Residential, commercial, industrial

The main rule to follow is that emissions should be reported in common units (i.e., $CO^2$equivalents). Emissions from residential, commercial, and industrial sectors are fairly straight forward to compute, given standard assumptions (i.e., efficiency of devices), carbon emission factors of fuels used, and data on fuel consumption of each sector. Such data can either be derived from fuel bills or directly from energy providers or surveys.

### 5.3.2 Waste

Emissions from waste can prove harder to obtain. On top of the quantity of waste generated by the city, knowledge of the average composition of waste and the way in which the waste is being processed is also required to be known. Composition of waste gives information on the carbon content of the waste material, which is generally highly variable in nature. The way in which the waste is actually processed determines the actual level of emissions. If the waste is recycled there are hypothetically zero-emissions; if it is burnt then it releases carbon dioxide and ashes; and if it is processed anaerobically, then it results in producing CH4 and other solid by-products. Such information is available only at the regional level and assumptions have to be made for estimating the city-level information.

### 5.3.3 Transportation

Emissions from transportation can be obtained in two ways. The first method involves estimation of emissions by using the data on quantities of fuel sold at petrol stations within the city. The average emission factors are applied depending on the characteristics of the fleet (i.e., the share of cars, trucks, and two-wheelers) to obtain the level of emissions. The second method to estimate emission levels is to obtain data on average Vehicle-Kilometers-Travelled (VKT) within the city from transport municipal offices. Such data is generally measured and available in terms of peak VKT per day. A correction factor is applied to such VKT figures to convert the information into average VKT per year. Emissions are derived from these numbers by applying constant emission factors depending on the characteristics of the vehicle fleet.

As per Comprehensive Mobility Plan-Dehradun, 2012, in past 12 years, the number of registered vehicles had increased @ 11% per annum and 89% of them were two-wheelers and cars.

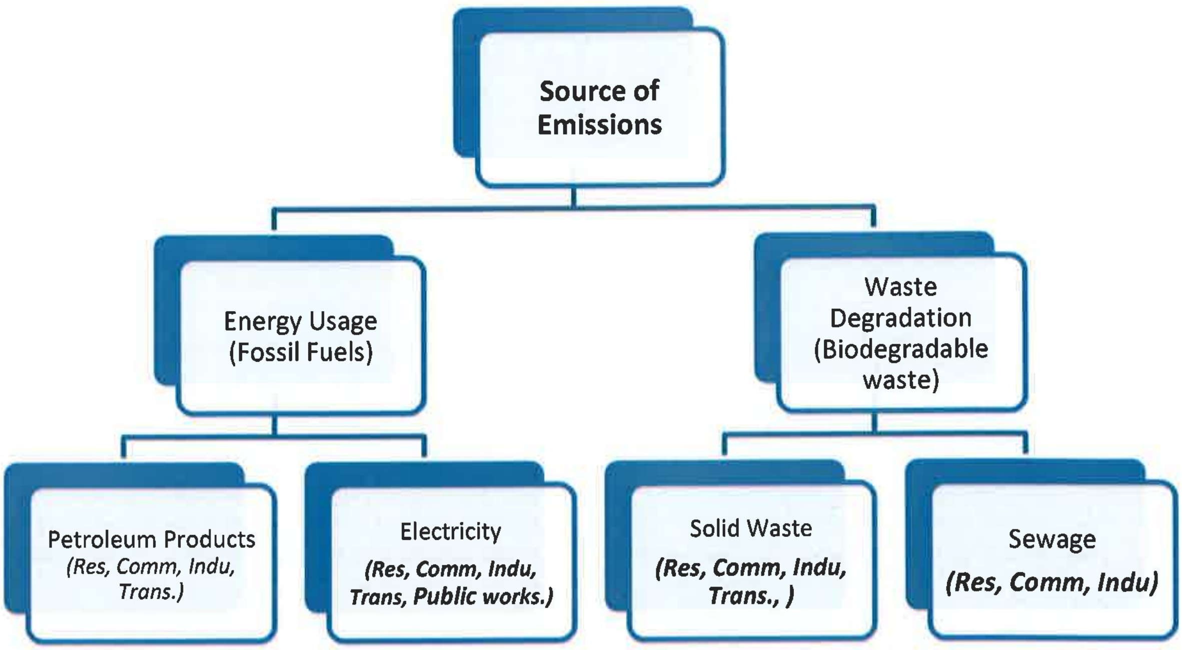
Intra city public transport is being operated by private operators. There are 16 private buses routes and 10 main tempo routes through 337 buses and 1300 tempos respectively (CMP Dehradun, 2012). Growth of taxis and IPT mode are at the rate of 25% and 28% respectively and public transport fleet at the rate of 7% pa. An inadequacy of public transport and facilities can be observed leading to more loss of fuel and production time, traffic congestion, deteriorating environment condition and road accidents.

In a user study by *College of Management and Economic Studies, University of Petroleum and Energy Studies*, Dehradun in 2011, it was found that overall satisfaction levels of people in Dehradun with respect to existing transport facilities are low and availability of transport is playing an important parameter for choosing the means of transport. Further in a study by *IIT Roorkee* it had been recommended to improve the quality and supply of buses and the services coverage of buses in the city.

Due to the heterogeneity of transport system and different technology background, society needs more indigenous and integrated plan for sustainable urban mobility. To reduce the pollution in the city, public transport enhancement, adoption of non-motorized vehicles, e-rickshaw and alternative fuel and technology are important. Providing proper stops and transport infrastructure, clear Right of Way for the safe circulation of buses, increasing frequency of buses to reduce the waiting time and discourage the use of private vehicles, discouraging cars in the core areas could be adopted to reduce the pollution and make sustainable transport system in the city.

## 5.4 Greenhouse gas inventory of Dehradun

The following figure depicts the various sources which cause carbon emissions.




- Activities in Dehradun contribute to 0.57 Million TeCO2 annually
- Per capita emissions for Dehradun have been 0.71T/Year in 2007-08
- The Corporation Level Emissions are about 7.14 per cent of the total city emissions.

## 5.5 Sectors identified for carbon inventory

| Sector | Fuels used |
|---|---|
| **Residential** | Electricity, LPG, Kerosene |
| **Commercial** | Electricity, LPG, Kerosene |
| **Industrial** | Electricity, LPG, Kerosene, Diesel, Furnace oil |
| **Transportation** | Petrol, Diesel |
| **Utilities/Municipal services** | Petrol, Diesel, Electricity |

## 5.6 Energy Consumption and Emissions

### 5.6.1 Electricity consumption

Currently, the residential sector having largest number of consumers account for around 24% of the total electricity consumption in India (MOSPI, 2017). And, national level estimations for business as usual scenario suggest a growth of energy consumption in residential buildings by more than eight times by the year 2050 (GBPN, 2014). Average annual increase of 3.2% from 2012-2040 have been estimated by EIA. For controlling the upsurge in energy demand, residential sector ought to be the center of energy efficiency strategies developed and implemented.

The following table shows the Energy consumption trend in Dehradun:

**Table 5-1: Electricity Consumption in Dehradun**

| Year | Total Electricity Consumption (in Million Units) |
|---|---|
| **2005-2006** | 351.22 |
| **2007-2008** | 457 |
| **2016-2017** | 723.7 |

***Source:*** UPCL

It is evident from the above-mentioned table that the pattern of electricity use within the city has undergone significant changes in the last few years; the consumption has grown from 351 Million units in 2005-06 to 723 Million Units in 2016-17 in the non-govt. sector.

**Table 5-2: Infrastructure available for Electricity Distribution in Dehradun District (as on 31.02.2012)**

| 33/11 KV Substations | | | 11/0.4 kV substations | | | | |
|---|---|---|---|---|---|---|---|
| **No.** | **T/F (No.)** | **MVA** | **T/F (No.)** | **MVA** | **33 KV (km)** | **11 KV (km)** | **LT Line (km)** |
| 44 | 82 | 441.5 | 4923 | 523.28 | 830.05 | 5169.3 | 10261.22 |

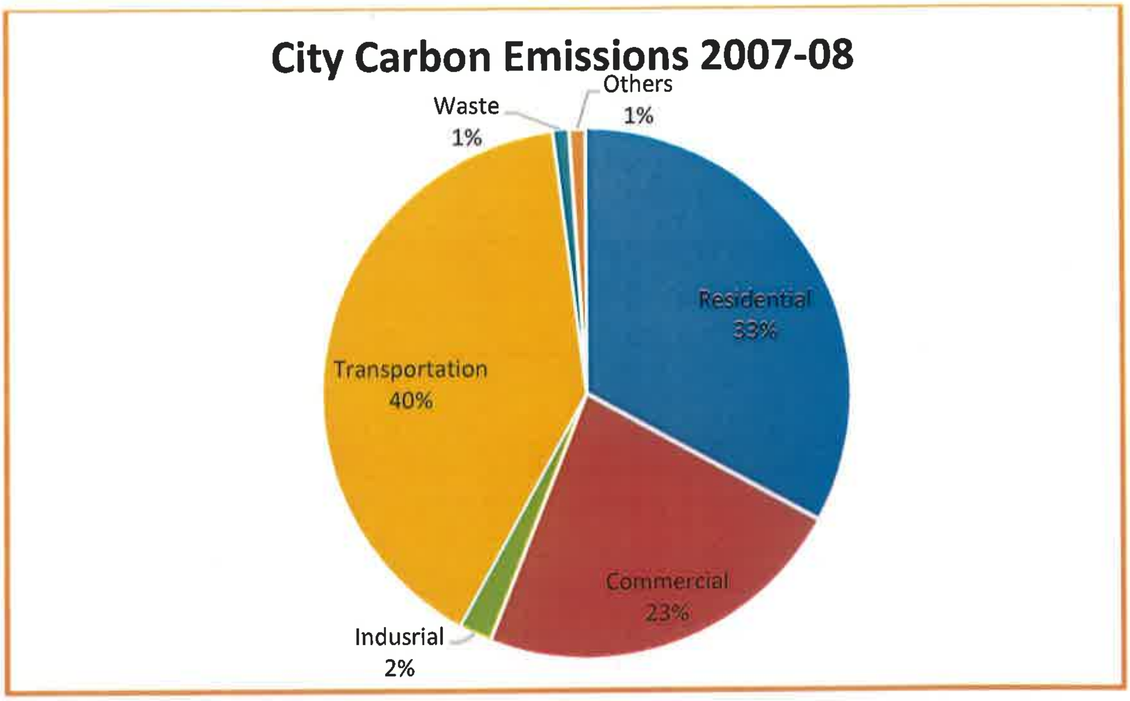
***Source:*** *Solar City Plan, Dehradun*

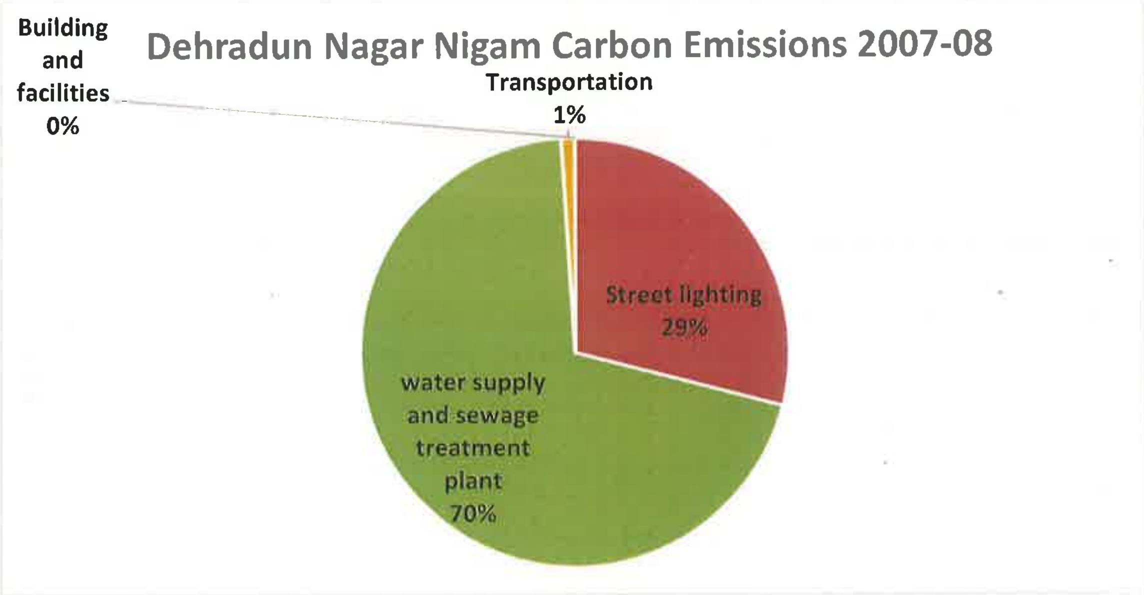
### Table 5-3: Community Energy Consumption in Dehradun (2007-2008)

| Sector | Energy/Fuel | Quantity |
|---|---|---|
| **Residential** | Electricity (Million kWh) | 234.66 |
| | LPG (MT) | 28699 |
| | Kerosene (kL) | 10668 |
| **Commercial** | Electricity (Million kWh) | 192.7 |
| **Industrial** | Electricity (Million kWh) | 19.34 |
| **Transportation** | Diesel (kL) | 44435 |
| | Petrol (kL) | 42457 |
| **Waste** | MSW (tpd) | 143 |
| **Others** | Fuel Wood (MT) | 525 |
| | Electricity (Million kWh) | 10.16 |

***Source:*** *ICLEI (2015), Energy and Carbon Emissions Profiles*

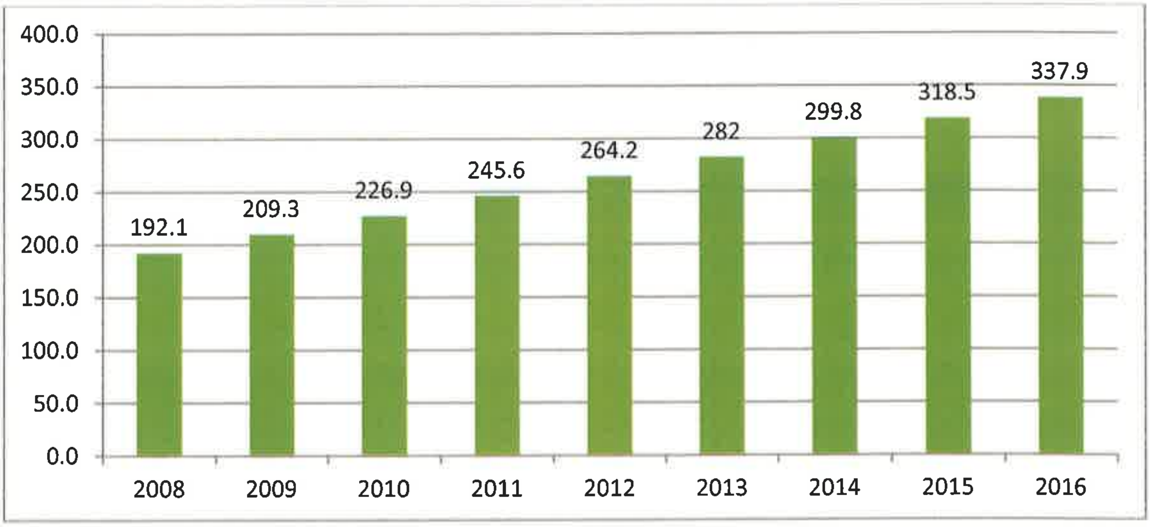
It was observed that the principle sectors drawing electricity from the low tension (LT) lines were found to be the residential and commercial sectors. These sectors were found to be drawing more than 50% of the total electricity from LT lines used in the city. However, additional break-up of electricity consumption by the (high tension) HT consumers was not available with the UPCL. This made analysis of electricity end use from the HT consumption complicated. However, at most instances HT electricity was being used for running high peak load energy setups like water pumping stations, hospitals, sewage treatment plants, theatres, heavy load commercial setups, and industrial units.






#### *5.6.1.1 Electricity consumption in the residential sector*

Growth in electricity consumption in residential sector



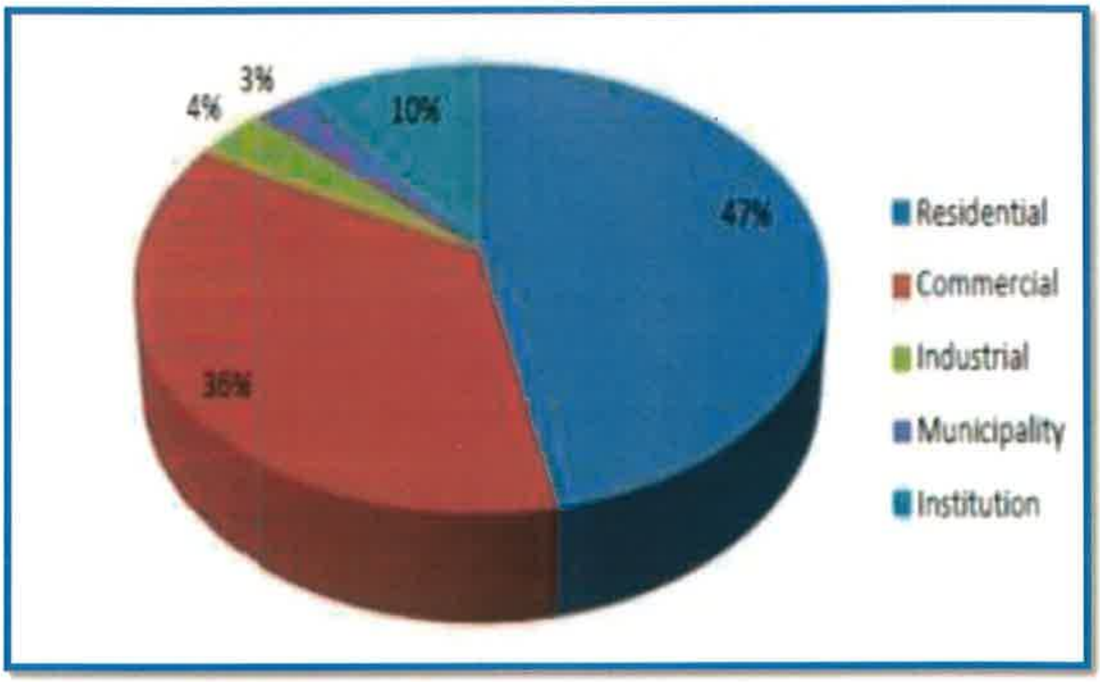

#### *5.6.1.2 Electricity use in the commercial and industrial sector*

Electricity use in the commercial and industrial sectors is a good substitute for assessing the level of economic activity in the city of Dehradun. A portion of the electricity consumed in the city is used to support its public infrastructure projects. Amongst other things, it is used to provide street lighting, to operate the sewage and water treatment plants and to run the government offices.

Major areas of commercial activities are Paltan Bazaar, Thamawala, Moti Bazaar, Jhanda Bazaar, Gandhi Road and areas between Saharanpur Chowk and Prince Chowk. Tertiary category includes businesses, transport and services which constitute 75% of all the commercial activities and are projected to increase to 77% by 2025. Use of solar water heating systems in a far greater measure (in hotels especially) could very well lead to reduced dependence on the conventional fuel.

Although most of the heavy industrial developments have been happening outside the boundary of the city area, the old / abandoned units within the city limits are slowly getting transformed into retail and commercial spaces, aligned with the objectives of walk to shop and walk to work. New and more energy-intensive air conditioned malls and retail spaces have been growing in the city.

The following chart shows the electricity distribution across various sectors in Dehradun city. .




***Source:*** Solar City Plan for Dehradun, 2011

### Table 5-4: AT & C Losses statement for Dehradun

| EDC Dehradun | AT & C Losses |
|---|---|
| Consumer | 181952 |
| Load (KW) | 546897 |
| Input (KW) | 933.87 |
| Sold (MU) | 802.526 |
| Assessment (in Rs.) | 35751.75 |
| Collection (in Rs.) | 44422.49 |
| Billing Efficiency | 85.94 |
| Collection efficiency | 124.25 |
| AT&C | (-)6.78 |

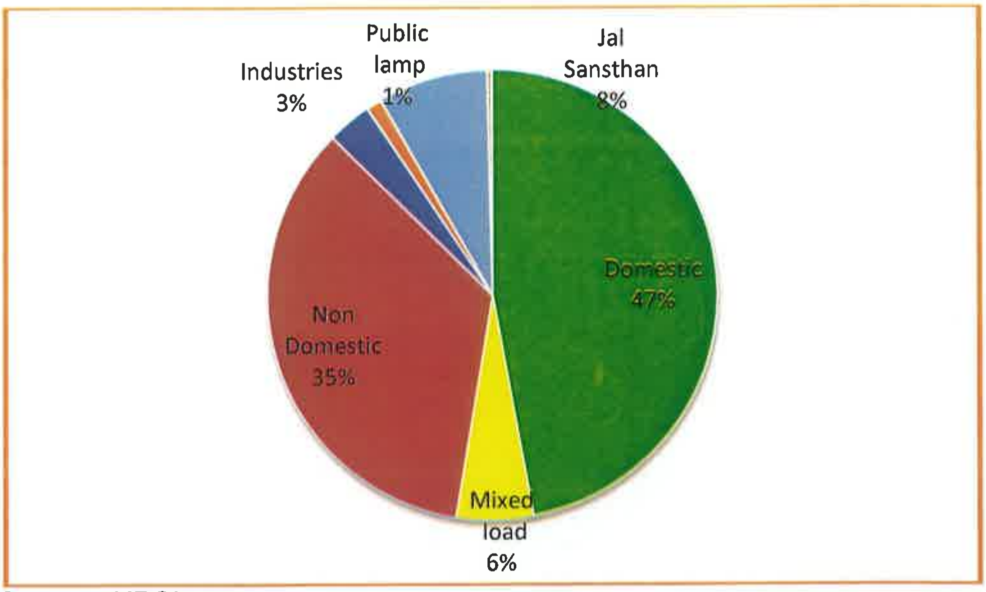
***Source:*** UPCL

## Table 5-5: Details of Electricity Consumption in Dehradun under various sectors in 2014 and 2016

| | 2014 | | | 2016 | | |
|---|---|---|---|---|---|---|
| **Category Type** | **No. of consumers** | **Load (KW)** | **Energy Sold (MU)** | **No. of consumers** | **Load (KW)** | **Energy Sold (MU)** |
| ***Domestic other than BPL*** | 142756 | 281163 | 338.15 | 148218 | 312664 | 373.894 |
| ***BPL*** | 734 | 734 | 0.48 | 743 | 752 | 0.615 |
| ***Mix connections*** | 9 | 14343 | 50.52 | 9 | 14343 | 48.821 |
| ***Non-Domestic other than snow bound*** | 29075 | 180333 | 236.4 | 32033 | 189813 | 271.701 |
| ***LT Industries*** | 397 | 6658 | 8.85 | 393 | 6317 | 9.186 |
| ***HT Industries (upto 1000 W)*** | 24 | 7218 | 16364 | 25 | 7581 | 19.306 |
| ***Private Tube well*** | 14 | 100 | 0.1 | 21 | 152 | 174 |
| ***Total Non Govt.*** | ***173009*** | ***490549*** | ***650.93*** | ***181439*** | ***531622*** | ***723.696*** |
| ***Public Lamps*** | 253 | 3364 | 9.73 | 301 | 3352 | 9.838 |
| ***Jal Sansthan*** | 168 | 8867 | 60.87 | 195 | 9691 | 66.348 |
| ***Other water works/ Plastic Recycling Plant*** | 9 | 335 | 1.42 | 10 | 2027 | 2.124 |
| ***State Tube well*** | 5 | 166 | 0.16 | 5 | 166 | 0.495 |
| ***Pump Canal*** | 3 | 45 | 0.05 | 2 | 39 | 0.025 |
| ***Total Govt*** | ***438*** | ***12777*** | ***72.25*** | ***513*** | ***15275*** | ***78.83*** |
| **Total Govt + Non Govt** | **173447** | **503326** | **723.19** | **181952** | **546897** | **802.526** |

***Source:*** UPCL

## Figure 5-2: Power Consumption in Dehradun city, 2017




***Source:*** *UPCL*

## 5.7 Electricity consumption

Among different energy sources the electricity consumption, especially for the non-OECD countries, tops the increase in residential energy use (EIA, 2016). This section describes the projections made on the scenarios generated on the basis of the energy data collected in the study and using the information from past studies and different initiatives undertaken or proposed by the state or central government. The city level data on residential electricity consumption (REC) has been obtained from Uttarakhand Power Corporation Limited (Table xx). The projections have been made for year 2021 and 2031 using regression analysis. These projections have been developed to estimate the increase in electricity consumption in the residential sector, and do not include other fuel sources. Population of Dehradun city as estimated by the master plan has been used up to year 2025. The population growth assumed to be stabilizing at a rate of 2% in 2031 (Master Plan 2025).

The projections of energy consumption at city level have been estimated under two main scenarios: Business-as-usual (BAU) and Alternative (ALT). The BAU Scenario refers to the reference scenario to reflect a situation on how the city would grow without implementation of any management strategy and ALT Scenario refers to the case of implementation of interventions and adoption of reforms as per the specific schemes. In the ALT scenario, three scenarios have been considered for projection of electricity consumption. The included interventions are aligned mainly with the targets of solar city mission for Dehradun city and potential reduction in energy consumption from the behavior change of the residents. The solar city mission aims at minimum 10% reduction in projected demand of conventional energy at the end of the mission, which can be achieved through a combination of energy efficiency measures and enhancing supply from renewable energy sources. Out of this 5% will be from renewable energy sources.

### Table 5-6: Population and residential electricity consumption growth in Dehradun city

| Year | Population (Thousands)[1] | REC (Thousand kWh) |
|---|---|---|
| 2011 | 657 | 245629.0 |
| 2012 | 680 | 264252.5 |
| 2013 | 704 | 282066.2 |
| 2014 | 728 | 299880.0 |
| 2015 | 750 | 318503.5 |
| 2016 | 773 | 335686.2 |
| 2017 | 796 | 353507.9 |
| 2018 | 820 | 372104.5 |
| 2019 | 844 | 390701.0 |
| 2020 | 865 | 406973.0 |
| 2021 | 887 | 424019.8 |
| 2022 | 909 | 441066.6 |
| 2023 | 932 | 458888.3 |
| 2024 | 955 | 476710.0 |
| 2025 | 977 | 493756.8 |
| 2026 | 999 | 511168.6 |
| 2027 | 1021 | 528206.4 |
| 2028 | 1043 | 544827.5 |
| 2029 | 1065 | 561797.7 |
| 2030 | 1086 | 578299.2 |
| 2031 | 1108 | 595130.7 |

**Note**: Population growth rate assumed to be stabilizing at about 2% in 2031 and red colour indicate projected values for business as usual scenario

Energy efficiency, particularly in the residential sector, through a change in individuals' behavior alone represents a significant energy saving potential. Some studies have highlighted the potential energy savings through energy related behavior change (Simanaviciene et al., 2001; Karatasu et al., 2013; Khan and Halder, 2016). Additional savings can be achieved if residents switch to energy efficient appliances (Karatasu et al., 2013). Although, behavior of residents is a key determinant of total energy consumption, the saving potentials due to behavior change has not received much research interests in the past. The present study has attempted to explore the saving potential that can be attained due to behavior change in the residents. A description of all the scenarios generated is provided in the Table 5-6.

**Table 5-7: Scenarios considered for electricity projections and GHG saving potential for the Dehradun city**

| Scenario | Description |
|---|---|
| BAU | This is the reference scenario where projections are made on the basis of current situation without including any intervention. |
| ALT–I | Saving potential = 10%<br>This scenario tackle the supply side management where, targets of solar city mission i.e. fossil energy demand reduced by 10% with 5% share from renewable energy are achieved (Solar City Master Plan Dehradun, 2012). |
| ALT–II | Saving potential = 15%<br>This scenario considers both demand and supply side management of electricity consumption. The targets of solar mission and addition reduction of 5% by behavior change of the residents reducing the energy consumption are achieved (Karatasu et al., 2013; Khan and Halder, 2016). |
| ALT–III | Saving potential = 20%<br>This scenario is an extension of ALT-II. It represents and optimistic situation where target of solar mission and addition reduction of 10% by behavior change of the residents reducing the energy consumption are achieved (Karatasu et al., 2013; Khan and Halder, 2016). |

For all the scenarios GHG emission mitigated were calculated using correction factor of transmission losses. The corrected emission factor was calculated as below:

$$Corrected\ EF = 0.82\ kg\ \frac{CO_2}{kWh} * T\&D\ Losses$$

Emission factor[16] = 0.82 kg $CO_2$/kWh (average value of the emission factor from the electricity consumption all over India). The values for the T&D losses are taken as 18% for Dehradun city. The data is taken from *Indiastat* website which publishes all electricity statistics of Government of India, which were used to correct the emission factor as below:

$$Corrected\ EF = \frac{Emission\ factor}{(1 - T\&D\ loss\ fraction)}$$

[16]1 *CEA, 2016. $CO_2$ Baseline Database*

**Table 5-10: Scenarios considered for electricity projections and GHG saving potential in water supply and losses for the Dehradun city**

| Scenario | Description | Water loss factor |
|---|---|---|
| BAU | This is the reference scenario where projections are made on the basis of current situation without including any intervention. Thus assuming that water losses would remain unchanged. | 0.40 |
| ALT-I | This scenario assume water losses to be reduced to 50% of the existing losses due to interventions proposed in on-going projects under AMRUT scheme. The water losses are expected to be reduced due to application of technological interventions and timely detection and repair of damages. The saved energy consumption and GHG emissions were calculated. | 0.20 |
| ALT-II | This scenario considers optimistic assumption of reducing water losses up to 25% due to further technological interventions such as smart metering and improved efficiency of water supply along with timely detection and repair of damages to reduce the water leakages. The saved energy consumption and GHG emissions were calculated. | 0.10 |

1. Calculation of total water supplied by multiplying the per capita water supply per day with the population

$$Total\ Water\ Supplied = Per\ capita\ water\ supply \times Population$$

2. Actual water treated and pumped to account for the water losses which were taken as 40%. This lost water goes unaccounted for and is and additional burden in the form of electricity consumed in its treatment and pumping. In order to calculate the water losses during supply due to leakages the following scenarios have been considered for the city.

$$\text{Total water lost}\left(\frac{\text{l}}{\text{d}}\right) = \text{Total water supplied}\left(\frac{\text{l}}{\text{d}}\right) \times \text{Water loss factor}$$

3. The total amount of water that to be supplied by incorporating the water losses was calculated using the following formula:

$$\text{Actual water to be supplied}\left(\frac{\text{l}}{\text{d}}\right) = \text{Water supplied (l/d)} + \text{Water lost}\left(\frac{\text{l}}{\text{d}}\right)$$

4. The total energy consumed for supplying the total water was calculated as sum product of 'a' and 'b' described below energy

    a. Energy consumption in conventional treatment of $1m^3$ raw water[18] = 0.11 kWh

---

[18]*Plappally and Lienhard, 2012*

$$\text{Energy Consumed for water treatment (kWh/d)} = \text{"}Total\ water\ to\ be\ supplied\ (l/d) \times Electricity\ consumption\ in\ conventional\ treatment\ of\ water\ (kWh/m3)\text{"}$$

b. Electricity required in pumping of 1 $m^3$ of water (Municipal Supply)[19] = 2.06 kWh

$$\text{Energy Consumed for pumping of water to be supplied (kWh/d)} = \text{"}Total\ Water\ to\ be\ supplied\ (l/d) \times Electricity\ consumption\ in\ pumping\ of\ water\ (kWh/m3)\text{"}$$

5. For all the scenarios GHG emission were calculated using correction factor of transmission losses. The corrected emission factor was calculated as below:

$$Corrected\ EF = 0.82\ kg\ \frac{CO_2}{kWhh} * T\&D\ Losses$$

- Emission factor[20] = 0.82 tonnes $CO_2$/MWh (average value of the emission factor from the electricity consumption all over India)
- The values for the T&D losses are taken as 18% for Dehradun city. The data is taken from Indiastat website which publishes all electricity statistics of Government of India, which were used to correct the emission factor as below:

$$Corrected\ EF = \frac{Emission\ factor}{(1 - T\&D\ loss\ fraction)}$$

**Table 5-11: Corrected emission factor electricity consumption incorporating the T& D losses**

| Year | T&D Losses (fraction) | Corrected emission factor (kg $CO_2$/kWh) |
|---|---|---|
| 2011 | 0.18 | 1.00 |
| 2021 | 0.10 | 0.91 |
| 2031 | 0.05 | 0.86 |

6. The GHG emissions mitigated due to the reduction in leakages during water supply was quantified by comparing the emissions in the ALT-1 and ALT-II scenario. The following mathematical formulae were applied to estimate the GHG emissions.

[19] MoEF, 2014. *Low carbon lifestyles toolkit*

[20] *1 CEA, 2016. $CO_2$ Baseline Database*

$$GHG\ Emissions\ (tonnes\ of\ CO2\ eq.) = Total\ Energy\ Consumed\ for\ water\ supply\ (kWh/year) \times Emission\ factor\ (kg\ CO2/kWh)$$

**Table 5-12: Potential electricity consumptions and GHG emissions saved due to different interventions in water supply**

| Year | Population | Electricity saving potential (thousands kWh) | | GHG emissions saved (tonnes of $CO_2$) | |
|---|---|---|---|---|---|
| | | ALT-I | ALT-II | ALT-I | ALT-II |
| 2021 | 887000 | 56646.8 | 84970.3 | 51.61 | 77.42 |
| 2031 | 1108000 | 70749.7 | 106124.6 | 61.07 | 91.60 |

The projections indicated an energy saving potential of 14.3% and 21.4% for ALT-I and II scenario, respectively as compared with the BAU scenario. Consequently, a GHG emission mitigation has been projected to be achieved with reduction in electricity consumption due to water losses reduced. As evident from the Table 5-11, scenario ALT-II with both technical and timely repair of breakdown and leakages can giving GHG savings up to 77 tonnes and 91 tonnes for 2021 and 2031, respectively.

### 5.7.1 Sewage treatment

#### *5.7.1.1 Generation and collection*

Like solid waste, waste water, and sewage is another challenge before the city authorities that require to be looked into. The lack of segregation of the different forms of waste and unplanned disposal of the same had historically led to a persistent problem of blockages in drains and sewerage lines in Dehradun. Rapid urbanization leading to increased construction and road works in Dehradun have led to reduced space for managing sewerage lines and narrowing of the natural drainage networks within the city. This resulted in increased incidences of flooding and urban distress. A large portion of the sewage generated is also left untreated due to the lack of treatment facilities in the city. Table below presents the status of sewage and treatment in Dehradun city:

**Table 5-13: Sewage generated in the city and the treatment capacity**

| Description | Amount (in MLD) |
|---|---|
| Sewage generation and collected | 68 |
| Other un-channelized sewage | 62 |
| Total Sewage (A)+(B) | 130 |
| Installed capacity of all STPs | 70 |
| Treatment plant capacity in per cent | 54% |

The lack of treatment facilities is further aggravated by toilet facilities not connected to the sewage network. An estimate suggests that there is around 62 MLD of sewage being generated in the city which is not connected to any sewer lines. These households will however very soon be added to the sewage network, thereby increasing the load on the present capacity. It is, therefore, important to plan the network and build sufficient treatment facilities catering for the future.

#### *5.7.1.2 Treatment and management of sewage*

The city generates about 130 MLD of sewage of which only 54 percent is treated. This means about 62 MLD of sewage is left untreated and leaks into open water bodies or underground drains. At present about 0.6 lakh establishments in the city have a sewage connection which needs to be substantially increased.

Other than the sanitation and health hazards of untreated sewage, it is also a source of $CH_4$ emissions. However, with controlled treatment, the emissions can be significantly reduced for increased environmental benefits.

Out of the total households within the city, about 77% have individual toilet facilities, implying that the remaining 23% households have to rely on either public toilets or open defecation, resulting in a large amount of untreated sewage flowing back into the water systems and higher emissions than if it were to be treated. The following section examines the emissions on account of the solid and sewage waste generated within the city of Dehradun, based on the ways in which they are currently treated.

### 5.7.2 Wastewater Management

The sewerage collection and treatment in the city is in poor condition. Due to the rise in economic and social status of city population in past years, the wastewater management has received a great attention. The coverage of sewerage networks carrying the wastewater is only 30% in the present scenario. Around 80% of the water consumed is generated as wastewater. Of the 155 lpcd water supply, around 124 lpcd is generated as wastewater. Further, there is no reuse and recycling facility for wastewater in the city. Under this section, energy consumption for treatment and supply of wastewater are projected for the year 2021 and 2031. The treatment considered is conventional treatment of wastewater. Energy consumed in conventional treatment of wastewater has been taken as 1.05 $kWh/m^3$ wastewater (Singh et al., 2012). Also, the increase in GHG emissions due to the quantified increase in wastewater quantity collected and treated have been projected. The scenarios generated are aligned with the targets of AMRUT mission as committed in smart city proposal for the city. The Table 5-13 describes the scenarios considered for this study. This is followed by brief details of the Key steps followed for the same.

### Table 5-14: BAU and ALT Scenarios

| Scenario | Description | wastewater collected & treated (lpcd) |
|---|---|---|
| BAU | This is the reference scenario where projections are made on the basis of current situation without including any intervention. Currently, only 10% of the wastewater generated is being treated. Thus for 124 lpcd wastewater generated, only 12.4 lpcd gets treated. | 12.4 |
| ALT-I | This scenario assume the wastewater collection and treatment to be increased to 50% due to interventions proposed in on-going projects under AMRUT scheme. With increased amount of wastewater treated (62 lpcd), the increase in energy consumption and GHG emissions were calculated. | 62 |
| ALT-II | This scenario considers optimistic assumption of achieving 100% collection and treatment of wastewater generated in the city. This is due to interventions proposed in on-going projects under AMRUT scheme. The increase in energy consumption and GHG emissions were calculated. | 124 |

1. Calculation of total wastewater to be treated by multiplying the per capita amount of water treated per day with the population

$$Total\ wastewater\ treated = Per\ capita\ waste\ water\ treated\ \times Population$$

2. The energy consumed for treatment of wastewater was calculated as below;

Energy consumption in conventional treatment of 1m$^3$ wastewater= 1.05 kWh[21]

$$\text{Energy Consumed for wastewater treatment (kWh/d)} = \text{"}Total\ water\ to\ be\ be\ treated\ (l/d) \times Electricity\ consumption\ in\ wastewater\ treatment\ (kWh/m3)\text{"}$$

3. For all the scenarios GHG emission were calculated using correction factor of T&D losses. The corrected emission factor was calculated as below:

$$Corrected\ EF = 0.82\ kg\ \frac{CO_2}{kWhh} * T\&D\ Losses$$

- Emission factor[22] = 0.82 tonnes $CO_2$/MWh (average value of the emission factor from the electricity consumption all over India)

[21] *Singh et al., 2012*

[22] *CEA, 2016. $CO_2$ Baseline Database*

- The values for the T&D losses are taken as 18% for Dehradun city. The data is taken from *Indiastat* website which publishes all electricity statistics of Government of India, which were used to correct the emission factor as below:

$$Corrected\ EF = \frac{Emission\ factor}{(1 - T\&D\ loss\ fraction)}$$

**Table 5-15: Corrected emission factor electricity consumption incorporating the T& D losses**

| Year | T&D Losses (fraction) | Corrected emission factor (kg $CO_2$/kWh) |
|---|---|---|
| 2011 | 0.18 | 1.00 |
| 2021 | 0.10 | 0.91 |
| 2031 | 0.05 | 0.86 |

4. The GHG emissions due to increased wastewater collection and treatment were quantified by comparing the emissions in the ALT-1 and ALT-II scenario. The following mathematical formulae were applied to estimate the GHG emissions.

$$GHG\ Emissions\ (tonnes\ of\ CO2\ eq.) = Total\ Energy\ Consumed\ for\ wastewater\ treatment\ (kWh/year) \times Emission\ factor\ (kg\ CO2/kWh)$$

New technologies based on aerobic treatment are expected to be used for sewage treatment. The selection of these technologies would depend on the quality of treated effluent, land requirements, and operation and maintenance costs. As the quantity of wastewater collected and treated increases, there will be an increase in electricity consumptions and associated GHG emissions would increase for both the scenarios as indicated in the Table 5-15.

**Table 5-16: Potential electricity consumptions and GHG emissions due to different interventions in wastewater treatment**

| Year | Population | Electricity consumption (thousands kWh) | | GHG emissions (tonnes of $CO_2$) | |
|---|---|---|---|---|---|
| | | ALT-I | ALT-II | ALT-I | ALT-II |
| 2021 | 887000 | 8950273 | 17900547 | 8154.69 | 16309.39 |
| 2031 | 1108000 | 11180274 | 22360548 | 9650.34 | 19300.68 |

As earlier stated in previous section on sewage in Dehradun, it is to highlight that, with a population of 7,28,000 in the year 2017, Dehradun generates about 130 MLD of sewage discharge. The total sewage of the city reaches the treatment plants with a collection efficiency of 54 per cent. The emissions from the sewage generated from the city are calculated based on the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories methodology for methane emission calculations from wastewater. The step-by-step calculations are explained below:

**Step 1**

The population of the city is multiplied with the average amount of degradable organic compound that is generated per person per year to calculate the total fermentable waste generated in the city.

**Step 2**

The waste generated is divided into two parts for emission calculations, a) the untreated portion and b) sludge generated from the treatment plants which are multiplied with the default methane conversion factor of the anaerobic treatment system.

**Step 3**

The maximum methane producing capacity of the resulting treated wastewater and the sludge is multiplied with the released output to arrive at the number for total methane produced from sewage in Dehradun.

An important variable in the whole calculation is the assumption for the default number for per capita BOD contribution in Dehradun. The BOD contribution for urban centers in Uttaranchal i.e., 16.42 kg BOD/year (45 g /Cap./ day as per the CPHEEO Manual) has been assumed for Dehradun.

The CH4 emissions from wastewater in Dehradun are estimated to be 1204.48 MT of CH4 for the year 2016–17. This is equivalent to about 25, 294.08 MT of CO2e for the same year or 0.0347 MT of CO2e per capita.

### 5.7.3 Consumption of petroleum products

Petroleum use is directly related to the development of any country or region. The heavy use of personalized transport in the form of two and four wheelers has caused a rapid growth in the overall demand for petroleum products within Dehradun. In addition, the demand for domestic and industrial LPG has also grown given the increasing residential and industrial usage of the fuel.

***Energy Consumption in Dehradun city during (2003-2004)***

| **Energy/ Fuel** | **Quantity (2003-04)** |
|---|---|
| Electricity | 351.22 Million KWh |
| Petrol | 29,300 KL |
| Diesel | 34,602 KL |
| LPG | 1896 T |
| Kerosene | 1510 kL |

***Energy Consumption in Dehradun city during (2007-2008)***

| Sector | Energy/Fuel | Quantity |
|---|---|---|
| **Residential** | Electricity (Million kWh) | 234.66 |
| | LPG (MT) | 28699 |
| | Kerosene (kL) | 10668 |
| **Commercial** | Electricity (Million kWh) | 192.7 |
| **Industrial** | Electricity (Million kWh) | 19.34 |
| **Transportation** | Diesel (kL) | 44435 |
| | Petrol (kL) | 42457 |
| **Waste** | MSW (tpd) | 143 |
| **Others** | Fuel Wood (MT) | 525 |
| | Electricity (Million kWh) | 10.16 |

### *5.7.3.1 Use of petroleum products in the transport sector*

The unchecked growth of population has put forth a tremendous demand for infrastructure and mismatch between demand and supply of transport infrastructure resulted in delays, fuel loss, airand noise pollution and accidents and loss of productive time and energy. All over the world public transport system has been playing an important role in meeting the transport demand of the cities.

Vikram (Transport service) is the main mode of public transport in the city and operated from the road side, utilising the road ROW as terminal and causing the delay of other vehicles plying on the road.The existing intra city public transport system is being operated by private operators through bus and tempo. The private buses are running on 10 routes having a fleet of about 100 buses. About 10 main tempo routes are operating in the city with about 1300 tempos on the roads. The fuels being used by various modes of transportation are as listed below:

**Autos:** Diesel & petrol fuel.

**Vikram**: Diesel fuel

**Buses:** diesel fuel.

**Goods Carriers**: Diesel.

The transport sector is the largest consumer of energy in the form of petroleum products. Petrol or Motor Spirit, Diesel, Auto LPG, and CNG are the principle forms for energy used to drive mobility within the city.

The increasing number of two and four wheelers on the roads, which primarily use petrol, has increased the demand of fuel in Dehradun. The fuel sales of petrol have been growing in proportion with the total number of registered petrol vehicles in the city. The similar is true for diesel vehicles such as buses, taxis, heavy, and light commercial vehicles.

#### *5.7.3.2 Domestic use of petroleum products*

Petroleum products for domestic use comprise of LPG (domestic) and kerosene. In Dehradun, kerosene is sold through select channels of the Public Distribution System (PDS) whereas LPG (domestic) is sold directly to homes by the fuel companies. The rising incomes and increasing standards of living have led to a drop in the overall sale of kerosene across the city and most households have now switched to LPG (domestic). Kerosene's share in domestic consumption of petroleum products has declined and it can be said that the fuel is primarily used by low-income households.

### 5.7.4 Emissions from petroleum products

The heavy use of petroleum products in Dehradun has resulted in increased levels of CO2 emissions. The table below highlights the usage of various Petroleum products in Dehradun for **the year 2016-17:**

**Table 5-17: Usage of various petroleum products in Dehradun (2016-17)[23]**

| LPG | Petrol | Kerosene | Diesel |
|---|---|---|---|
| 55637 MT | 89648 kL | 22765 kL | 94834 kL |

In view of the above, it is necessary to being all these fuels in one standard unit so that total emissions could be calculated. This section gives the calculations carried out to estimate CO2 emissions on account of use of petroleum products in the city. Emissions from petroleum are calculated using Indian fuel specific emission factors used in India's National Communication to the UNFCCC Secretariat.

#### *5.7.4.1 Emissions generated from the use of petroleum products*

The product specific fuel sales information that was provided by different fuel companies in Dehradun were first converted into a uniform unit of metric tonnes (MT) for ease of calculations as presented in Table below:

**Table 5-18: Conversion factors for KL to MT of particular petroleum products**

| Conversion Factor | LPG | Petrol | Kerosene | Diesel | Fuel Oil | CNG |
|---|---|---|---|---|---|---|
| **KL to MT** | 0.542 | 0.74 | 0.806 | 0.839 | 0.939 | 0.185 |
| **For Example**<br>Petrol Consumption= xMT [A]<br>Emissions factors using fuel calorific values for Petrol<br>3.06999 tCO2 /MT [B]<br>Emissions from Petrol sales in 2016-17<br>tCO2 [A*B] | | | | | | |

[23] *Data Collected form University of Petroleum and Energy Studies, Dehradun*

The following table shows fuel usage in Dehradun for year 2016-17 and all the fuels are converted in same units of MT:

**Table 5-19: Type of Fuel Usages**

| Fuel Type | Usage during 2016-17 | Usage during 2016-17 (In MT) |
|---|---|---|
| LPG | 55637 MT | 55637.00 |
| Petrol | 89648 kL | 66339.52 |
| Kerosene | 22765 kL | 18348.59 |
| Diesel | 94834 kL | 79565.73 |
| | TOTAL | **2,19,890.8 MT** |

Once assimilated in the uniform units of mass, the subsequent data is converted into CO2 equivalent emission values using Indian fuel-specific emission factors as shown in Table below:

**Table 5-20: Derivation of petroleum emission factors from energy content**

| Petroleum Product | Emissions by energy content (T CO2/MJ) | Calorific value (MJ/kg) | Emissions by weight (T CO2/kg) | Emissions per tonne (T CO2/MT) |
|---|---|---|---|---|
| Diesel | 74.1 | 43 | 3186 | 3.19 |
| Petrol | 69.3 | 44.3 | 3070 | 3.07 |
| Kerosene | 71.9 | 43.8 | 3149 | 3.15 |
| LPG | 63.1 | 47.3 | 2985 | 2.98 |

The emissions are subsequently calculated by multiplying the amount of fuel sales in units of mass with the CO2 emission factors per tonne given in table above. The calculations for Dehradun are as done below:

**Dehradun City (2016-17)**
Petrol Consumption= **2,19,890.8 MT** [A]

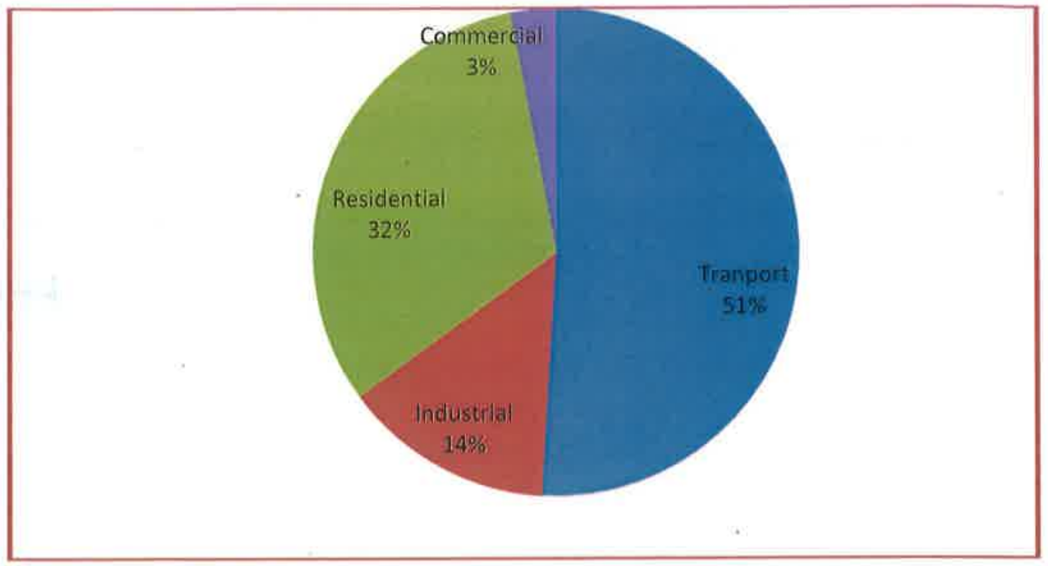
Emissions factors using fuel calorific values for Petrol
3.06999 tCO2 /MT [B]

Emissions from Petrol sales in 2016-17

tCO2 [A*B] = 2,19,890.8 MT **X** 3.06999 tCO2 /MT

= **6,75,062.56**tCO2

**Figure 5-3: Share of emissions from use of petroleum products in different sectors in Dehradun**




## 5.8 SOLID WASTE

One of the major challenges faced by any urban centre revolves around the disposal of its waste. With a rapidly increasing population with higher per capita incomes and changing lifestyles, the magnitude of the challenge has also been increasing. This has resulted in the creation of larger quantities of waste at the residential units, restaurants, shops, and commercial units.

### 5.8.1 Solid Waste Disposal

#### *5.8.1.1 Generation and collection*

It is to highlight that a proper system of primary collection of waste from the doorstep in all 60 wards of Dehradun has been started from August 2011. At present the waste is deposited at current trenching site. The existing transportation work is scientifically designed. A few years back the Doon Valley Waste Management (DVWM) has introduced containers and dumper machines under JnNURM. The municipal authority does not have any facility for processing of municipal solid waste. The entire waste of the city is disposed of at the dumping ground untreated.

The city does not have any engineered landfill nor has adequate land for scientific disposal of waste. The city has a parcel of land located on Sahastra Dhara Road, Dandalakhound, where presently little over 200 MT of mixed waste brought from the city is disposed every day. Another land parcel was being considered at old Mussoorie Road near Shanshashi Aashram, but was rejected due to steep slope. Few other sites were also explored but constraints like, other state boundary, National Park, Airport, River Ganga etc. were existing while making selection of land for said purposes.

Bio-medical waste of the city is treated at PCRI Haridwar and the industrial waste treated by industries at their own level. However, the sector remains largely unorganized and segmented to address the issue of increasing waste in the future.

Unavailability of adequate toilet facilities for the entire population in the city of Dehradun still results in discharge of large volumes of untreated sewage. Sewage treatment facilities in the city are not adequate for all the sewage and wastewater that is collected. Only about 70% of the amount collected is treated. There is a lot of scope to improve the collection rate and treatment facilities of sewage in the city of Dehradun.

#### *5.8.1.2 Solid waste treatment and management*

Better planning in collection, transportation, segregation, storage, and processing of solid waste is required to increase efficiencies of the system and minimize environmental degradation. Solid waste has the potential to create increased incidence of disease and health hazards if not disposed with proper care. Methane, a green-house gas with a Global Warming Potential of about 21 times that of CO2, is one of the principle emissions from the solid waste dumping sites. Planned disposal of solid waste is required for an improved local environment and for mitigating the global challenge of a warming environment.

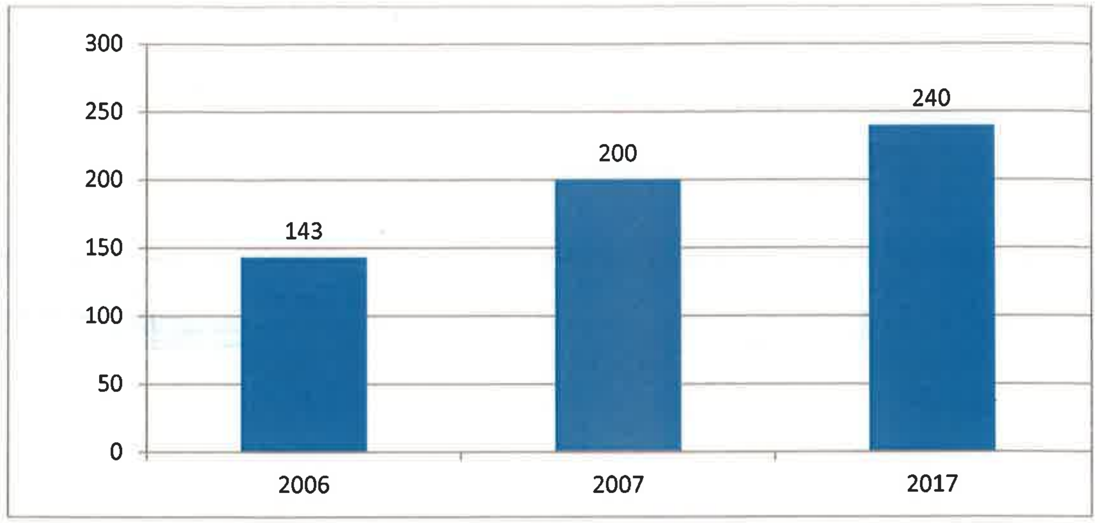
### 5.8.2 Emissions from Solid Waste Disposal

Greenhouse gas emissions in the form of methane (CH4) are generated from the fermentation of bio-degradable matter present in solid-waste. The emission volumes generated are a direct function of the amount of waste generated in the city. Linked to the rapid explosion in the population, these emissions numbers have also grown manifold. Absence of a scientific method with the city civic bodies to treat almost all the solid waste that it generates, its present capacity to treat fermentable matter is just about adequate and fluctuation could affect the efficiency.

#### *5.8.2.1 Solid waste disposal*

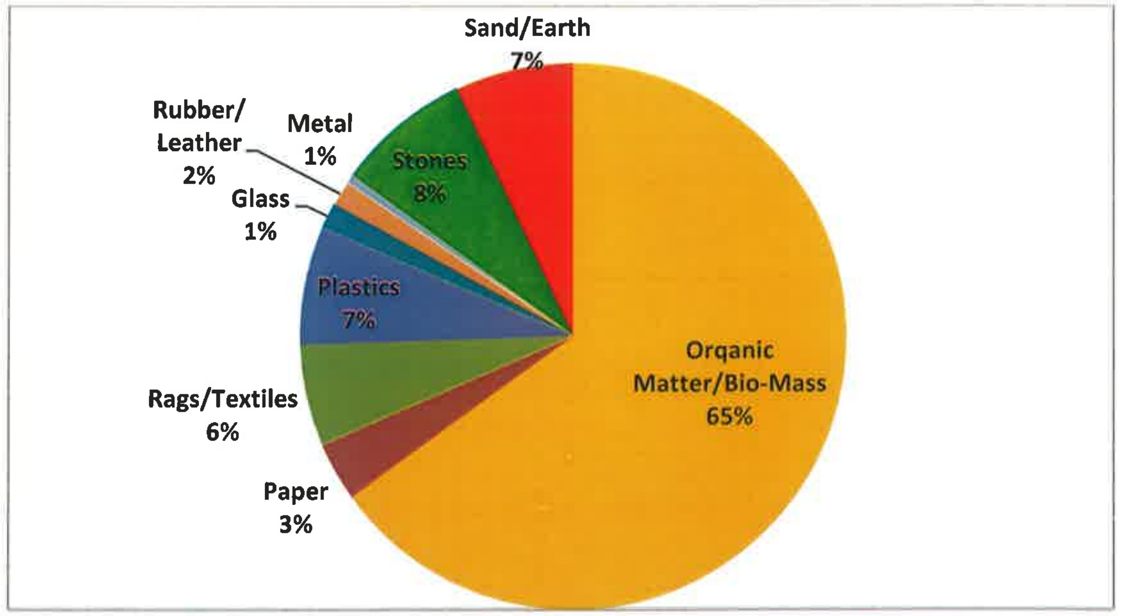
Even if we accept the Dehradun Nagar Nigam estimates, majority of the total amount of about 240 MT (as per estimates of City Development Plan of Dehradun) of solid waste that is generated by the city every day is not managed scientifically.

**Figure 5-4: Solid Waste Generated in Dehradun in MT/Day**




The waste management facilities are now in a position of converting the waste that they are treating to a greener energy source as also explained in the later sections of this report. The proportion of decomposable matter in the solid waste mix of Dehradun is about 65 percent, resulting in approximately 156 MT of bio-degradable waste generation in the city. The remaining constituent of the waste (35%) is made up of either inert or recyclable materials like metal, glass, paper, plastic, rubber, and leather that go back into the system or to dumping sites. The biodegradable portion of the waste is segregated and taken to the various treatment centers, which are at present working at full capacity to meet these requirements.

**Figure 5-5: Composition of Municipal solid waste in Dehradun**




The following calculative methodology presented, as prescribed in the IPCC 2006 guidelines for GHG emissions inventory for estimating the emissions from solid waste is used to calculate the emissions in Dehradun.

| |
|---|
| Methane emissions (MT/yr) = 63,772.8 |
| MSWT x MSWF x MCF x DOC x DOCF x F x (16/12) – R x (1- OX) |
| where: |
| MSWT = total MSW generated (MT/yr) |
| MSWF = fraction of MSW disposed to solid waste disposal sites |
| MCF = methane correction factor (fraction) |
| DOC = degradable organic carbon (fraction) |
| DOCF = fraction DOC dissimilated |
| F = fraction of CH4 in landfill gas (default is 0.5) |
| R = recovered CH4 (MT/yr) |
| OX = oxidation factor (fraction - default is 0) |

Calculating the **CH4 emission** in present case= 2880X 0.65 X 0.6 X 0.56 X 0.5 X 0.5 X (16/12)

= 209.67 MT/ year

### Table 5-21: Variable values and calculated emissions from Solid Waste Disposal in 2016-17

| VARIABLE | VALUE |
|---|---|
| **Total MSW generated** | 2880MT/year |
| **% of MSW disposed to landfill sites** | 65% |
| **Methane correction factor*** | 0.6 |
| **Degradable organic carbon** | 56% |
| **Fraction DOC dissimilated*** | 0.5 |
| **Fraction of CH4 in landfill gas*** | 0.5 |
| **Recovered CH4** | 0% |
| **Oxidation factor** | 0 |
| **Calculated CH4 emission** | 209.67 MT/year |
| **Total CO2 equivalent emissions** | **4403.25** MT/year |

** These are IPCC default correction factors.*

The default methane correction factors have been used for calculating the emissions based on the methodology suggested in the IPCC guidelines. It has been assumed that 100% of the waste that is generated within the city is collected every day and dispatched to the appropriate treatment facilities.

However, about 65% of the waste generated is sent to scientifically monitored landfill sites, and that is the only portion of waste responsible for generating emissions from solid waste. This translates to about 209.67 MT/year of CH4 emissions from Dehradun in the year 2016-17. To make the emissions from solid waste comparable with emissions from other sources, the Global Warming Potential of 21[65] that is assigned with $CH_4$ is multiplied to the

$CH_4$ emissions figures to generate the CO2e numbers. This results in 4403.25 MT/year of CO2 equivalent emissions from Dehradun.

In per capita (considering present population of Dehradun city as 7,28,000) terms this translates into **0.60 tCO2e** emissions for the year 2016–17 on account of solid waste disposal.

The combined emissions from both solid waste disposal and sewage wastewater area bout 28,54,495.64 MT of CO2e for the year 2016–17.

## 5.9 Overall Emissions

The overall emissions generated from the Dehradun city in the year 2016-17 are28,54,495.64 MT of CO2e. This translates to about 3.92 metric tonnes of CO2e per capita in the same year.

**Table 5-22: CO2 emissions generated in Dehradun in 2016–17**

| Categories | tCO2e emissions (2016-17) | Per capita tCO2e emissions | Share |
|---|---|---|---|
| **Residential** | | | |
| *Electricity* | 2,73,213.00 | 0.34 | 13% |
| *Petroleum products* | 2,16,020.02 | 0.3 | 11% |
| **Transport** | 3,44,281.91 | 0.47 | 18% |
| **Commercial** | | | |
| *Electricity* | 1,97,305.74 | 0.27 | 10% |
| *Petroleum products* | 20,251.88 | 0.03 | 1% |
| **HT Electricity** | 2,34,543.00 | 0.32 | 12% |
| **Waste** | | | |
| *Solid Waste* | 4403.25 | 0.6 | 23% |
| *Sewage* | 25,294.08 | 0.03 | 1% |
| **Industrial** | | | |
| *Petroleum products* | 94,508.76 | 0.13 | 5% |
| *Electricity* | 52,227.99 | 0.07 | 3% |
| **Others** | 57,564.27 | 0.08 | 3% |
| **Grand Total** | **15,19,613.90** | **2.64** | 100% |

As shown in the table above, the maximum share of the emissions generated comes from the Solid Waste disposal being 23%.

## 5.10 Upcoming Technological Innovations in Dehradun and Surrounding Areas

In view to address energy efficiency couple of innovations are emerging in and around the urban areas of Dehradun which need special mention to draw conclusions on potential follow up. These include CGD (City Gas Distribution) network, Waste to energy (without segregation), Gasification of mixed waste

Natural gas has emerged as one of the most environment-friendly fuels available in recent times. Its usage helps in reducing the poisonous release from the industrial and transport sector. In addition to it, the supply of natural gas through pipelines is continuous, safe and reliable. In this context, the city government of Dehradun must take the advantage of the energy efficiency interventions from Government of India as done by the Udham Singh Nagar in Uttarakhand. It is important to mention here that Udham Singh Nagar district is connected to the country's natural gas grid through GAIL (India) Limited's pipeline network. In addition to it, for the first time that an awareness campaign of this nature is being carried out in Udham Singh Nagar.

In order to supply environment-friendly piped natural gas (PNG) to households and compressed natural gas (CNG) to vehicles the City Gas Distribution (CGD) networks are already being developed in Udham Singh Nagar and Haridwar districts in Uttarakhand. The same can be implemented in Dehradun which will enhance the energy efficiency of Dehradun.

### 5.10.1 Waste to Energy:

Uttarakhand is coming up with India's first project to produce electricity from non-segregated waste. Using an innovative German technology called gasification, an estimated 500 metric tonnes of waste will produce 25 megawatt of electricity every day. In addition to it, there will be no emission, landfill or other waste from the process.

### 5.10.2 Gasification of mixed waste

So far the technological under the gasification technology, mixed waste will be treated at ultra-high temperature in the absence of oxygen to produce a synthetic gas that will be used further for production of electricity. The first plant sets to take off in Roorkee under PPP mode. The Roorkee Municipal Corporation has already started the project. As per arrangement, the plant in Roorkee will get waste from Dehradun, Roorkee, Haridwar, Rishikesh and all the adjoining areas on a daily basis. Functioning in three shifts, the plant will be operational throughout the year. The project has an investment worth Rs 500 crore to introduce the modern methods to clean up the city.

Initially, garbage dumped at Shahastradhara road near Dehradun will be transported to Roorkee and then, depending on the success of the plant, further action regarding disposal of waste of Dehradun in Roorkee will be taken. State Industrial Development Corporation of Uttarakhand (SIDCUL) will be at the forefront in spearheading the project.

The process will result in just two by-products: i) synthetic gas, also called green gas (which will be used to make electricity) and ii) the end product which would be a sand-like residue (called non-leachable inerts) which can be used for construction and road-making.

### 5.10.3 Institutional and Fiscal Arrangements

It is important to mention here that electricity would be generated at Rs 10 per kilowatt and the company would work on BOOM basis, that is, build, own, operate and maintain. It is more important that the government will have to shell out absolutely no funds for the project.

The electricity will be sold by them to UPCL, while revenue will also be generated through sale of recyclable valuable materials and non-leachable inert. Starting from industrial and hazardous wastes including liquid oil wastes like heavy oil, tar sands, bio-diesel, oil sludge, hydro-oils etc., biomedical waste and plastic wastes, to sludge of STPs/ETPs/drain silts, bio-wastes, agriculture waste and slaughter wastes including carcasses, a wide range of waste will be utilized in making electricity.

Finally, the study points out and elaborate the potential for energy efficiency on the city under alternate scenario covering alternative I, II & III at 10%, 15% & 20% respectively giving due regard to 10% basic reduction toward demand of fossil fuel and behavior change in a ratio of 5 to 10%. This paves way for further actions towards reduction in the use of the fossil fuel and behavior change and promoting a wider participation by local community and civil society.

# CHAPTER 6- HOUSING SCENARIO & ASSESSMENT OF RESIDENTIAL SECTOR IN DEHRADUN

In India, the residential sector accounts for 13 percent of total annual energy consumption. Dehradun has transformed into an attractive real estate destination in the recent years. Proximity to Delhi and other important northern cities, good infrastructure, affordable realty rates and scenic beauty are all driving the market for residential and commercial real estate development. Residential sector has a major contribution in terms of energy consumption with a near consistent 8% rise in annual energy consumption. Building energy consumption has seen an increase from low 14 percent in the 1970s to nearly 33 percent in 2004-2005.

## 6.1 Benchmarking Growth of housing in Dehradun

This section of the study shows comparative study of growth of housing in Dehradun to the growth of housing in other metro cities like Delhi, Mumbai, Kolkata, Chennai, and Bhopal.

The Housing shortage in India in the beginning of 12th five year plan (2012) was estimated to be 18.78 million. As per census of India 2011, the total number of census houses in urban areas is 110.14 million. As per census, there are 76.13 million houses used for only residential purposes and 2.35 million houses used for residential-cum other uses, the two together giving the housing stock of 78.48 million[24].

The data on urban housing stock from various population censuses excluding the non-serviceable katcha units are presented in the Table 6-1, given below.

**Table 6-1: Census Data on Total Housing stock in Different categories in Urban areas in India**

| Census Years | Permanent Pucca (in millions) | Semi Permanent/Pucca (in millions) | Temporary serviceable/Katcha serviceable(in millions) | Total Housing Stock (in millions) |
|---|---|---|---|---|
| **1961** | 6.44 | 4.90 | 1.96 | 13.30 |
| **1971** | 11.80 | 4.35 | 2.35 | 18.50 |
| **1981** | 18.09 | 6.80 | 3.11 | 28.00 |
| **1991** | 29.79 | 6.21 | 3.30 | 39.30 |
| **2001** | 41.17 | 8.08 | 1.72 | 50.97 |
| **2011** | 66.17 | 9.10 | 2.23 | 77.50 |

*[24]Report of the technical group on Urban Housing shortage (TG -12) (2012-2017), Ministry of Housing and Urban Poverty alleviation.*

**Table 6-2: Total number of housing stock in Uttarakhand as per Census of India 2001 &2011**

| HOUSING STOCK 2001-2011 | | | | |
|---|---|---|---|---|
| State | Total Census houses | | Residential & Residential-cum-other use | |
| | 2011 | 2001 | 2011 | 2001 |
| Uttarakhand | 3,383,410 | 2,566,282 | 653000 | 668000 |

***Source:*** *Census of India 2001-2011, Housing Stocks*

**Table 6-3: Distribution of Total number of Housing Stock on the basis of structure in Dehradun as Per Census of India, 2001**

| Total number of housing stock in Dehradun | 1981 | 1991 | 2001 |
|---|---|---|---|
| **Kutcha** | 1143 | 1603 | 1532 |
| **Semi Pucca** | 14906 | 20945 | 32736 |
| **Pucca** | 33636 | 48636 | 72056 |
| **Total** | 49685 | 71184 | 106324 |

***Source:*** Census of India, 2001, 2011

## 6.2 Composition of Group housing and Future Potential for Group Housing

About 64% of the residential typology in Dehradun is plotted; however the newer construction mainly consists of the multi storied housing of (G+3) stories as more than G+3 is not permitted, because of the fact that Dehradun is under seismic zone. Plotted development mainly exists within the municipal area. Group housing development mainly exists in the core area of Dehradun city.

In Dehradun, most of the group housing colonies are 25 to 30 years old constructed dwelling units of (2 to 3) BHK having a height of (G+2) and (G+3). Majority of the Group housing colonies belong to LIG and MIG group of people. But because of rapid urbanization and industrialization process and being a capital city of Uttarakhand there has been an increase in demand of establishing various growth centers which facilitates the growth of Real estate sector in the city. Various new upcoming group housing colonies have come up in a trend to cater to the middle and high-income group of the people so as to cover up all luxurious facilities to be provided in Group housing colonies in Dehradun.

As far as future potential of group housing in Dehradun is concerned, It is expected to have huge scope of it, because of the fact that there is less number of group housing societies in the city, Proximity to Delhi and other important major growth centers such as proposed Information Technology (IT) centre which stimulate the development of Real estate sector in Dehradun.

## 6.3 Importance of Group Housing in relation with Compact City Development

It has been seen that the residential sector in an urban area is responsible for consuming a substantial part of the energy right from the construction phase to the building use and maintenance (United Nation Human Settlement Programme, 2012)

Therefore, the housing activities require exploring innovative mechanisms/ strategies to better plan energy and resource consumption thereby providing support to facilitate climate change mitigation/adaption efforts. Sustainable development of Group housing is seriously compromised by organizing cities around "urban sprawl" and private car mobility. More scattered residential environs require more land, resource and infrastructure (water, gas, electricity, roads) and lead to a disintegration of the city space, including between socially segregated areas.[25]

Relatively compact mixed-use and mixed-income areas, which integrate housing, work, facility and entertainment in close proximity, are believed to constitute an important strategy for reducing these negative footprints. A more compact city also allows easier and more affordable access by low-income residents to urban services and employment opportunities and a better sense of community integration, less chances of energy loss, low level of GHG emission released from vehicles.

**Characteristics of Compact city Development**

- **Form of Space**
  - High-dense settlements
  - Less dependence on private automobile (<high density)
  - Clear boundary from surrounding area
- **Space Characteristics**
  - Mixed land use
  - Diversity of life (<complex land use)
  - Clear identity
- **Function**
  - Social fairness (<high dense settlements)
  - Self-sufficiency of daily life
  - Independence of governance (<clear boundary)
- **Sustainable mode of Transport**
  The population densities are high enough to support public transport and to make it feasible to operate. Also, because compact city are high dense and mixed use, the theory is that people can live near to their work place and leisure facilities. Hence, the demand for travel is reduced overall and people can walk and cycle easily.

[25]*Sustainable housing for sustainable cities: a policy framework for developing countries first published in Nairobi in 2012 by UN-Habitat, Copyright © United Nations Human Settlements Programme 2012.*

- **Sustainable use of land**

  By reducing sprawl, land in the countryside is preserved and land in towns can be recycled for development.

- **Offers good accessibility**

  In social terms, compactness and mixed uses are associated with diversity, social cohesion and cultural development.

### 6.3.1 Contribution to Energy Efficiency

Cities with a compact development have a potential for increasing green, open areas and large area of vegetation that help to reduce the amount of pollutants in the low atmosphere; remove carbon dioxide during photosynthesis and emit oxygen. Compact city development promotes walking and cycling in order to reduce the transportation cost which results in less emission released from the vehicles.

Compact city development promotes the concept of sustainable development which results in adopting all such technological intervention, spatial planning module (like mixed land use, integration of vegetation into the design of individual buildings such as greening roofs and walls, 'pocket parks', and the planting of trees in courtyards) that helps in reducing the GHG emission and demands less energy.

### 6.3.2 Different Ways of Compact City Development to Decrease the Energy Demand from Residential Sector

Energy savings mean avoided energy and CO2generation. Compact city development provides the residential sector one of the most cost-effective mechanisms for the reduction of CO2 emissions. Therefore, in order to reduce energy demand from residential sector a Compact city development could be a good possible solution.

## 6.4 Findings

The findings from the macro level data and household survey are being discussed here:

**Table 6-4: Distribution of Housing Stock in Dehradun in Municipal Area**

| Uses | 1999 (Appx. No) | 2017 (Appx. No) |
|---|---|---|
| **Residential** | 55,000 | 1,25,000 |
| **Non Residential** | 1,000 | 20,000 |

***Source:*** Property Tax Department, Nagar Nigam, Dehradun (2017)

It can be seen from the above table that in less than 20 years the number of households have more than doubled in the city area. One reason is inclusion of surrounding areas in the city limits and as told by officials in the Nagar Nigam, a lot of migration to the city has been noticed since Dehradun became the state capital.

### 6.4.1 Household Surveys

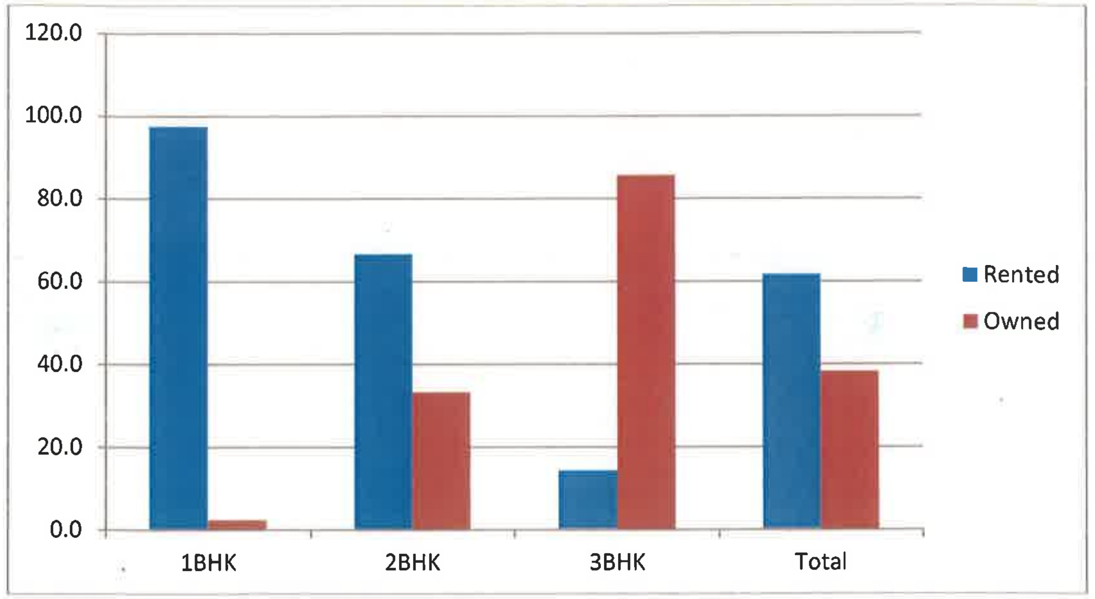
The household surveys were conducted in the residential areas for collecting data on energy consumption.

Household survey being done in residential Areas in Dehradun

Household survey has been acknowledged as a common method for identifying the energy consumption patterns (Poznaka et al. 2014). The household surveys using questionnaire (Annexure 4) were conducted in different residential areas of Dehradun city for collecting data on energy consumption. To understand the energy consumption patterns of **households' members of different housing groups the behavioural aspects, habits of energy** use were also included in the questionnaire thus allowing us to examine different determinants of electricity consumption. The survey was conducted in three rounds covering six localities- two each belonging to LIG, MIG and HIG housing. The present section details out the analysis of the primary surveys conducted in Dehradun during the field investigations in various residential areas. A total of 120 households were surveyed in residential areas namely New Cantonment Road, Aashirwad Enclave, Vijay Colony, Kalidas Road, Vishal Lok Colony, Garwahli Colony, Kiddupur and Raipur Estate. 500 LIG households were covered in first phase of survey and another 500 in the second stage. Later 80 of MIG and HIG households were also included on the suggestion of the expert committee.

The figure below highlights the ownership status of the various households surveyed. As is evident from the figure below that around 60% of the inhabitants own the household with rest 40% as the tenants.

**Figure 6-1: Ownership of the house**




The figure below is showing the distribution of various households surveyed according to their built up areas.

**Figure 6-2: Area of House (in Sq.Ft)**

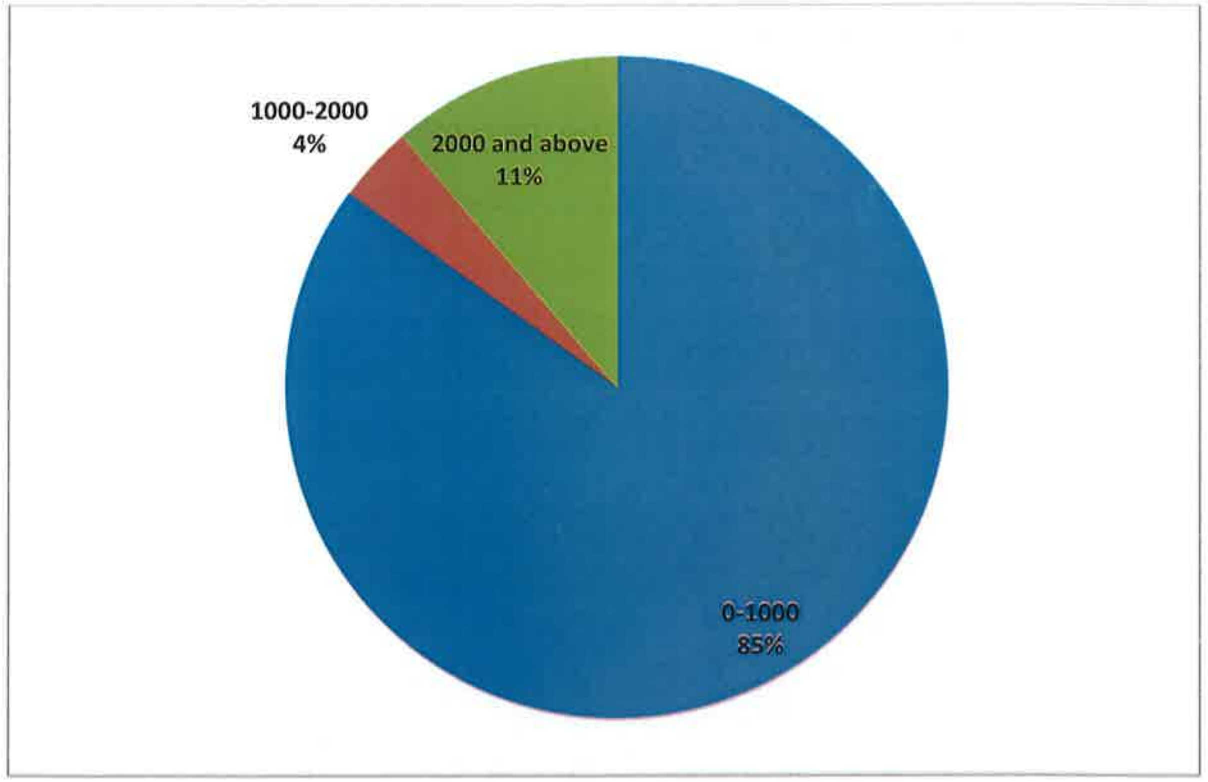
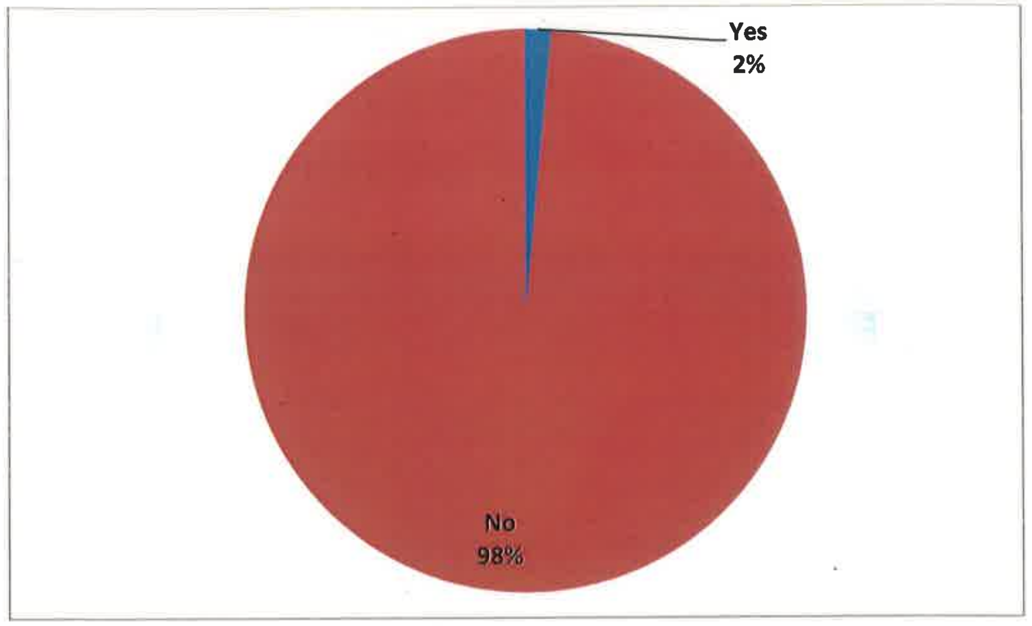


**Figure 6-3: Provision of Rain water Harvesting**




As shown in the figure above, nearly 98% of the respondents were not having provision of Rain water harvesting in their households. This is an area of concern which needs attention of the concerned civic agencies.

As shown below, there is a variation in the age of the buildings surveyed with 34% buildings having an age upto 15 years, 29% having an age of 15 to 30 years and rest 37% having an age of 30 or more years.

**Figure 6-4: Age of Building**

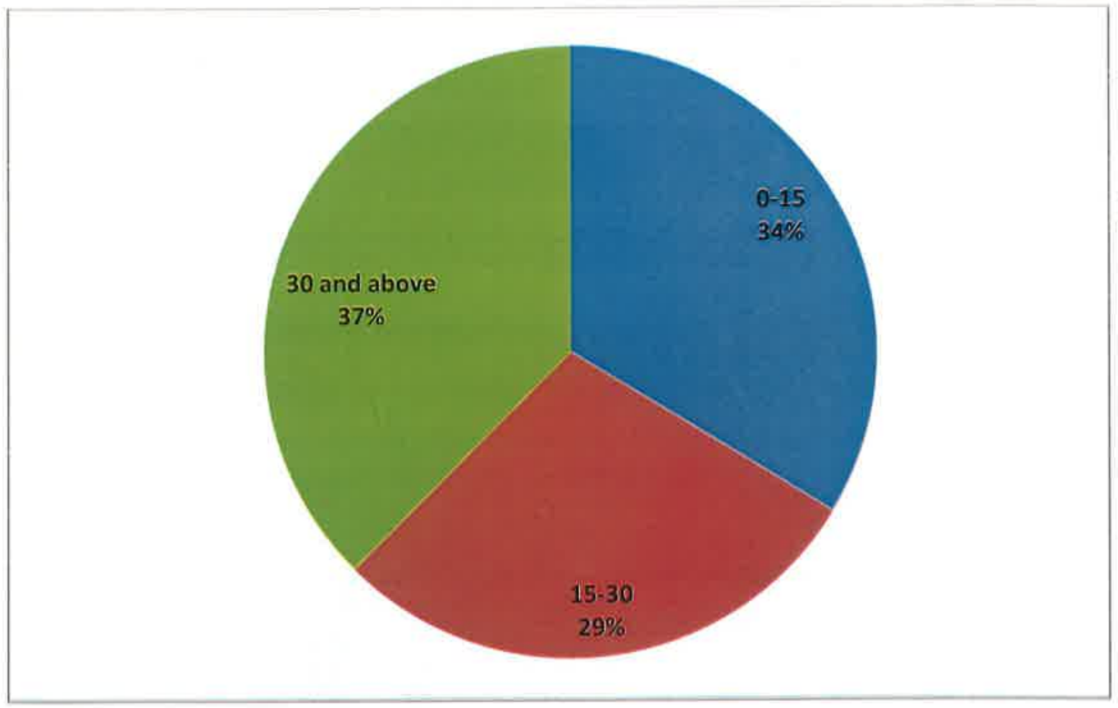
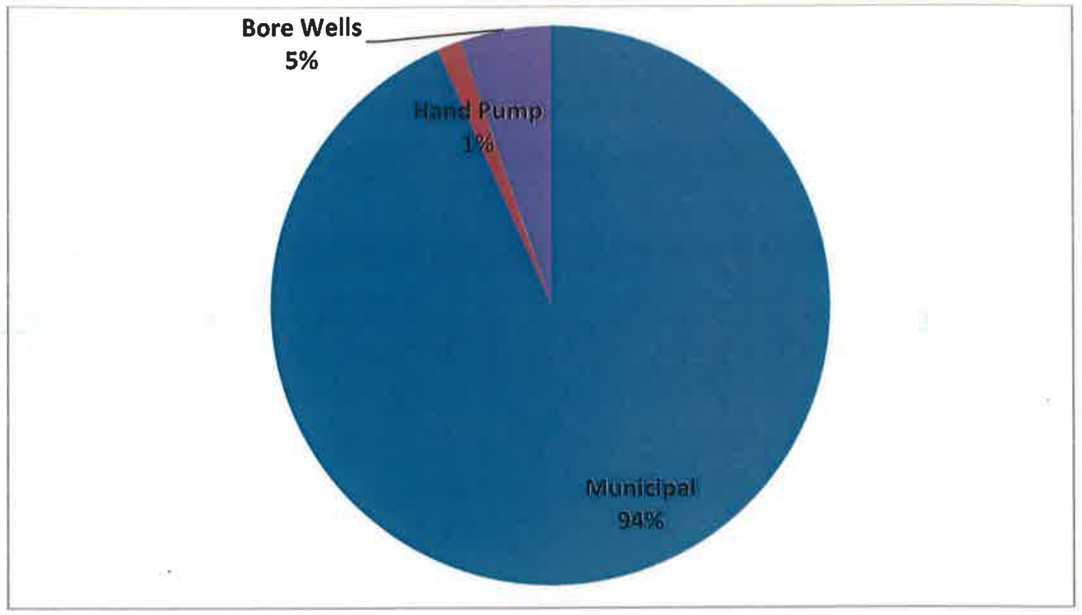
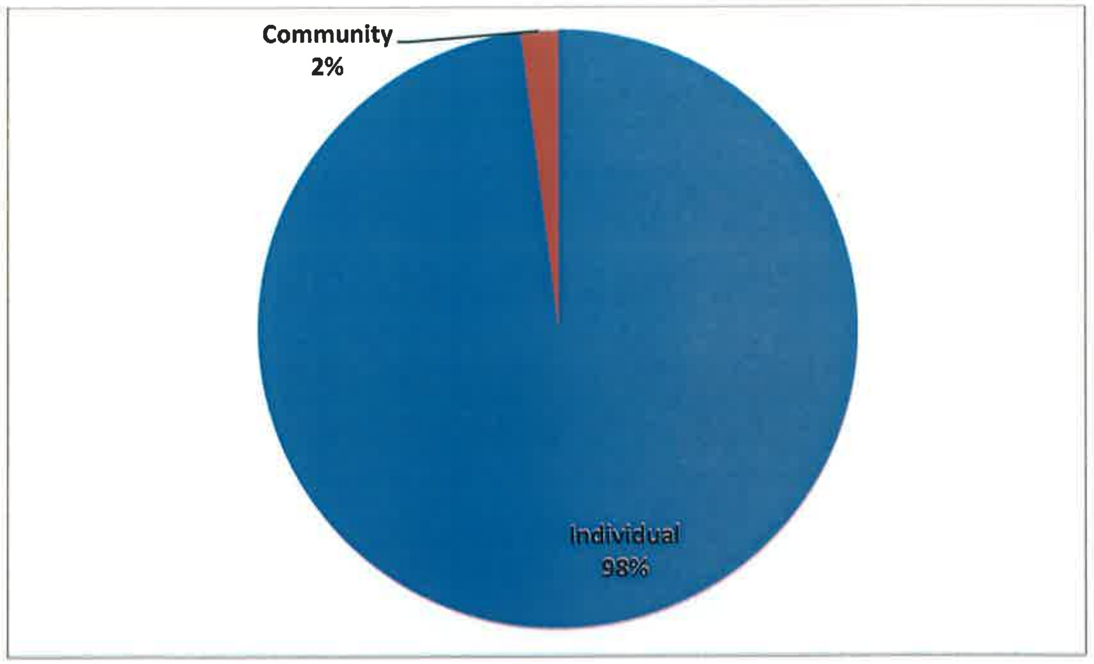


**Figure 6-5: Source of Water**



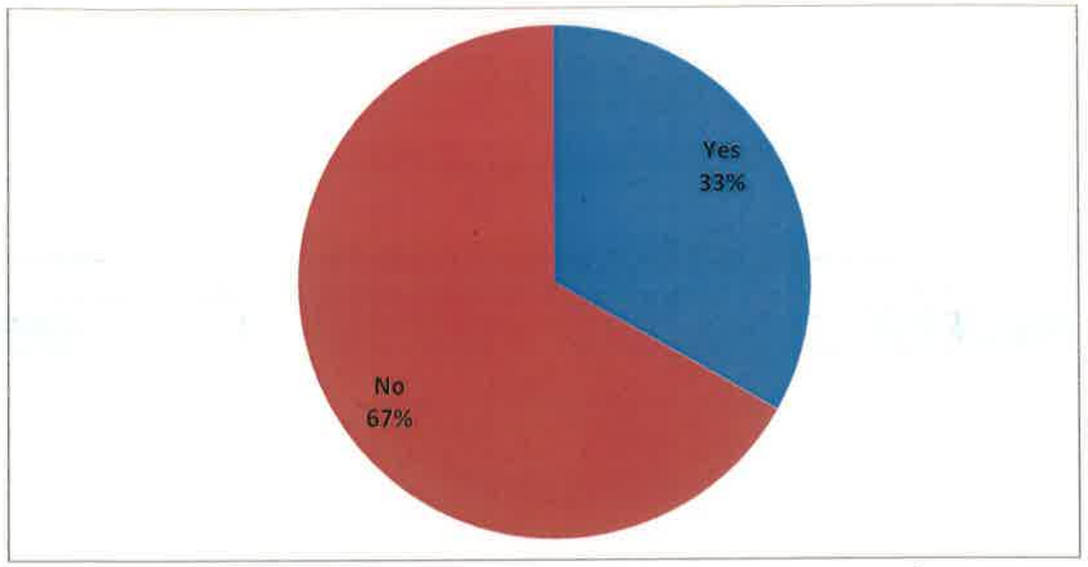

The figure above shows the various sources of water in the households surveyed. It is evident that primarily residents are getting water supply from the Dehradun Nagar Nigam. During the surveys and the subsequent analysis done afterwards revealed that the average water consumption per day was around 139.3 litres. It is to add that the average solid waste generated was 576.6 grams per capita per day. This also shows that the Dehradun city is having a household consumption pattern, comparable to other big metropolitan cities of India.

**Figure 6-6: Type of Connection**



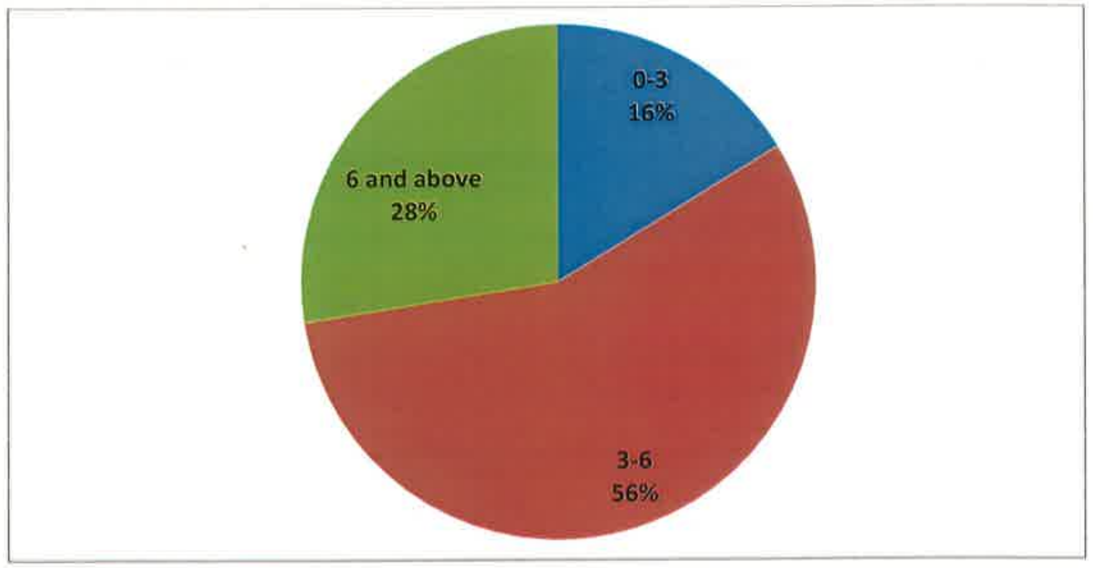

After surveying the households it was found that around 98% of the households have individual water connections as also shown in figure above.

**Figure 6-7: Usage of water pumping motors**



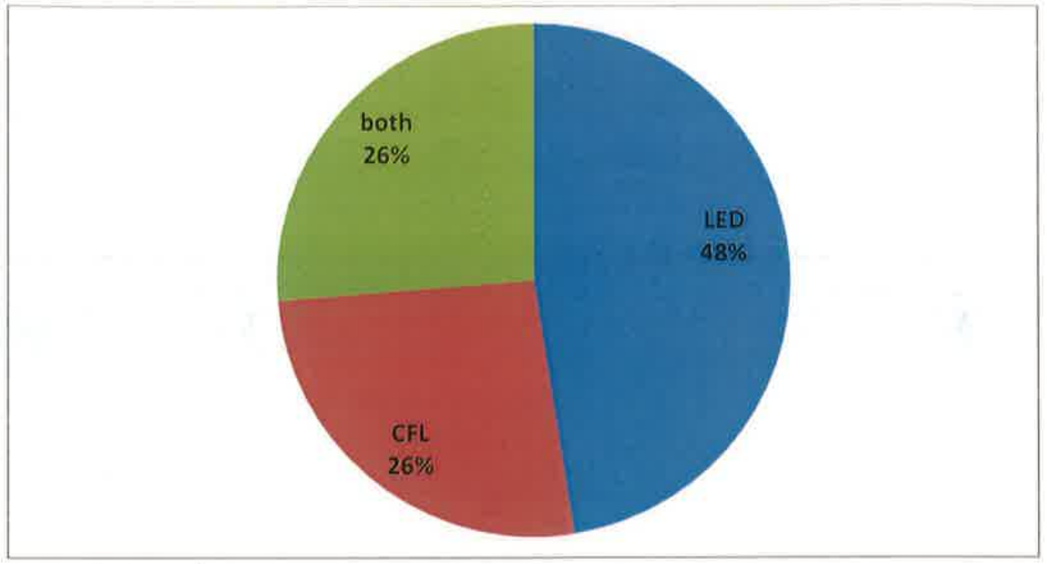

Around 33% of the respondents were using the water pumping motors as shown in the figure above. The figure below further shows the distribution of the hours for which there is water supply in various households.

**Figure 6-8: Frequency of Water supply (in hours)**



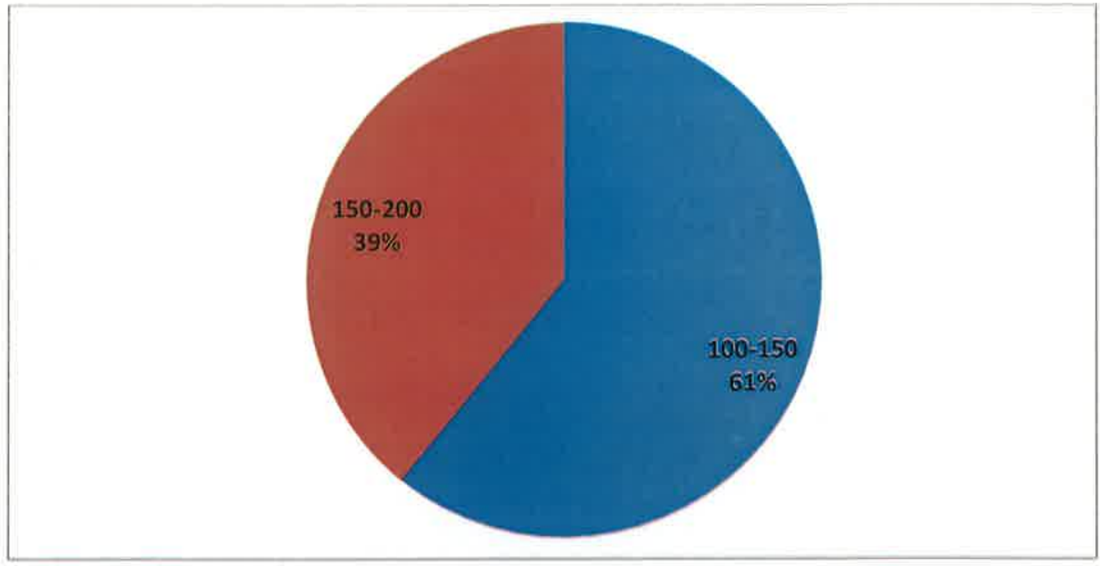

57% of the respondents were satisfied with the water quality in their households. Since majority of the households is getting water from municipal supply, it confirms that the Municipal Corporation is supplying treated water. However, many of them were treating the water also through water purifiers.

**Figure 6-9: Usage of LED and CFL**




As shown in the figure below, nearly 61% of the respondents were willing to pay Rs 100-150 if given an opportunity to use the appliances running on renewable sources of energy. Around 39% were willing to pay Rs150-200, which indicates that people in general are willing to pay for having energy efficient devices.

**Figure 6-10: Willingness to pay per month for Renewable energy Instruments**




As shown in the figure below, out of the total respondents 32%, 66% and 2 % owned Cars, Two wheelers and other vehicles respectively. All HIG households had cars whereas some MIG and LIG households also owned cars but majority of them owned two wheelers or other vehicles. In addition to this, the average distance travelled by Car and Two-wheelers was found to be 6.8 kms and 11.8 kms respectively.

**Figure 6-11: Vehicle Ownership**

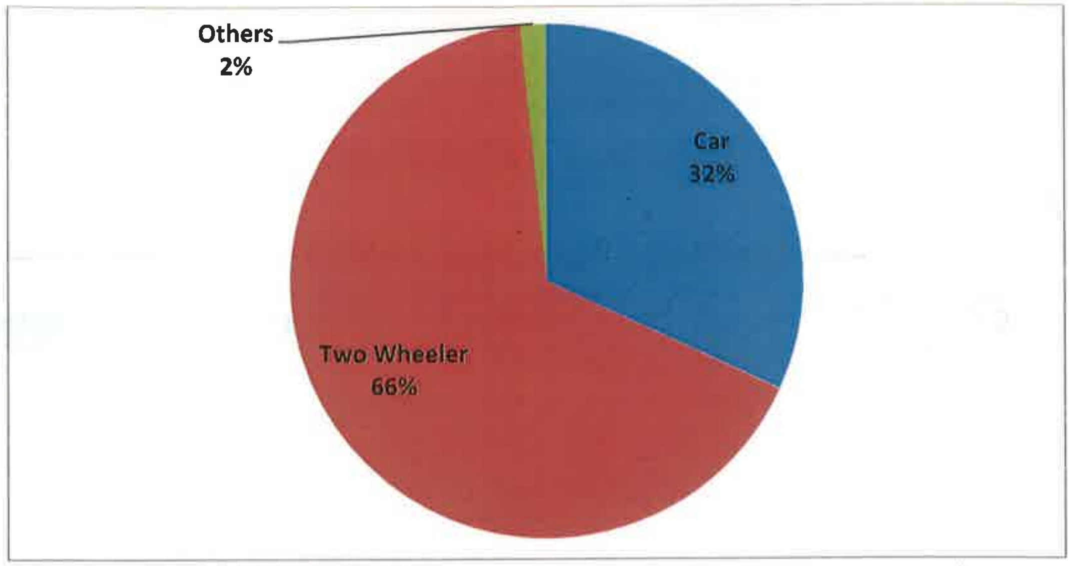
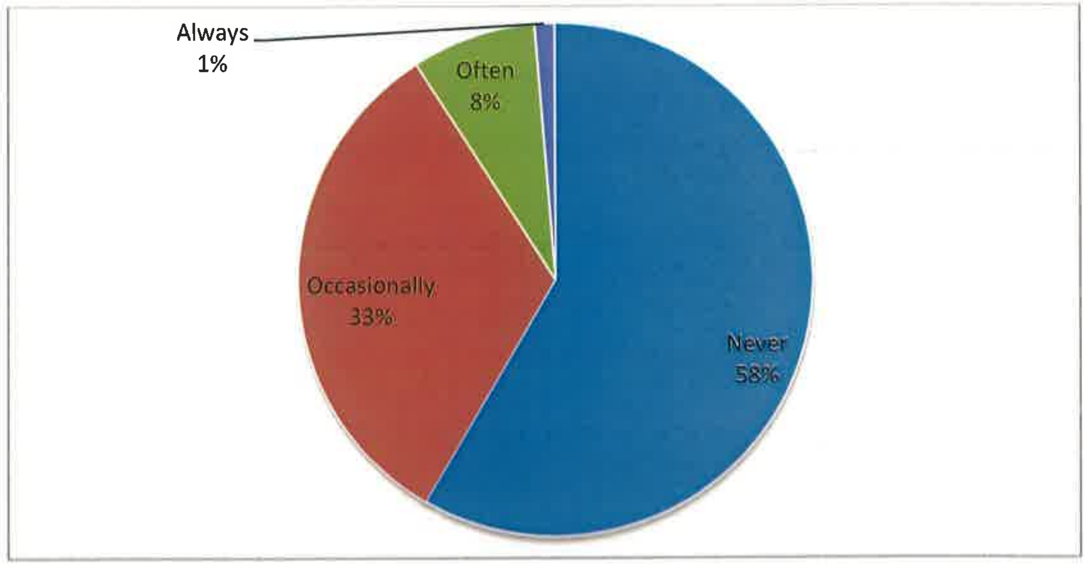
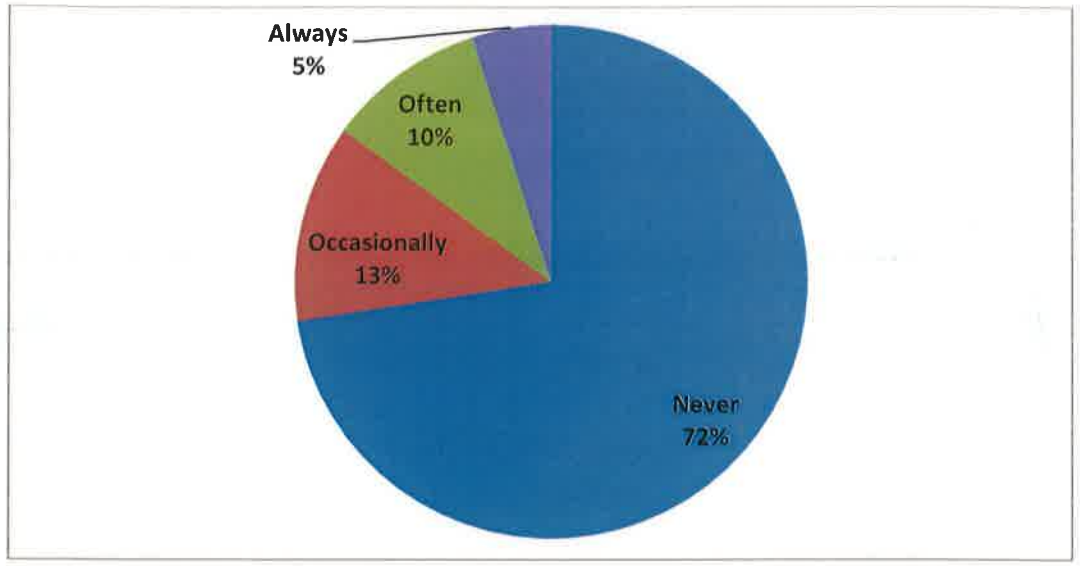



**Figure 6-12: Frequency when occupancy in Car is More than 1**



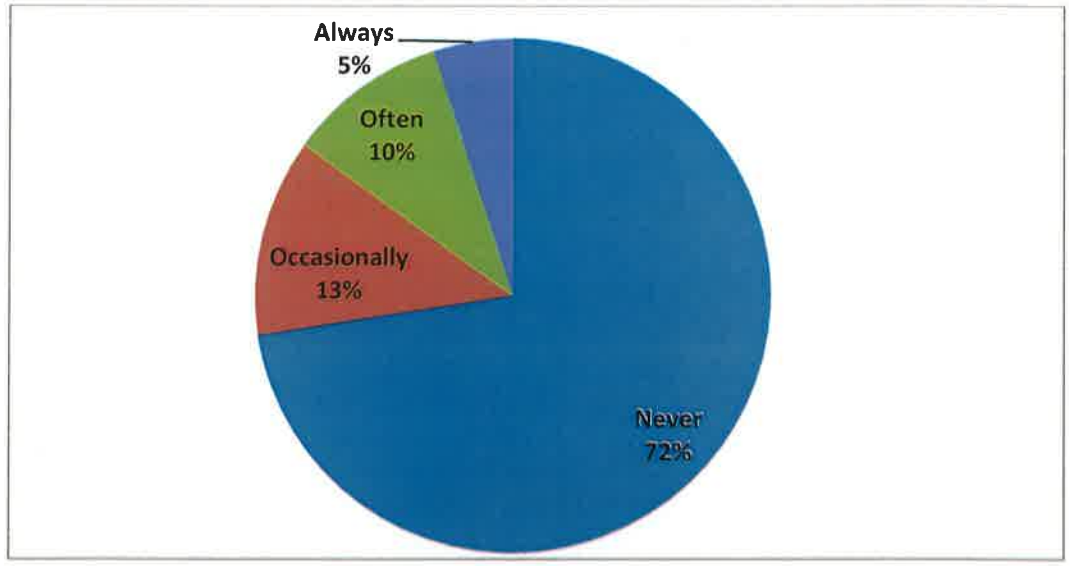

As shown in the figure above, around 58% of the respondents agreed that they travel alone in Car and 33% were with another occupant in car occasionally. It can be seen that people mostly travel alone in the car leading to impact on carbon emissions.

**Figure 6-13: Usage of Solar Energy in Electrical Appliances**




Around 72% respondents have never used the solar appliances and 5% were found using solar appliances. Interestingly around 13% used them occasionally and 10% were using it quite often.

**Figure 6-14: Usage of Treated Waste Water for Domestic Purpose**




Around 72% respondents never used the treated waste water for domestic use purpose and 5% were found using waste water for daily purposes at home. However as shown in figure below, around 61% of respondents were willing to pay for better infrastructure initiatives/ provision.

**Figure 6-15: Willingness to Pay for betterment of Infrastructure**

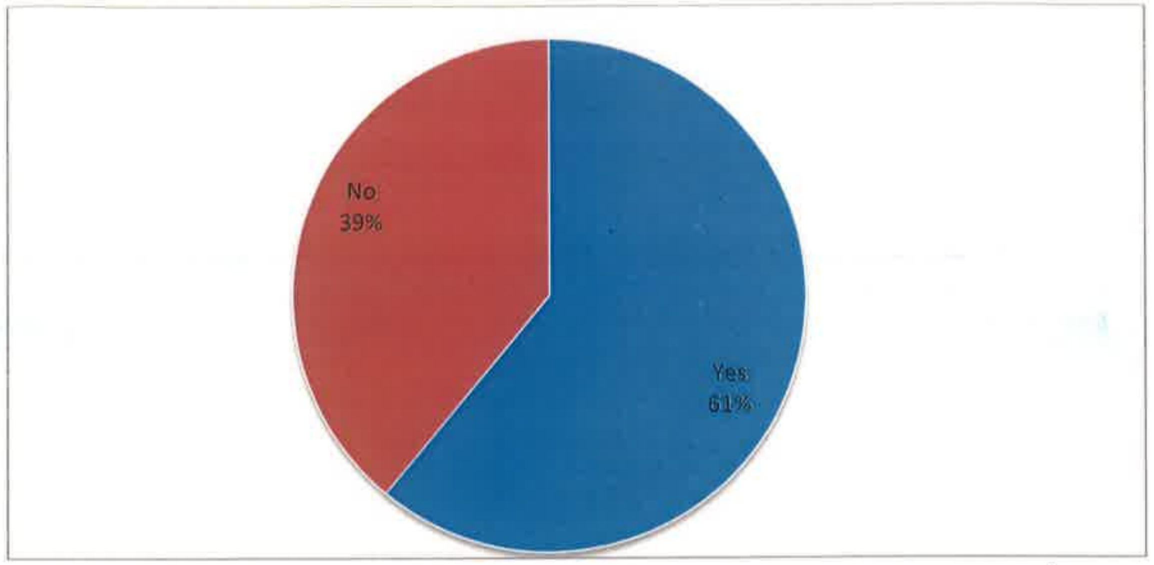
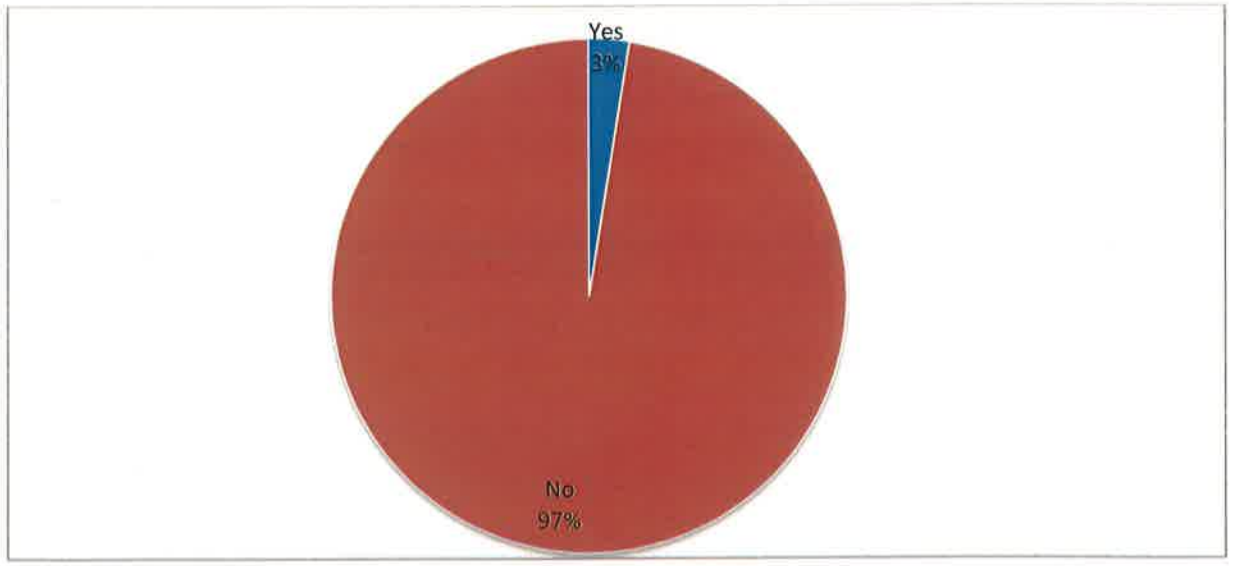
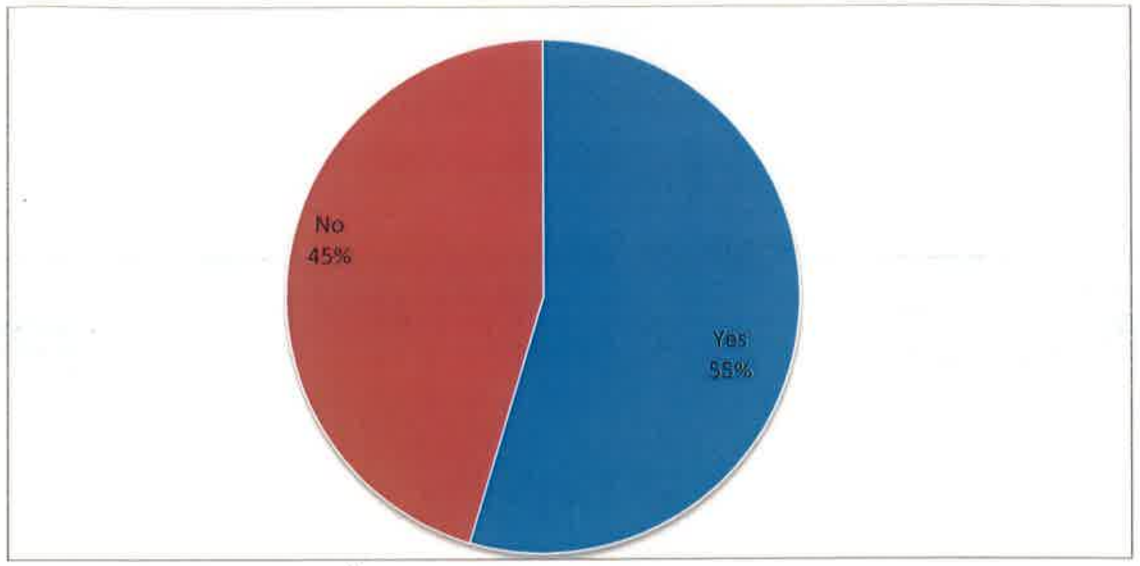



**Figure 6-16: Practicing Rain Water Harvesting at House**




It was found that around 97% respondents were not practicing the rain water harvesting at their households. It was also observed that around 55% of the respondents were aware about their RWA's work towards clean energy initiatives. Since housing societies are comparatively new, it has started taking place but in other areas, the individual households have not gone for this on a large scale.

**Figure 6-17: Response on RWA's work towards Clean Energy**




### 6.4.2 Household energy consumptions

During the survey, data on important aspects as identified by the questionnaire were collected from household members. The data attributes included both quantitative and qualitative aspects such as: age, education level, and socio-economic characteristics of households' members, number, type and usage of electrical appliances, as well as the information related to behaviour, awareness and knowledge level on energy efficiency.

The focused Group Discussions in the localities and survey through face-to-face interviews helped in identification of the factors influencing the electricity consumption in households. Also, it helped in knowing the behaviour, attitude, and knowledge of the members of different group housings surveyed within the scope of this study. Electricity consumption for each housing group was estimated by multiplying the appliance' wattage[26] with the time (hours) of its usage. The wattage of electric appliances was considered as an average value for the appliances as the required details (wattage and model numbers) of each appliances used by surveyed members was not available. Some of the assumptions have been taken related to social aspects such as wattage for washing machine was considered differently: semi-automatic for LIG and MIG while fully-automatic for HIG. As it can be seen in Table 6-6, households were found differing greatly from each other with various characteristics. The highest reduction in electricity consumption was observed in MIG and HIG houses which use large number of electric appliances and also have relatively higher income.

[26]*World Bank, (2008). Residential consumption of electricity in India.*

**Table 6-5: Different characteristics of group housing societies surveyed**

| Group housing | Average income (INR/month) | Electricity consumption (kWh/month) | Number of electric appliances | Per capita consumption (kWh/day) |
|---|---|---|---|---|
| LIG | 23400 | 255.70 | 12 | 2.13 |
| MIG | 28207 | 303.48 | 21 | 4.17 |
| HIG | 58500 | 603.16 | 28 | 7.56 |

Most of respondents in all three group housings showed willingness to reduce electricity consumption but chief motivation for this was the perceived economic benefits. Only some of the members showed environmental benefits as a motivation to change their routine habits of electricity consumption. Usually people were willing to take on energy efficiency activities to an extent that require small investment of financial resources, for instance switching to energy efficient lights (LEDs). The households' members were not willing to invest large amount of their financial resources in achieving energy efficiency. Though most of the residents were willing to uptake energy efficient activities on economic incentives, they were not thoughtful of taking care of environment and indicated that government bears the greater responsibility. However, the perception of people towards using the renewable energy sources substituting the electrical appliances such as solar water heaters, solar lights were relatively positive but they appeared to be inquisitive of knowing the payback period of investment in renewable energy sources.

Some more responses to various questions are given below:

***Are you aware of any government initiative on Clean Energy (such as Solar Energy/ Devices) in your area?***

| Yes | No | No Response |
|---|---|---|
| 58.75 | 26.25 | 15 |

***Are you using***

| LED | CFL | Both |
|---|---|---|
| 26.25 | 47.5 | 26.25 |

***Are you using any appliances in home which uses solar energy?***

| Yes | No | No Response |
|---|---|---|
| 0 | 86.25 | 8.75 |

***Is any Waste to Energy conversion Plant/ initiative being practised by your RWA?***

| Yes | No | Not aware |
|---|---|---|
| 17.5 | 58.75 | 21.25 |

***Whether using solar energy in day-to-day usage of electric appliances***

| Never | Occasionally | Often | Always | No response |
|---|---|---|---|---|
| 88.75 | 2.5 | 5 | 0 | 3.75 |

***Whether the RWA in your society is working towards Clean Energy***

| Yes | No | Not aware |
|---|---|---|
| 51.25 | 42.5 | 6.25 |

***Whether willing to pay for the betterment of infrastructure***

| Yes | No | No response |
|---|---|---|
| 58.75 | 37.5 | 3.75 |

## 6.5 Conclusions from the Primary Surveys

Electric and Electronic appliances are the major contributor of energy consumption in households in which TV, Single Door Refrigerator, Ceiling Fan, Washing Machine, Geyser and Iron Box are the prominent one. It was found that electronic items like (T.V, Home theatre, DVD player, and Mixer grinder) do not contribute to a large extent. This is because of the fact majority of the households i.e. more than 50% of the households do not have these electronic items. More than 70% of the households have single door refrigerator in which more than 65% of the households have a usage for a whole day. Refrigerator plays a critical role in releasing CFC which is a major source of Greenhouse gas emission therefore it is a major concern of consideration. It was also found in the primary survey that many households of all the colonies do not have four-wheelers, majority of the households have two-wheelers.

The consumption of electricity is considerably more in MIG and HIG households which is understandable as type of electrical gadgets is more and varied there. Similarly, HIG and MIG houses are using their personal vehicles including four and two wheelers leading to increased use of fossil fuels. However, the use of solar panels and related gadgets are being used by such households in greater proportions as compared to LIG households. Interestingly, majority of households are willing to contribute towards energy efficient gadgets across the types of households.

The respondents were of the view that the government agencies should publicize more about the steps that can be taken at the household level to reduce energy consumption. Recent drive by government to convert normal bulbs to CFL through subsidy were appreciated and many people bought them to save on future spending on their electricity bills. People are also in general willing to contribute towards purchase of energy efficient appliances, however the awareness about such thing is presently low. For example, one respondent purchased a 3 star rated Air conditioner for his home because it was cheaper and he was not aware about the options. Most of the people talked to, did not look for energy efficiency when buying items like washing machine or hair dryer, though some cared for it while buying items which display energy efficiency ratings on a prominent place on the product.

Some of them expressed opinion that the government agencies should interact with population to tell them the advantages of energy efficiency or apprise them about the measures being taken. For example, many respondents were aware that Dehradun has been selected for Solar City Mission as they had read about it in newspapers but they were not aware about its features. It seems, particularly in this case, the agency has already received a lot of applications for assistance under the programme, so it is not being proactive as the budgets might be lower for assistance. The *Nagar Nigam* has taken some initiatives like going for waste management, which was absent till now or change of bulbs on Chakrata Road but public is not aware about the planning. Since a lot of agencies are involved which can help induce energy efficiency in provision of services to the citizens, a concerted effort may be planned at the city level to effectively engage the citizens in this endeavor.

# CHAPTER 7- GUIDELINES FOR ACHIEVING ENERGY EFFICIENCY IN DEHRADUN-DERIVED FROM THE SITE ANALYSIS

The present study has attempted to explore the energy saving potential that can be attained with the targets of solar city mission for Dehradun city and potential reduction in energy consumption from the behavior change of the residents. The highly optimistic scenario having energy saving potential of 20% attributed to both technical and behavioral change was found giving GHG savings up to 77 tonnes and 103 tonnes for 2021 and 2031, respectively.

The available technological interventions to ensure reduction of the ecological footprint have been explored and are presented in this chapter. Following these measures in our daily life, a check could be put on the increasing carbon emissions. It is imperative to promote improvement in energy efficiency in residential sector for leading to a reduction in GHG (greenhouse gas) and a reduction in the incidence of fuel dependence.

For creating awareness amongst the various stakeholders within the city to improve energy efficiency, the following section of the report outlines the various measures that could be adopted for bringing down the energy demand in the residential sector.

## 7.1 Recommendations for curtailing energy demand in Residential Sector

Energy is one of the most important building blocks in human development, and, as such, acts as a key factor in determining the economic development of all countries. In an effort to meet the demands of a developing nation, the Indian energy sector has witnessed a rapid growth. Areas like the resource exploration and exploitation, capacity additions, and energy sector reforms have been revolutionized.

However, resource augmentation and growth in energy supply have failed to meet the ever increasing demands exerted by the multiplying population, rapid urbanization and progressing economy.

Almost all residential buildings in India have areas of energy waste that can be greatly reduced by practical, energy–efficient upgrades. In a number of cases, enrichments to energy systems can improve comfort and productivity, as well as save energy and money. It is to highlight that the Energy efficiency measures do not operate in isolation from one another. Here we discuss key energy efficiency measures, and how it is linked with efficient performance for the long term.

## 7.2 Achieving Energy Efficiency

### 7.2.1 Technological

The following sections tries to outline the ways in which the GHG could be reduced in the Residential Sector:

#### *7.2.1.1 Street Lighting Energy Efficiency Programme has high potential of energy savings (20-25 per cent)*

- 100 per cent timer-based operation and installation of power saver
- Performance-based contracts for street lighting maintenance
- Design-based street lighting and LEDs for traffic signals
- Use of energy efficient fixtures

#### *7.2.1.2 Building and Facilities Energy Efficiency Programme*

- Implementation of measures for lighting and fans such as micro controller for lights and fans, occupancy sensors, capacitors bank daylight sensors with dimmable ballast, electronic ballast and tri-band phosphor tube lights, etc.
- Energy auditing

#### *7.2.1.3 Pumping System Efficient Projects for water supply and drainage pumping stations*

Efficient water supply with reduced losses due to leakage can save 14% and 21% energy consumption attributed to treatment and supply of municipal water are projected for the year 2021 and 2031, respectively. This translated into GHG emissions saving potential of 77 tonnes and 91 tonnes for the scenario of reducing water supply losses by 50% (ALT-I) and 25% (ALT-II), respectively as compared with the BAU scenario. These projections have been made with the assumptions aligned with the objectives of AMRUT Mission for making Dehradun a Smart City. Following recommends emerge from our study:

- Proper pump system design (efficient pump, pump heads with system head)
- Water and Energy Audit to reduce UFW
- Installation of power saver and variable speed driver
- Power factor improvement, e.g. installation of capacitors, etc.

#### *7.2.1.4 Residential/Commercial and Industrial Sector*

- Solar water heating system for buildings



ouseholds replacing at
the next five years

figure

es, etc.

out renewable energy
ere willing to pay for
ings and not for the

rgy and energy

d energy efficiency

ncies would anticipate
reasing the residents'
of how to save energy
activities. This directly
growth of residential
nticipated in exploring

dic surveys should be
entions undertaken by
onal level residential
lines. This would help
nption with fairly high

lic parks

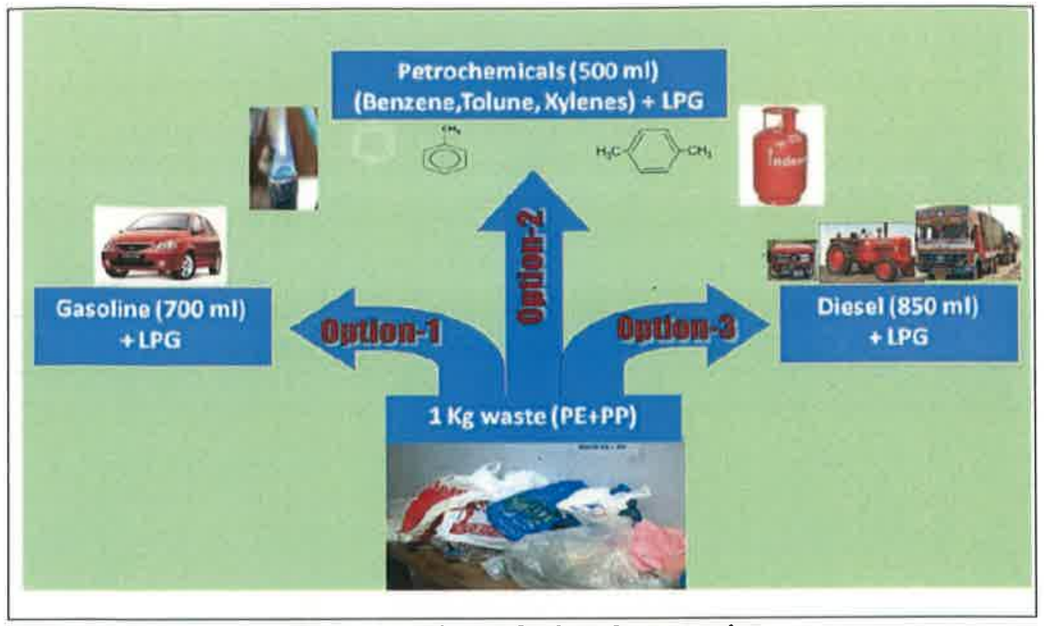
esel consumption

- Solar AC system in hospital buildings
- Solid waste management (composting, bio-methanisation, etc.)

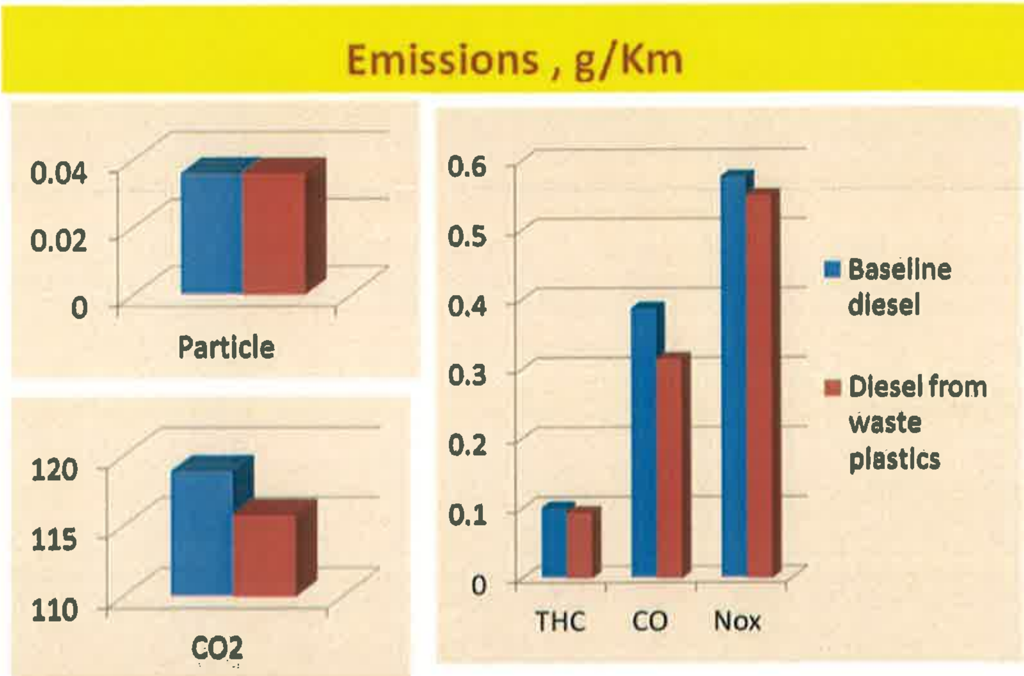
#### *7.2.1.9 Waste to Energy*

**Table 7-1: Waste plastics to fuel and aromatics (CSIR-IIP-GAIL Process)**

| | | |
|---|---|---|
| 1. | Title of Product/Design/Equipment | Technology for converting waste plastics to gasoline, diesel and aromatics |
| 2. | IPR Status Patent/Copyright/Trademark secured in Indian/Abroad IPR Details | Indian Patent application |
| 3. | Application/Uses | To convert waste plastics to either gasoline or diesel or aromatics alongwith LPG |
| 4. | Salient Technical Features including Competing Features | • Exclusive production of either gasoline or diesel or aromatics alongwith LPG<br>• Gasoline and diesel meeting Euro III/IV fuel specification<br>• Utilization of polyethylene and polyuproylene type waste plastics<br>• No toxic commissions |
| 5. | Level/Scale of Development | • Developed bench scale, capacity 7-10 Kg/hr<br>• 1 TPD demo unit proposed to be set up |
| 6. | Environmental Consideration | • A major portion of the waste plastics, which are hazardous to environment can be utilized to obtain valuable petroleum products<br>• Process is completely environment friendly |
| 7. | Status of Commercialization | Commercialization to be taken up after setting p of 1 TPD demo unit |
| 8. | Major Raw Materials to be Utilized | All types of waste polyetheylene and polypropylene |
| 9. | Major Plant Equipment and Machinery Required | Reactors, Heat Exchangers, Column |
| 10. | Techno-Economics | To be evaluated |
| 11. | Technology Package | Would be available after setting up of demo unit |
| 12. | Contact Details | 0135-2525794 |
| 13. | Photograph | |




**Waste plastics to fuel and aromatics**




**Engine Tests with diesel obtained from waste plastics**

Conclusively, this study has highlighted two main aspects for further scope of the work. First is behavior related change in energy consumption patterns which has not yet come into mainstream research in the area of energy efficiency and has the significant saving potential as indicated by some of the studies reported from other parts of the world. Second aspect is related to technology and joint effort of institutional bodies from government and non-government fronts. For instance Bureau of Energy Efficiency can collect and provide data on sale of different energy-star rated appliances and distribution companies (DISCOMs) can collect and provide chronological data on electricity consumptions patterns of residential consumers (classified into categories like rural and urban consumers). Availability of such data can equip the researchers to assess the future energy demands with high accuracy and also in assessing the efficacy of any implementation program. Consequently, more specific policy actions can be taken based on the integrated assessment of the energy efficiency at city level which can be used as reference for other cities as well.

## 7.3 Points for consideration for HUDCO while Funding Projects

HUDCO has taken up several projects in Dehradun. During discussions with the officials at HUDCO regional office in Dehradun, it was observed that HUDCO seeks clearances from the Central Pollution Control Board for getting approval of urban development projects. It is to also highlight that there is no State level Environmental Committee at present in Uttarakhand for scrutinizing the urban development and infrastructure related projects. Projects are sent to Central Pollution Control Board for clearances which included Environmental Impact Assessment. HUDCO funds only those projects which are cleared by CPCB. The Annexure 4 indicate role of HUDCO regional office in development of the Dehradun area.

## 7.4 HUDCO's Role in Promotion of Energy Efficiency

As a techno financing institution of government of India, HUDCO has to support its borrowing agencies to promote energy efficiency in their respective jurisdiction. As emerges from the study, a few important areas deserve special attention namely Development of Green Buildings and Neighborhoods, Energy efficient Transport system and Waste Management. HUDCO's actions in this regard will cover technical support / financing and capacity building in respective areas.

1. Technical/financing support will include a line of credit for technical upgradation towards public transport, waste treatment plants/collection mechanism and centres.
2. A separate line of credit on energy efficiency may be initiated with necessary support from government of India and respective provincial governments.
3. In this regard, Viability Gap Funding (VGF) may also be included in a participatory manner covering a tripartite support from Centre, province and local bodies.
4. The housing and real estate projects funded by HUDCO need to give special focus on green buildings i.e. use of renewable energy, rain water harvesting, water recycling, segregation/processing of Garbage at source and use of LED lights etc. These projects may also include vertical farming as applied by couple of cities such as New Delhi, Hyderabad etc.
5. HUDCO appraisal systems for housing and real estate projects should give due cognizance to promotion of energy efficiency through Landscaping, Ratio of built and open spaces, orientation, location of water bodies, Building envelop, Controlled ventilation, Energy efficient doors and windows, High efficiency heating and cooling system and pitched roofs
6. The capacity building will cover research and training through HSMI and network of HUDCO Chair institutions.
7. A series of case studies on focus areas as above such as waste management in Bengaluru, *Janmarg* of Ahmedabad, Sabarmati River front Development in Ahmedabad, lake development in Hyderabad and Bengaluru etc. may be documented for dissemination among stakeholders.

8. Energy efficiency should be taken up on recent innovations as applied in and around Dehradun covering Waste to energy without segregation, gasification technology
9. A detailed plan of action on above points may be included in the training and research agenda of HUDCO.
10. Further, as part of CSR (Corporate Social Responsibility of HUDCO may initiate couple of demonstration projects to achieve energy efficiency through efficient transport system and waste management giving due cognizance to energy efficiency.

These initiatives as explained above covering residential sector and energy efficiency in municipal services will go a long way to create demonstration effect and sensitise stakeholders to replicate energy efficiency in a wider sense.

# REFERENCES


- Government of India, Ministry of Environment and Forests (2009), India's GHG emissions profile, Results of Five Climate Modelling studies'
- Anderson, J. E., Wulfhorst, G., Lang, W. (2015). Energy analysis of the built environment—A review and outlook. *Renewable and Sustainable Energy Reviews*, *44*, 149-158.
- CDP (2007). City Development Plan Dehradun. Available at: jnnurmmis.nic.in/toolkit/CDP_DEHRADUN.PDF (Accessed on October 23, 2017).
- CEA (2016). $CO_2$ Baseline database for the Indian power sector.
- CGWB (2011). Ground water brochure Dehradun, Uttarakhand. Available at: www.cgwb.gov.in/District_Profile/Uttarakhand/Dehradun.pdf (Accessed on October 15, 2017).
- Cheng, H., Hu, Y. (2010). Planning for sustainability in China's urban development: Status and challenges for Dongtan eco-city project. *Journal of Environmental Monitoring*, *12*(1), 119-126.
- CPCB (2011). Status report on municipal solid waste management. Available at: www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdf (Accessed on October 12, 2017).
- Draft Master Plan of Dehradun (2025).
- GBPN, (2014). Residential Buildings in India: Energy Use Projections and Savings Potentials.
- Government of India, Ministry of Environment and Forests, (2009) 'India's GHG emissions profile, Results of Five Climate Modelling Studies'
- Indiastat, (2014). Transmission and Distribution Losses as Percentage of Availability of Power in Uttarakhand, 2007 -2014. Power & Energy Division, Planning Commission, Govt. of India.
- Keirstead, J., Jennings, M., Sivakumar, A. (2012). A review of urban energy system models: Approaches, challenges and opportunities. *Renewable and Sustainable Energy Reviews*, *16*(6), 3847-3866.
- Kenworthy, J. R. (2006). The eco-city: ten key transport and planning dimensions for sustainable city development. *Environment and urbanization*, *18*(1), 67-85.
- MNRE, (2014). Background paper on solar cities. Available at: mnre.gov.in/file-manager/UserFiles/Bakground_Paper_on_Solar_Cities.pdf
- MoEF, (2014). Low carbon lifestyles toolkit.
- MOSPI. (2017). Energy Statistics 2017 (Vol. 22). New Delhi: Central Statistics Office, MOSPI.
- MSME Uttarakhand, 2014. Brief industrial profile of state. Available at dcmsme.gov.in/dips/state_wise_dips/SIPSR%20-%20Uttarakhand.pdf (Accessed on October 15, 2017).
- Ministry of Power. (2015). 24x7 Power for all Uttarakhand, A joint initiative by Government of India and Government of Uttarakhand. Available at: powermin.nic.in/sites/default/files/uploads/Uttarakhand_24x7-PFA_Final_Doc_14_Sep_15.pdf
- Plappally, A. K., Lienhard V, J.H., (2012). Energy requirements for water production, treatment, end use, reclamation, and disposal. Renewable and Sustainable Energy Reviews, 16(7), 4818-4848.
- Poznaka, L., Laicane, I., Blumberga, D., Blumberga, A., Rosa, M. (2015). Analysis of electricity user behavior: case study based on results from extended household survey. Energy Procedia, 72, 79-86.
- Prayas (Energy Group), 2016. Residential Electricity Consumption in India: What do we know?
- Rawat, M., Ramanathan, A. L. (2011). Assessment of methane flux from municipal solid waste (MSW) landfill areas of Delhi, India. *Journal of Environmental Protection*, *2*(4), 399-407.
- Tiwari, K., Khanduri, K., (2011). Land Use / Land cover change detection in Doon valley (Dehradun Tehsil), Uttarakhand: using GIS & Remote Sensing technique. *International journal of geomatics and geosciences*, 2(1), 34-41.

— Shukla, Y., Shnapp, S., Rawal, R., (2015). Residential buildings in India: Energy use projections and savings potentials. *European Council for an Energy Efficient Economy (ECEEE) Summer Study Proceedings*, 1193-1206.

— Song, Y., (2011). Ecological city and urban sustainable development. *Procedia Engineering*, *21*, 142-146.

— Solar City Master Plan Dehradun, (2012).

— World Bank, (2008). Residential consumption of electricity in India. A background paper on India: strategies for low carbon growth

— Wu, Kang Li., Kuo, Hsing-Ping., (2005). Marketing eco-community under the Trend of Globalization: A study of Taiwan experience. Available at: eshare.stust.edu.tw/EshareFile/2009_12/2009_12_7f2b65b7.pdf (Accessed on October 12, 2017).

— Yu, L., (2014). Low carbon eco-city: New approach for Chinese urbanisation. *Habitat International*, *44*, 102-110.

— 2011, C., 2011. What is literacy rate of Dehradun district ?. [Online] Available at: http://www.census2011.co.in/questions/578/district-literacy/literacy-rate-of-dehradun-district-2011.html [Accessed 28 December 2017].

— Asia, I.-S., 2009. Energy and Carbon Emissions Profiles of 54 South Asian Cities. [Online] Available at: http://e-lib.iclei.org/wp-content/uploads/2015/04/Energy-and-Carbon-Emissions-Profiles-for-54-South-Asian-Cities.pdf [Accessed 28 December 2017].

— Bank, W., 2013. CO2 emissions (metric tons per capita). [Online] Available at: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2013&start=2013&view=map&year=2013 [Accessed 27 December 2017].

— BP, 2017. Energy Economics, Statistical Review. [Online] Available at: http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html [Accessed 28 December 2017].

— Change, U. N. C., 2017. Global Warming Potentials. [Online] Available at: http://unfccc.int/ghg_data/items/3825.php [Accessed 28 December 2017].

— Inventories, I. G. f. N. G. G., 2006. CHAPTER 3-SOLID WASTE DISPOSAL. [Online] Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf [Accessed 28 December 2017].

— Investment Program Management Unit, U. D. D. G. o. U. (., 2012. India: Uttarakhand Urban Sector Development Investment Program – Project 1. [Online] Available at: https://www.adb.org/sites/default/files/project-document/73074/38272-023-ind-rp-01.pdf [Accessed 28 December 2017].

— MoNRE, 2017. Solar/Green Cities. [Online] Available at: http://mnre.gov.in/schemes/decentralized-systems/solar-cities/ [Accessed 27 December 2017].

— ToI, 2013. Recipe for disaster in Uttarakhand: 1 crore population, 2.5 crore tourists. [Online] Available at: https://timesofindia.indiatimes.com/india/Recipe-for-disaster-in-Uttarakhand-1-crore-population-2-5-crore-tourists/articleshow/20721226.cms [Accessed 27 December 2017].

— ToI, 2015. Innovative waste disposal plant will generate electricity. [Online] Available at: https://timesofindia.indiatimes.com/city/dehradun/Innovative-waste-disposal-plant-will-generate%20electricity/articleshow/47680503.cms [Accessed 28 December 2017].

# Annexure

***Annexure 1***

Officials contacted during various primary and secondary surveys in Dehradun:

| Sr.No | Name of Official | Designation | Contact No | Department/ Agency |
|---|---|---|---|---|
| 1 | Shri Manish Pant | IT Officer | 7579068418 | Nagar Nigam, Dehradun |
| 2 | Shri Bhawar Chand | Office Assistant to Senior Municipal Health Officer | 0135-2714074 | |
| 3 | Shri. Dharmedra P | Tax superintendent | 9411714615 | |
| 4 | Shri Anuj | PS to the Commissioner | 0135-2714074 | |
| 5 | Shri Jagdish Rawat | Admin officer | 0135-2768895 | Uttarakhand Power Corporation Ltd |
| 6 | Mr Virendra | PS to Managing Director | 0135-2768895 | |
| 7 | Ms Anjula Singh | Junior Engineer | 0135-2768895 | |
| 9 | Dr V Shanmugam | Vice Chairman | 0135-6603102 | Mussorie Dehradun Development Authority |
| 10 | Ms Geeta Khulbe | Town Planner | 0135-6603102 | |
| 11 | Shri Jagmohan Dutt | Transport Planer | 9761272724 | |
| 12 | Ms Anuja Singh | Under Secretary | 8006406505 | |
| 13 | Ms Asfa Siddiqui | Urban Planner | 0135-2524188 | Indian Institute of Remote Sensing |
| 14 | Ms Lakshmi Shah | Junior Engineer | 7500026979 | Uttarakhand Pey Jal Nigam |
| 15 | Ms Neelima Garg | General Manager | | |
| 16 | Shri Sooth | Admin officer | 8006406506 | Mussorie Dehradun Development Authority |
| 17 | - | Dy General Manager | 0135- 2521553 | Uttarakhand Renewable Energy Development Agency |

*Annexure 2*

Agencies providing various infrastructure services in Dehradun:

| Urban Infrastructure/ Services | Planning and design | Construction / Implementation | O & M |
|---|---|---|---|
| Water and Sanitation | UPJN, UJS | UPJN, UJS | UJS |
| Sewerage and Drainage | (small projects) | (small projects) | UJS |
| Solid Waste Management | UPJN, UJS | UPJN, UJS | DNN |
| Urban Transport (Roads) | (small projects) | (small projects) | PWD, MDDA, |
| Urban planning and town planning | DNN | DNN | DNN |
| Pollution | State Pollution Control Board | | |
| Renewable Energy | Uttarakhand Renewable Energy Development Agency (UREDA) | | |
| Electricity | Uttarakhand Power Corporation Ltd (UPCL) | | |
| Transport | Regional Transport Office | | |

UPJN: Uttarakhand Pey Jal Nigam
UJS: Uttarakhand Jal Sansthan
DNN: Dehradun Nagar Nigam
PWD: Public Works Department
MDDA: Mussoorie-Dehradun Development Authority

### HUDCO's Role in Development of Dehradun Area

HUDCO regional office at Dehradun plays a significant role in the development of the city and adjoining areas. For successful commencement, execution and completion of the projects the HUDCO office is very helpful due to the following reasons.

- HUDCO provides for Viability Gap Funding under central Sponsored Project i.e. PMAY, AMRUT, Inter City Metro project etc.
- HUDCO also provides financial assistance for State Government Flagship Projects i.e. River Front Development, Multi-level Parking Facilities, Social Infrastructure projects i.e. Reorganization/ Augmentation of water supply schemes, Sewerage & City Roads, etc.
- Development of infrastructure Inter-city Road, development of State Highways, MDR, ODR, Village Road with Bye-pass and ROB /RUB's.
- Funding of composite Housing Scheme of Various Development Authorities.

As could be seen from the table below that HUDCO finances primarily in the housing sector in Dehradun through MDDA.

**Annexure Table 1: Status of projects funded by HUDCO at present in Dehradun (figures in Rs. in Crores)**

| Sr No | Scheme Name/ Agency | Loan Sanctioned | Loan Released | Gap | Remark |
|---|---|---|---|---|---|
| 1 | Construction of Housing Scheme at Transport Nagar, Dehradun/ MDDA | 50.00 | 42.00 | 8.00 | Scheme is in progress |
| 2 | Integrated Affordable Housing Scheme at Aamwala Tarla, Dehradun Land /MDDA | 102.83 | 20.00 | 82.83 | Scheme is in progress |
| 3 | HIG Housing Scheme for 338 DU's Near ISBT, Dehradun / MDDA | 72.00 | 20.00 | 52.00 | Scheme is in progress |
| 4 | Land Acquisition under Land Pooling with Peripheral Infrastructure Development for Housing and Housing related infrastructure works at Dehradun / MDDA | 400.00 | 0.00 | 400.00 | Sanctioned on 28/02/2017 |

***Source:*** *HUDCO Regional office, Dehradun*

The table below outlines the loan disbursement status of various projects funded by HUDCO and likely to receive funding in 2017-18.

## Annexure Table 2: Projects expecting disbursement by HUDCO in Dehradun during 2017-18

| Sr No | Scheme Name/ Agency | Undisbursed Loan Amount | Expected disbursement |
|---|---|---|---|
| 1 | Construction of Housing Scheme at Transport Nagar, Dehradun/ MDDA | 8.00 | 8.00 |
| 2 | Integrated Affordable Housing Scheme at AamwalaTarla, Dehradun Land /MDDA | 82.83 | 31.41 |
| 3 | HIG Housing Scheme for 338 DU's Near ISBT, Dehradun / MDDA | 52.00 | 40.00 |
| 4 | Land Acquisition under Land Pooling at Dehradun /MDDA | 400.00 | 100.00 |

***Source:*** *HUDCO Regional office, Dehradun*

The table below highlights the various projects which are in pipeline for funding by the HUDCO for the year 2016-17.

## Annexure Table 3: Major Proposals for funding by HUDCO in Pipeline for 2016-17

| S. No. | Name of Scheme | Project Cost | Loan Amt. | Present Status |
|---|---|---|---|---|
| 1 | Construction of colony at 132KV substation at Majara, Dehradun | 90.85 | **63.60** | Mission team Constituted |
| 2 | Construction of Separate building for SLDC at 132KV substation at Majara, Dehradun | 15.93 | **11.15** | Mission team Constituted |

***Source:*** *HUDCO Regional office, Dehradun*

***Annexure 4***

**Indian Institute of Public Administration, I.P.Estate, New Deli-110002**

Research Project on *Energy Efficiency in Eco cities – Dehradun, May 2017*

**Questionnaire**

1 Name of Enumerator :
2 Name of the Head of the Household:
3 Address and contact no. :
4 Ownership of the house : Rented/ Owned
5 Area of House :
6 Provision of Rain water Harvesting Yes ☐ No ☐
7 Type of Unit : 1BHK ☐ 2BHK ☐ 3BHK ☐
8 Age of the Building : ☐ years
9 Household Information

| Age | Sex | Educational Qualification | Occupation | Monthly Income | Daily Commute (in Km) | Mode of Travel | Travel Time |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

10 Source of Water : Municipal/ Hand Pump/ Tankers/ Bore Wells/ Well/others/
11 Whether the connection is Individual ☐ / Community ☐
12 Whether you are using water pumping motors : Yes ☐ No☐
12.1 Duration for which MOTOR runs: ☐ hours
13 Water consumption per day in litres :
14 Frequency of water supply (in hours) :
15 Quality of water : Good ☐ Average ☐ Bad ☐
16 Whether you are purifying the water, type of the purifier : Yes ☐ No☐
16.1 If Yes, then how you purify: RO system ☐ UV system ☐ Simple water filter☐
17 Amount of Solid Waste generated per day by your house : _______________(in grams)
18 Average monthly electricity consumption in units (based on your electricity bills):
Nov'16_______; Dec ' 16_______ Jan'17_______; Feb ' 17_______ Mar'17_______; April' 17_______
19 Are you aware of any Government Initiatives on Clean Energy (such as Solar Energy/ Devices) in your area_______________________________________________
___
20 Are you using LED ☐ CFL ☐

21 What are the daily activities you undertake which show your Awareness on Energy Efficiency

21.1 ____________________

21.2 ____________________

22 Cooking fuel and the usage – No. Of Gas cylinder usage per month : ☐

22.1 Other cooking fuels being used , if any......

23 Are you using any appliances in home which uses Solar energy: ........................................

24 Is any Waste to Energy conversion Plant/ initiative being practised by your RWA____________________

25 Have you got benefit from the Ujjwala scheme initiated by the Prime Minister office. : Yes ☐ No ☐

25.1 If yes, How much Energy efficiency you achieved, please tell reduction in Monthly Electricity bill ( based on electricity consumption pattern)____________________ .

26 No. of other electric and electronic appliances and their type, capacity and usage in hours per day

| | SUMMER | | WINTER | |
|---|---|---|---|---|
| **Electrical Appliances (Used in Bedroom, Kitchen, living Room & Bathroom)** | No. | Usage (Hours /Day) | No. | Usage (Hours /Day) |
| Home Theatre | | | | |
| DVD Player | | | | |
| Microwave Oven | | | | |
| Juicer Grinder | | | | |
| Electric Cooker | | | | |
| Induction stove | | | | |
| Refrigerator | | | | |
| Vacuum Cleaner | | | | |
| Computer | | | | |
| Printer | | | | |
| Hair Dryer | | | | |
| Fan | | | | |
| Generator | | | | |
| Inverter | | | | |
| Dish washer | | | | |
| Washing Machine | | | | |
| Geysers | | | | |
| Electric Iron | | | | |
| Tube light | | | | |
| Incandescent bulbs/ Tube lights | | | | |
| CFL | | | | |
| LED | | | | |
| Halogen | | | | |
| Radiant Heater | | | | |
| Convection Heater | | | | |
| Oil Filled Radiator | | | | |
| Television | | | | |
| AC | | | | |
| Air Cooler | | | | |
| others | | | | |

27 Willingness to pay for renewable energy instruments (Rs per month)

0-50 ☐ 50-100 ☐ 100-150 ☐ 150-200 ☐

28 Vehicle ownership (Nos) : Car ☐ / Two Wheeler ☐ / others ☐

29 Average vehicle running distance per day: CAR ☐ kms, Two- wheeler ☐ kms

30 How often do you drive in a car with someone else : Never ☐ Occasionally ☐ Often ☐ Always ☐

31 How far do you travel by public transport in a week ☐kms

32 Whether Using Solar Energy in Day to Day use of Electric Appliances :
Never ☐ Occasionally ☐ Often ☐ Always ☐

33 Whether using Treated waste water for Domestic purpose :
Never ☐ Occasionally ☐ Often ☐ Always ☐

34 Whether willing to pay for the Betterment of infrastructure ☐ Yes ☐ No

35 Method of Solid waste collection :

____________________________________

36 Whether Rain water harvesting being practised in your house: ☐ Yes ☐ No

37 Whether the RWA in your society is working towards Clean Energy

38 Any other extra information recorded by the investigator/ survey enumerator: