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Ajmer Solar City Master Plan

Submitted to:



Ajmer Municipal Corporation

Supported by



Ministry of New and Renewable Energy

Government of India, New Delhi

Prepared and Submitted by:



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PROJECT INFORMATION

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Final Approver

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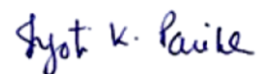
Preface

Rapid urbanization, economic prosperity and changing lifestyles have led to increased use of natural and fossil fuel resources. This has led to a rapid increase in exploitation of the earth's resources, resulting in severe climate change phenomenon around the globe, country and even at local level. Rajasthan faced some of the worst floods and mosquito borne disease outbreaks resulting in severe economic and health related losses. To mitigate effects of climate change Governments across the globe have pledged to reduce these impacts through INDC's of the UNFCCC, more recently signed and ratified in the CoP21 Paris agreement and also by meeting SDG's of the UN.

In India the Ministry of New and Renewable Energy has been promoting renewable energy interventions at grass root level and at MW scale in Solar, Wind, Biomass and Waste to energy and Bureau of Energy Efficiency has been promoting energy efficiency and star ratings in households and industry. These Departments coupled with other Ministries like MoP, MoPNG, MoUD, MoRTH, have taken substantial steps in promoting renewable energy, energy efficiency and urban renewal to cope with ever increasing multi sectoral stresses on our cities.

IRADe was awarded the work of preparing the solar city Master plan of Ajmer City in April 2016 by Ajmer Municipal Corporation after Ajmer was designated as part of the Smart City Program of MoUD. IRADe officials made several visits to Ajmer city to have project initiation meetings, MoU signing and primary data collection from relevant officials, important site visits of Ajmer city to develop a holistic solar city plan.

I would like to thank IRADe staff for their dedication to this work. Our heartiest thanks to Ajmer municipality for awarding this work and their Co-operation during execution of this work. We hope that it will be fully implemented by the AMC.



Dr. Jyoti Parikh

Executive Director

Acknowledgement

IRADe acknowledges the support and help it received from various organisations, departments and senior officials of the Government of Rajasthan.

We thank AMC, AVVNL, IOCL, HPCL, BPCL, DSO, DIC, RIICO, and ADA for the support, cooperation and help in data collection for the report.

We would especially like to thank **Sh. Dharmendra Ji Gahlot**, Mayor, **Sh. Priyavrat Pandya**, IAS, Commissioner AMC, **Sh. Ramesh Mathur**, SPV- Smart city, Ajmer, Ms. **Nohin Khanam**, A.EN.(Electrical) , **Sh. Laxmi Narayan**, J.EN.(Electrical) AMC, Ajmer for helping us at all levels and extending co-operation.

Lastly IRADe staff comprising of Mr.B.K.Sarkar, Mr.R.K. Tiwari, Mr.Mohit Kumar Gupta, Mr.S.Vamadevan, Mr.Akhilesh Kumar, are duly acknowledged for providing untiring support and help in organising logistics, staff support. Mr.Mohit Kumar Gupta for data analysis, presentation and survey work.

We are grateful to the Ministry of Urban Development and Ministry of New and Renewable Energy for supporting the project work.

We would like to thank Dr. Jyoti Parikh, Executive Director and Dr.Kirit Parikh, Chairman, IRADe for their valuable guidance and support during the completion of the project work.

Mr.Sharad Verma
Assistant Director

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ABBREVIATIONS AND ACRONYMS

AC	Air Conditioner	MWe	Mega Watt Equivalent
BEE	Bureau of Energy Efficiency	MWh	Mega watt hour
CDM	Clean Development Mechanism	NASA	National Aeronautical Space Administration
CERC	Central Electricity Regulatory Commission	O&M	Operations and Maintenance
CFA	Central Financial Assistance	R&D	Research and Development
CFL	Compact Fluorescent Light	RE	Renewable Energy
CO ₂	Carbon Dioxide	RET	Renewable Energy Technology
DG	Diesel Generator Sets	SNA	State Nodal Agency
DISCOM	Distribution Company	SL	Solar Lantern
EE	Energy Efficiency	SSL	Solar Street Light
GHG	Green House Gases	SHL	Solar Home Light
GWh	Giga watt hour	SPP	Solar Power Plant
HH	House Hold	SPV	Solar Photo Voltaic
HPSV	High Pressure Sodium Vapour	Sqm	Square Metre
Hrs/day	Hours per Day	STP	Sewage Treatment Plant
HVAC	Heating, Ventilation and Air Conditioning	SWH	Solar Water Heater
IRADe	Integrated Research and Action for Development	SWM	Solid Waste Management
IREDA	Indian Renewable Energy Development Agency		
AMC	Ajmer Municipal corporation		
kL	kilo Litre		
L	Litre		
LED	Light Emitting Diode		
LPD	Litres per day		
LPG	Liquefied Petroleum Gas		
m/s	Metres per Second		
MNRE	Ministry of New and Renewable Energy		
MSW	Municipal Solid Waste		
MT	Metric Tonnes		
MU	Million units		
MW	Mega Watt		

Chapter - 1

Introduction



About the Program

About 31% (380 million people, 2011 census) of the Indian population resides in urban areas. In post-independence era while population of India has grown three times, the urban population has grown five times. Urban areas are heavily dependent on fossil fuels (often imported), for the maintenance of essential public services, for powering homes, transport systems, infrastructure, industry and commerce. The fossil fuels are increasingly becoming more expensive due to scarcity of fuel and increase in demand. In addition to this, the environmental and social impacts of the consumption of fossil fuels are increasingly becoming a concern. These impacts include air pollution, global warming, waste disposal problems, land degradation and the depletion of natural resources. Urbanization and economic development are leading to a rapid rise in energy demand in urban areas. Urban areas have emerged as one of the biggest sources of Green House Gas (GHG) emissions, with buildings alone contributing to around 40% of the total GHG emissions. As per latest UN report one million people are moving to urban areas each week. It is estimated that around two-thirds of the world population will be living in cities by 2050. This will require a tremendous shift in energy resources in urban areas. In recognition of this, various cities around the world are setting targets and introducing policies for promoting renewable energy and reducing GHG emissions. London has announced 20% Carbon emission reduction by 2010; New York and 200 other U.S. cities have set similar targets. Tokyo has announced 20% share of renewable in total consumption by 2020 and Australian government has initiated a Solar Cities programme.

Several Indian cities and towns are experiencing 15% growth in the peak electricity demand. The local governments and the electricity utilities are finding it difficult to cope with this rapid rise in demand and as a result most of the cities/towns are facing severe electricity shortages.

There is a need to develop a framework that will encourage and assist cities in assessing their present energy consumption status, setting clear targets for and preparing action plans for generating energy through renewable energy sources and in conserving energy utilized in conducting urban services. The programme on “Development of Solar Cities” would support/ encourage Urban Local Bodies to prepare a Road Map to guide their cities in becoming ‘renewable energy cities’ or ‘solar cities’ or ‘eco/green cities’. The Ministry has already initiated various programmes in the Urban Sector for promoting solar water heating systems in homes, hotels, hostels, hospitals and industry; deployment of SPV systems/ devices in urban areas for demonstration and awareness creation; establishment of ‘Akshya Urja Shops’; design of Solar Buildings and promoting urban and industrial waste/ biomass to energy projects. The programme aims to consolidate all the efforts of the Ministry in the Urban Sector and address the energy problem of the urban areas in a holistic manner. The Ministry has launched a Scheme on “Development of Solar Cities: under which a total of 60 cities/towns are proposed to be supported for development as “Solar/ Green Cities” during the 11th Plan period. At least one city in each State to a maximum of five cities in a State is being supported by the Ministry. The cities may have population between 0.50 to 50 lakhs.¹

Goals and Objectives

The Goal of the program is to promote the use of Renewable Energy in Urban Areas by providing support to the Municipal Corporations for preparation and implementation of a Road Map to develop their cities as Solar Cities. The objectives of the programme are given below:

- to enable/empower Urban Local Governments 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 Urban Local Bodies 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.

The Ajmer Municipal Corporation with sanction of the Ministry of New and Renewable energy granted the job of development of Master Plan for Ajmer as Solar City to M/s Integrated Research and Action for Development (IRADe) which is an empaneled Solar City Consultant with the Ministry of New and Renewable Energy.

The Master plan to develop Ajmer as solar city provides insights into the challenges and opportunities for implementing energy efficiency strategies and outlines a set of actions for

¹ <http://mnre.gov.in/file-manager/dec-solar-cities/solarcity-scheme-2013-14-and-restof-12thplan.pdf>

how best to proceed to achieve the aim of reducing 10% of energy consumption in the next five years. It is actively addressing energy efficiency for the Ajmer Municipal Corporation which can significantly reduce Ajmer’s future energy growth, improve community resiliency, and position Ajmer as a competitive place to invest, live and grow. To allow Ajmer to advance with reducing energy demand and greenhouse gas emissions, key focus areas for deploying energy efficiency in major sectors are identified as

1. Residential Sector
2. Commercial and Institutional Sector
3. Industrial Sector
4. Municipal Sector

Solar energy is an inexhaustible source of energy and Rajasthan state due to its geographic location favor’s its development. Currently Ajmer is taking electricity from the state electricity board discom of Ajmer. The energy demand is increasing day by day. Keeping each point in the mind (cost of power, different losses, uncertain power cut), extracting power from solar is one of the ways to become independent for the power needs. To foster the energy efficient techniques, the report addresses the advancing method which are as follows.

- a) Develop an action plan with key stakeholder’s and Utilities
- b) Continue to improve local energy information for Ajmer
- c) Invest in the Resources and Knowledge to Advance Energy Efficiency

Aim of the Solar City Master plan

Ministry of New and Renewable Energy (MNRE), Government of India has launched a program on “Development of Solar Cities” in India. The program 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. A total of 60 cities/towns are proposed to be developed as “Solar Cities” during the 11th Plan period. At least one city in each State to a maximum of five cities in a State will be supported by the Ministry. The cities/towns included in the program will have population between 0.50 lakh to 50 lakhs which includes the floating population. Ajmer is one of the towns to be developed as solar city.

The role of energy in Cities

Energy comes in many forms. We use electricity to light our homes, our streets and the exterior of buildings. We also generate heat from the burning of fossil fuels to condition our homes and offices and to heat domestic hot water. Energy is also used to extract raw materials, to manufacture and distribute consumer goods, to grow food and to treat and pump water, transportation. Energy is central to the daily functions and actions of every community. Energy is an essential building block of economic development. Urbanization and

economic development are leading to a rapid rise in energy demand in urban areas. This requires a tremendous shift in energy resources in urban areas. In recognition of this, various cities around the world are setting targets and introducing policies for promoting renewable energy and reducing GHG emissions.

What is Energy Planning and Why is it Important?

As population and employment in a city grows, more fuel and materials are needed for generation, transmission and distribution of energy. Taking steps to reduce the amount of electricity or fossil fuels that is used in a home or business helps to lower individual utility costs and conserve natural resources. Improving energy efficiency means using less energy to accomplish an activity or goal. Some city goals could be to provide comfortable living and working spaces for residents, to enable residents and visitors to travel easily around the city or to promote economic prosperity. Among the drivers for incorporating energy efficiency and renewable as part of short-term and long-term community planning and economic development includes:

Response to climate change.

As part of the response to climate change, the local municipal corporations and local public sector are now exploring the role of energy efficiency and community renewable energy systems to improve adaptation and mitigation capacity of fossil fuels.

Sustainable energy planning.

Planning for energy can contribute to the sustainability of a community by reducing energy costs and lowering environmental impacts. Energy use, supply and demand not only depend on, but also can help shape the design and development of a community, and the activities of its citizens, businesses, institutions, government agencies and industry. Energy efficiency and the use of Renewable energy is now considered an important component of achieving successful long-term growth objectives for a community.

Transiting to new energy sources

Power density is a measure that captures the rate of energy produced per unit of earth area and is usually expressed in watts per square meter (W/m²). Fossil fuel deposits are by far the highest concentration of high quality energy in the magnitude of 10² or 20³ W/m². Hence only a small land area is needed to supply vast amounts of energy. Today's power producing techniques ensure that we receive fuels and electricity with power densities that are in the order of one to three magnitudes higher than regular power densities required to operate our buildings and cities. Indian city environment is designed around access to inexpensive fossil fuels. Reducing reliance on fossil fuels will require creating an environment that is energy efficient and supports renewable technologies, such as photovoltaics, solar hot water and wind. Understanding where energy is used in a community and where energy supply opportunities might exist can contribute to making effective energy efficiency decisions. Integrated energy mapping is grounded on assembling a wide range of data inputs that are

used to help baseline energy consumption in a community and evaluate the long-term effectiveness of energy reduction strategies. An important component of the process involves financial assessment and cost sensitivity testing. Key financial indicators allow for identified energy strategies to be ranked against one another in terms of cost effectiveness in achieving a desired target for energy, GHGs, energy cost or other objective.

About the City

History

Ajmer, is the administrative headquarters of Ajmer District in India's western state of Rajasthan. The city was founded by Ajaipal Chauhan, who established the Chauhan dynasty in the seventh century. Prithviraj Chauhan, the legendary last Hindu king of Delhi also ruled Ajmer. Surrounded by the Aravalli Mountains, Ajmer, also known as Ajaymeru which means the Invincible Hill.

The Dargah of the Great Sufi Saint Khwaja Moinuddin Chishti, is a sacred centre of pilgrimage is also located here. Ajmer has earned the epithet of "Madinatul Hind or the Madina of India". Ajmer is also the starting point for visiting Pushkar, the abode of Lord Brahma, lying to its west with a temple and a picturesque lake.

Ajmer is a centre of culture and education. It is famous for its rich Indo-Islamic, Royal Rajasthani, Indo-Saracenic and Jain styles of architecture. The city is home to the prestigious Mayo College, a school exclusively for Indian nobility, and King George Military School, both setup by the British. In addition, the city's built heritage includes Nasiyan (Red) Temple, Salemabad (Nimbark Peeth), Taragarh Fort, Adhai – Din Ka- Jhonpra (a religious structure), Ana Sagar (an artificial lake), the museum (Magazine, once the royal residence of Emperor Akbar of Mughal dynasty), Nareli (Jain Temple), etc.

In earlier days, the artists of this region used to do carving on wood and ivory, made vases and goblets, incised and embossed work on brass and blue pottery and appliqué work, ivory comb, necklaces etc.

Administration

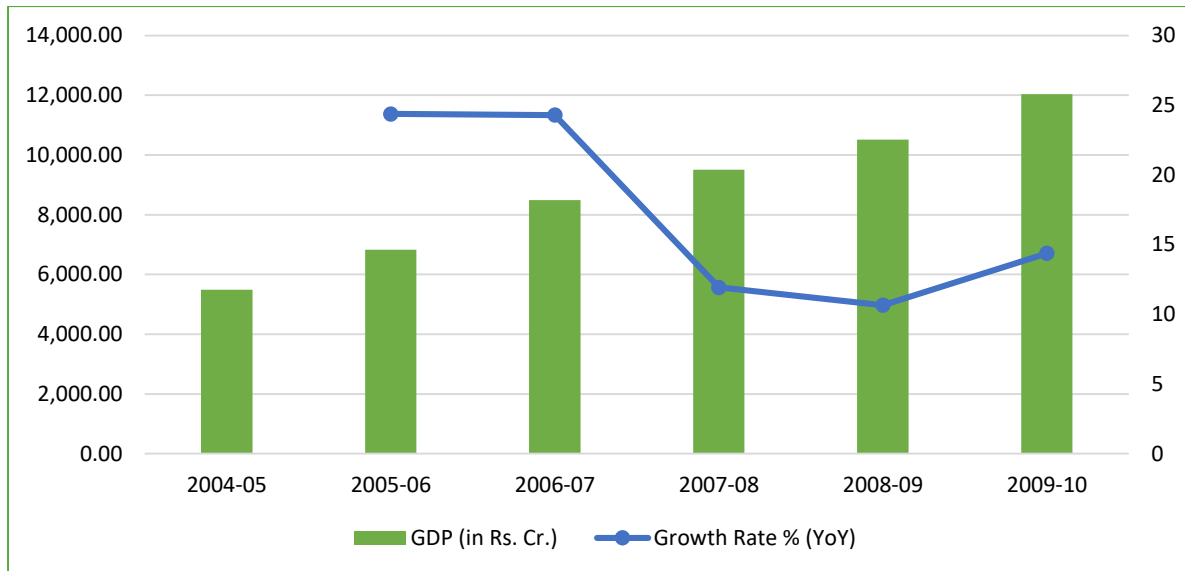
Ajmer district is one the 33 districts of Rajasthan, is also the administrative headquarter of the district. The district is divided into four subdivisions, Ajmer, Beawar, Kekri and Kishangarh, and further subdivided into nine tehsils, Ajmer, Beawar, Nasirabad, Kekri, Kishangarh, Sarwar, Bhinay, Masuda and Peesangan. Ajmer district has 1111 villages, out of them 1099 villages are inhabited and 12 villages are uninhabited. In Ajmer district 82 new villages and 3 new census towns have created as compared to 2001 Census.

Economy

Ajmer City has reasonable opportunities in religious and local tourism, a growing educational sector coupled with recent development in the realty sector have given Ajmer boost to the local economy. The district has 6 government colleges, one Medical Institute (RNT Medical

College and Institute), along with a few private Medical institutes and engineering colleges. The Mohan Lal Sukhadia University offers varied courses in Arts, Science and Commerce. Mayo college is also a well-known educational school. Tourism plays an important part in Ajmer's economy with many places of interest for the tourists as highlighted above. Figure-1 shows the GDP and growth trend of GDP for Ajmer district.

Figure 1 Ajmer District GDP and Annual growth rate of GDP



Source: Revenue Department, Government of Rajasthan

Regional Locations and Connectivity

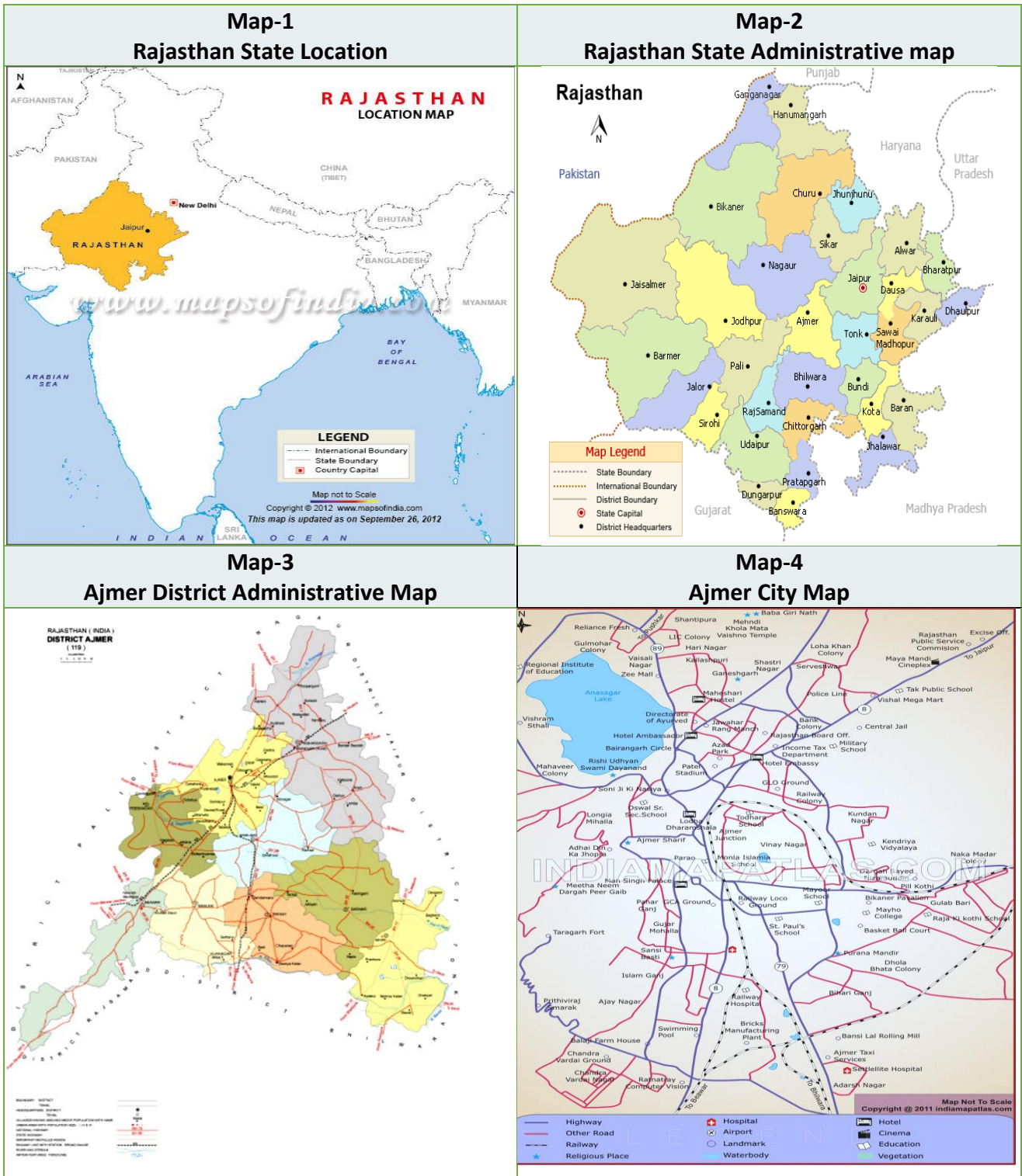
Ajmer city is situated in south-western part of Ajmer Tehsil. In geographical terms, Ajmer city is located at 26°45' N latitude and 74°64' E and longitude. It has an altitude of 486 meter above Mean Sea Level.

Ajmer district is well connected with all the modes of transport Road, Rail and Air. The Jaipur Airport is 120 km from Ajmer has daily flights to Delhi, Mumbai and other parts of the country. Ajmer Airport (Kishangarh Airport) is being constructed at Kishangarh on National Highway 8, 27 km North East of Ajmer. Ajmer also has direct trains network to major cities in Rajasthan as well as other States including Delhi, Maharashtra, Madhya Pradesh and Gujarat. Ajmer Railway Station is located at the heart of the city.

There is also bus connectivity to almost all the villages and cities around Ajmer. Ajmer is well connected to state capital Jaipur in northeast and Ahmedabad in southwest. Ajmer is connected to other centers to the state and other states by two National Highways NH-8 & 79 many state highways also pass through the district. The city is also well connected by Rail network with daily trains to Delhi, Jaipur, Ahmedabad and Mumbai.



Map-1 to 4 show the relative locations of Rajasthan state, Ajmer district, district map and Ajmer city.



Physiography

Ajmer is located in the center of a Bowl shaped valley basin and is surrounded by the Aravalli hills, sand dunes and lakes and ponds. Gneiss, Schist & Alluvium are the main geological formations. The general slope of the city is towards center of Anasagar lake.

Natural Drainage and Water Bodies

Ajmer is drained by Khari, Sagarmati, Sarsuti, Dei & Banas water channels. The streams are seasonal, which originates from nearby hills during monsoons. The region is surrounded with numerous water bodies. The major water bodies in the region are Lake Ana Sagar, Foy sagar and Pushkar lake. Artificial drains to tap runoff water have been constructed to fill these lakes.

Flora and Fauna

The vegetation in the district is very scanty, the natural vegetation has almost disappeared due to instance biotic interference. The over grazed and completely degraded area has now traces of trees, shrubs and grass species. The common trees available are Neem, Babul, Ber, Khejari, Thor, Juliflora, etc.

Climate

Ajmer city has particularly a dry tropical climate. The three main seasons, summer, monsoon and winter respectively, dominate the city of Ajmer. Situated at an altitude of 486 m above sea level, moreover in a desert area, Ajmer has a sultry type of climate. However, Ajmer is the only place in Rajasthan that has quite a moderate climate throughout the year. In summers, the scorching sun makes the city hot whereas in winters the weather is cold to pleasant.

Being located in the desert lands of Rajasthan, the climate and weather of Ajmer is usually hot. The summer season runs from Mid-March to June and touches the temperature of 40°C while winters reach upto 7°C. Monsoons arrive in the month of July heralded by dust and thunderstorms. The area annually receives around 450 mm of rainfall. This scanty amount of rainfall makes Ajmer more humid. The humidity reaches to the extent of 90 % during the months of Monsoons.

Ajmer Municipal Corporation

Ajmer Municipal Corporation is the oldest local Municipal Body of Rajasthan established in the year 1866. Ajmer Municipal Corporation is the administrative headquarters of the Municipal Commissioner and Mayor of Ajmer city. The Municipal Corporation of Ajmer comprises of 60 wards for efficient administration of the city.

Land Use and Master Plan

The Ajmer master development plan-2013-33 lays out the various development challenges and future road map for development of Ajmer. The plan envisages to cover 118 revenue villages in the city and the expected population of the city to reach 0.95 million by 2033. proposed a land use pattern upto year 2022. Industrial development has taken place around

HMT factory, IOCL depot on Beawar road and more recently around Makhupura, Parbatpura, Gagel and Shrinagar. The City has witnessed area expansion in last few decades, while the old walled city was limited to the areas near the Dargah, later on the city expanded around the Anna Sagar, railway line (loco shed) and the National highway and towards the Ajmer Pushkar road. Being a valley with mountainous ranges on most of the sides the city expansion was limited and development followed the highway pattern like the Ajmer Beawar and Ajmer Nasirabad Road.

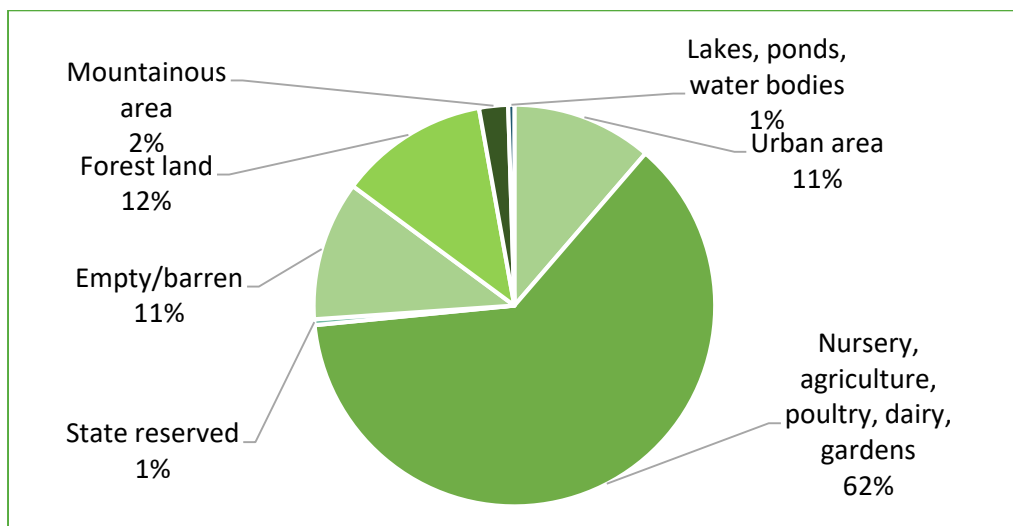
The total geographical area of the city is 75 Sq. km. Table-1 presents the land use statistics of the city and figure-2 the share of each.

Table 1 Land use Area statistics of Ajmer City

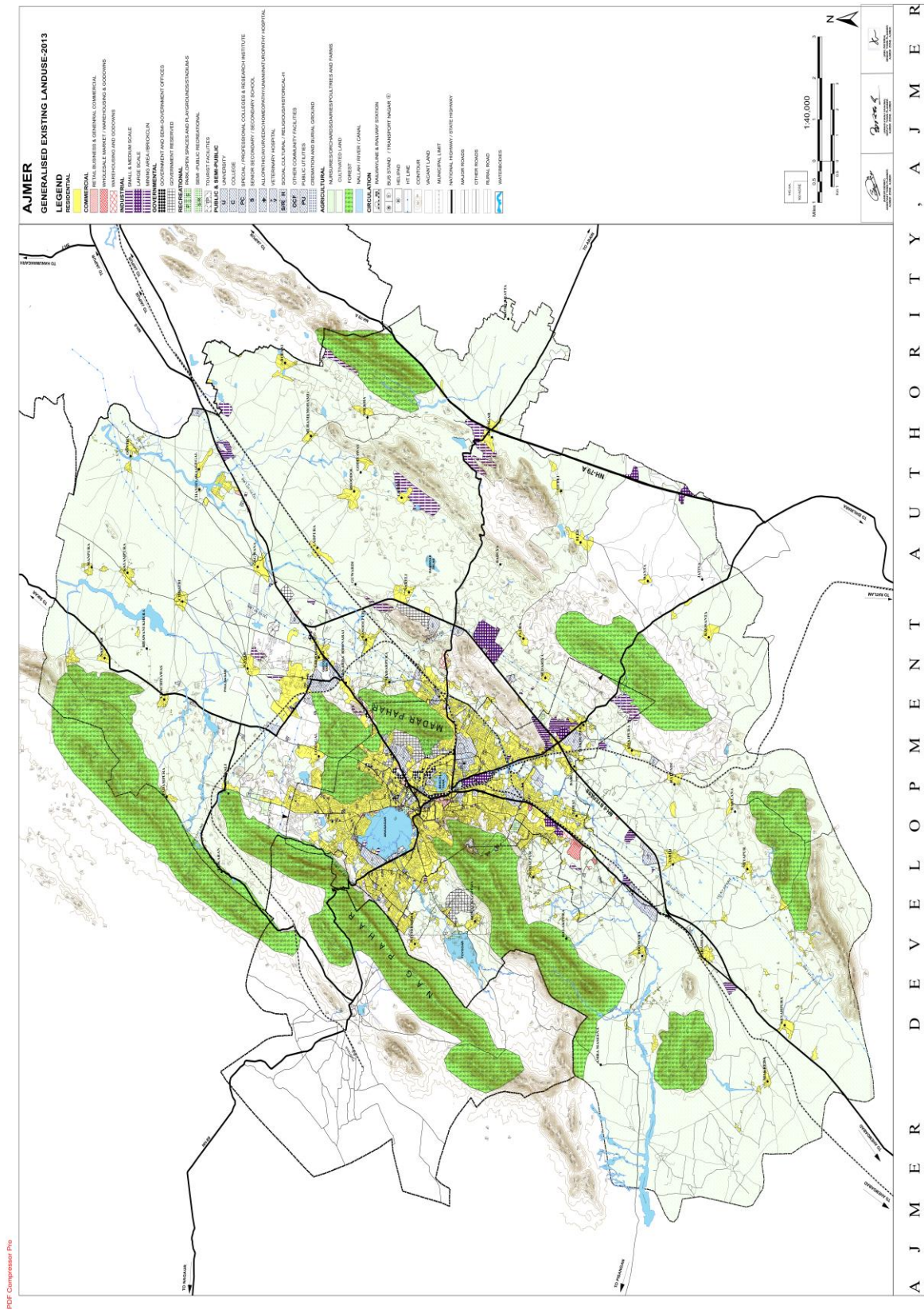
Sl.	Zone	Area in Ha.
1	Residential	5922
2	Commercial	282
3	Industrial	1094
4	State	96
5	Public services and others	1074
6	Entertainment	76
7	Circulation	31
8	Urbanized area	8575
9	Nursery, agriculture, poultry, dairy, gardens	47060
10	State reserved	354
11	Empty/barren	8502
12	Forest land	9118
13	Mountainous area	1769
14	Lakes, ponds, water bodies	375
15	Total Urban Area	75753

Source: City Development plan 2013-33, Ajmer Development Authority.

Figure 2 Land use pattern of Ajmer city



Map-5: Master Plan Map of Ajmer City



PDF Compressor Pro

Demography

In 2011, Ajmer had a population of 551360. In 2016 the total population of Ajmer is expected to be around 616846. Ajmer urban control area belt was prepared to control unplanned development. This belt is about 3 to 4 km radius around Ajmer. This belt consists of urbanized area, Urbanizable area and Municipal area and revenue villages. The land with in urban control area can be utilized apart from agriculture, for dairy, horticulture, farm houses, resorts, motels, amusement park, water park and agriculture based industries. Marwari and Hindi is the local dialect of the district and is widely spoken in villages and city.

Table 2 Population trend of Ajmer City

Sl.	Year	Population	Growth rate
1	1981	375593	42.11
2	1991	402700	7.22
3	2001	485575	20.57
4	2011	551360	11.93

Source: Census 2011 and ADA

Population Projection

Projected Population for Ajmer city upto 2033 as per the government master plan for the city is 0.95 million. Table below shows the trend of population growth. Population projection for the report would also take this population into consideration.

Table 3 Future Population trend of Ajmer City

Sl.	Year	Population	Growth rate
1	2011	551360	11.93
2	2021	689200	25.00
3	2033	947312	35.00

Source: Census 2011 and ADA

Sex Ratio

Males and females population constitute 51.36% (278545) and 48.64% (2,63,776) of the total population, respectively. The overall sex ratio is 947, which is higher than the National average.

Table 4 Comparison of Sex ratio- India, Rajasthan & Ajmer City

Area	Sex Ratio (Overall)	Sex Ratio (Children 0-6 yrs.)
India	940	914
Urban India	926	902
Rajasthan	926	869
Ajmer City	947	886

Literacy Rate

Total number of literate people in Ajmer City is 416511 (76.8%). Male literacy rate is higher at 81.40% (226757) compared to female literacy rate of 71.93% (189754). Table-5 shows the literacy details.

Table 5 Comparison of Literacy Rate- India, Rajasthan

Area	Total	Male Literacy Rate	Female Literacy Rate
India	74.04%	82.14%	65.46%
Urban India	84.90%	89.67%	79.92%
Rajasthan	67.66%	80.51%	52.66%
Ajmer City	76.80%	81.40%	71.93%

Source: Census 2011, Rajasthan

Smart City Concept - Ajmer

Concept

The concept of Smart City, varies from city to city and country to country, depending on the level of development, willingness to change and reform, resources and aspirations of the city residents. To provide for the aspirations and needs of the citizens, urban planners ideally aim at developing the entire urban eco-system, which is represented by the four pillars of comprehensive development-institutional, physical, social and economic infrastructure.

In the approach of the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities.

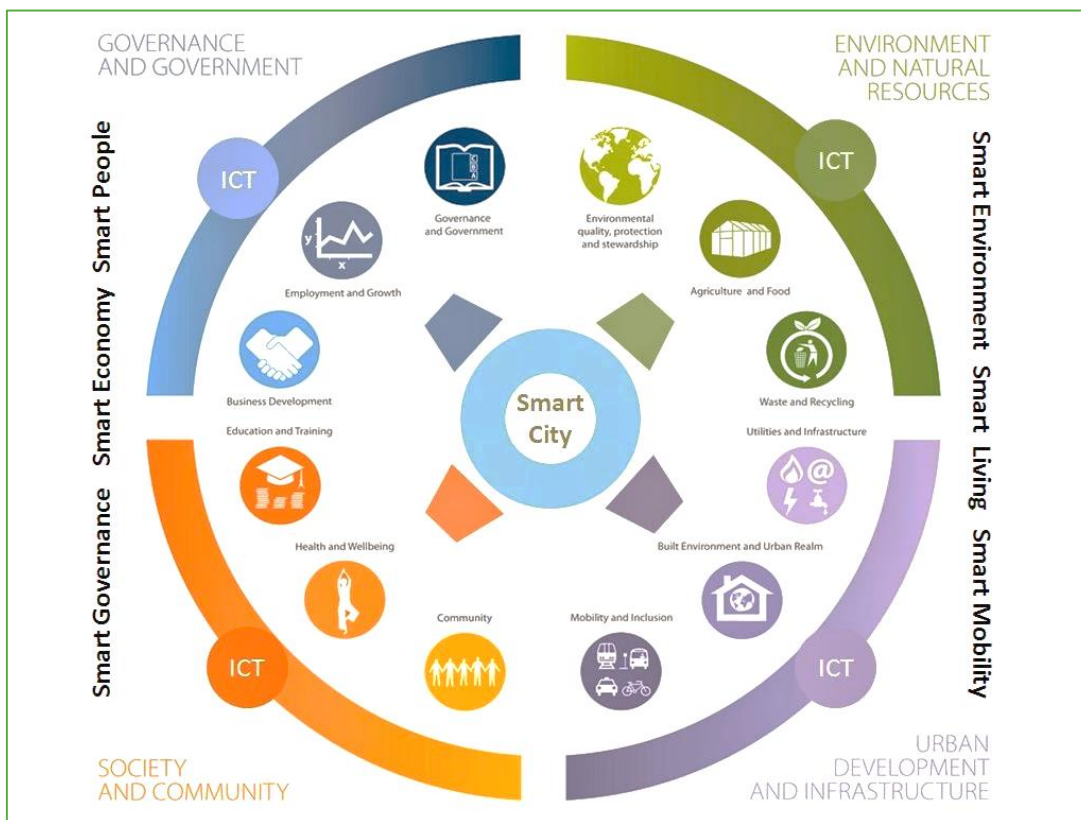
The core elements in a Smart City include e-governance and services, energy management, water and waste management, urban mobility, etc. Details aspects under each are presented below. Major role in the present smart cities concept is for use of IT and IT enabled services for governance and citizen linkages.

Figure 3 Smart City Solutions



Source: MoUD, Smart City Guidelines

Figure 4 Use of ICT as an enabler in Smart City Solutions



Source: Web research

Smart City Features

Some typical features of comprehensive development in Smart Cities are described below.

- i. Promoting mixed land use in area-based developments** — planning for ‘unplanned areas’ containing a range of compatible activities and land uses close to one another in order to make land use more efficient. The States will enable some flexibility in land use and building bye-laws to adapt to change;
- ii. Housing and inclusiveness** — expand housing opportunities for all;
- iii. Creating walkable localities** — reduce congestion, air pollution and resource depletion, boost local economy, promote interactions and ensure security. The road network is created or refurbished not only for vehicles and public transport, but also for pedestrians and cyclists, and necessary administrative services are offered within walking or cycling distance;
- iv. Preserving and developing open spaces** — parks, playgrounds, and recreational spaces in order to enhance the quality of life of citizens, reduce the urban heat effects in Areas and generally promote eco-balance;
- v. Promoting a variety of transport options** — Transit Oriented Development (TOD), public transport and last mile para-transport connectivity;
- vi. Making governance citizen-friendly and cost effective** — increasingly rely on online services to bring about accountability and transparency, especially using mobiles to reduce cost of services and providing services without having to go to municipal offices; form e-groups to listen to people and obtain feedback and use online monitoring of programs and activities with the aid of cyber tour of worksites;
- vii. Giving an identity to the city** — based on its main economic activity, such as local cuisine, health, education, arts and craft, culture, sports goods, furniture, hosiery, textile, dairy, etc.;
- viii. Applying Smart Solutions to infrastructure and services** in area-based development in order to make them better. For example, making Areas less vulnerable to disasters, using fewer resources, and providing cheaper services.

Ajmer as a Smart City

Under the smart city challenge of MoUD, GoI, Ajmer was selected amongst second list of cities selected in the country for developing it into a smart city. The city has also qualified for the HRIDAY, AMRUT scheme of MoUD. Ajmer city has gone ahead and formed projects for implementation of the smart city projects, based upon citizen level consultations held and the following project types have been highlighted for Ajmer. Ajmer has also formed the Ajmer Smart City SPV for undertaking the projects.

Area based Development - Retrofitting and Greenfield

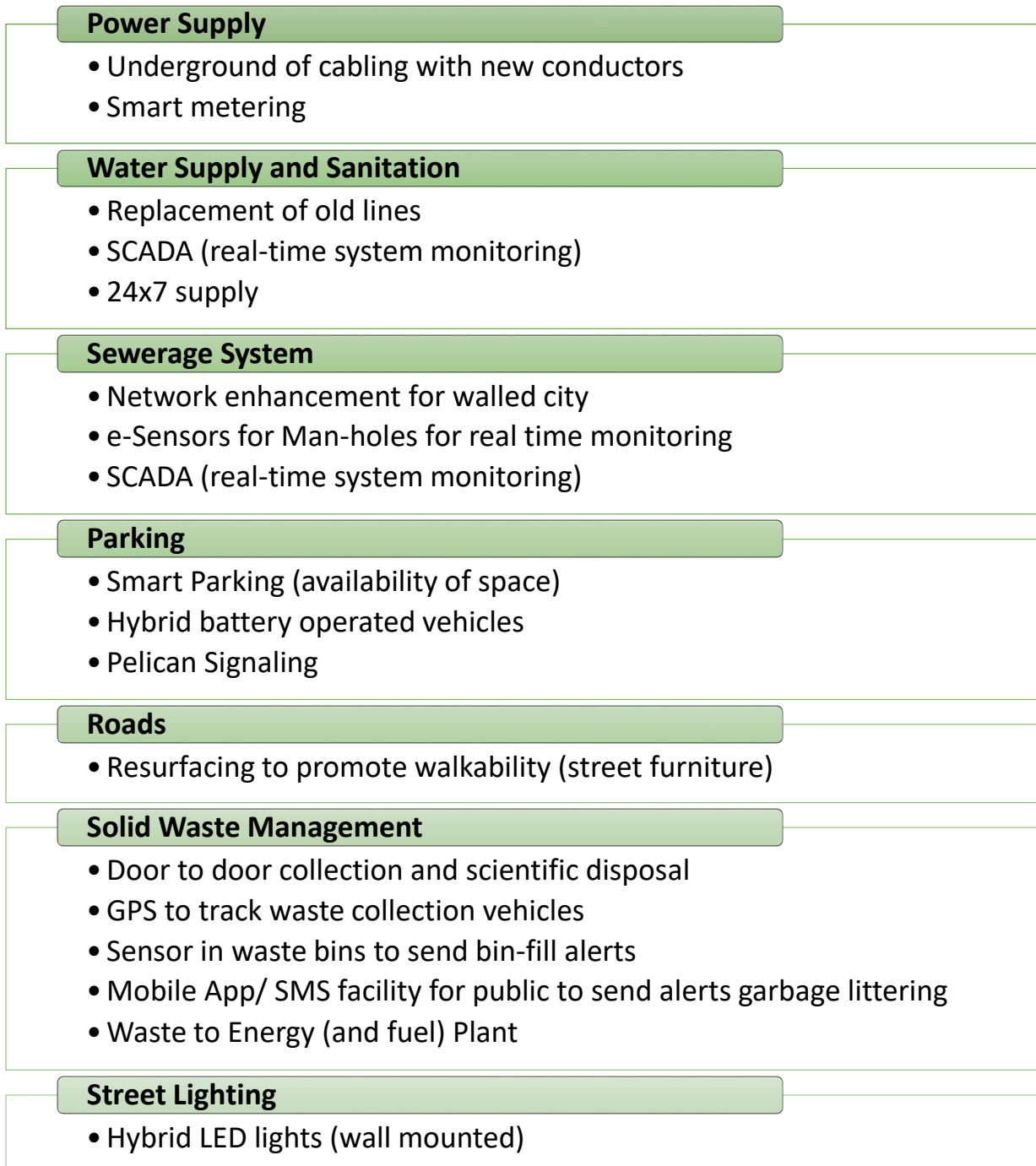
Pan City Development - Solid Waste Management and Public Transport (Intelligent Transport System)

Top priority sector was Tourism followed by Water and sewerage, lake and heritage conservation, public transport and walkability, safety security, others.

Area based Retrofitting – Walled City

Sectors Smart Proposals for the city were identified and each of the sectors with their most required interventions were identified and the same are presented. Based upon the above the following types of projects were highlighted for the city, in all the development and infrastructural sectors as presented in Figure-5.

Figure 5 Smart city interventions for Ajmer



Heritage/ tourist amenities

- Conservation of heritage by development regulations of façade development
- Organised signage's
- Bi-lingual Mobile App for visitors (including GPS locations)
- IT based ticketing and feedback system
- Bio-toilets

Safety and Security

- Installation of the CCTVs (Video crime monitoring)
- Automatic reporting of trouble spots

School Infrastructure

- Smart Class-room with comprehensive Multi-media applications

IT connectivity

- Wi-fi facility Lakes
- Real-time water quality monitoring system
- Suggest remedial measures

Source:http://Ajmersmartcity.in/wp-content/uploads/2015/11/mygov_1447826673190667.pdf

Ajmer Solar City

The Solar city concept arises from the fact that urban areas would be major energy consuming areas in future and it is necessary to take steps now to limit the use of fossil fuels for energy generation and promote energy efficiency with latest devices to promote DSM measures. MNRE has launched this scheme in 2009 and this forms part of the standard plan submission by all the cities selected under the smart cities concept of MoUD. In order to develop a solar city a lot of database is to be generated and compiled from various departments and the same is presented in Chapter-4 to fully understand the dynamics that go into development of a solar city.

City level growth plans, land use plans, infrastructure, local needs, Solar radiation data, wind resource data (Annexure-1), biomass, waste to energy potentials, topography, technology use, all have to be kept in mind to recommend a comprehensive solar city plan.

Integrated energy mapping

The integrated energy mapping process uses a combination of actual energy consumption data and energy simulation models to show where and how much energy is consumed by the entire City of Ajmer. All the energy consumed by the residential sector, commercial & institutional sector, industrial sector, and municipal sector are included in the analysis. Energy baseline is created for both 2008 and

2016 (baseline), and for the future development that is expected to occur between today and next 5-10 years, according to the Ajmer city's Official Plan and Growth Management Strategies for Ajmer City.

In the energy mapping process, we will divide the energy consumption of Ajmer city into four major sectors – residential sector, commercial & institutional sector, industrial sector, and municipal sector. In addition to calculating how much energy is consumed by the City for each case, total GHG emissions for the City and for each case are calculated as well. Alternative energy generation technologies will model for the potential to further reduce GHG emissions. Capital costs, operating costs, and operating cost savings are evaluated for each new building standard, building retrofit, and alternative energy generation technology. Cost sensitivity will apply to potential increases in energy prices, and additional cost metrics such as Internal Rate of Return (IRR) are calculated. In this way, alternative practices and cases can be compared and contrasted according on a cost-benefit basis. The outputs of the energy model –energy, costs, and GHGs, of the different scenarios and best alternative technology (BAT) options –are used to inform policy directions and decisions that are intended to reduce energy and GHG emissions for the entire Ajmer City. The process can also be used to provide insight into the most cost effective ways of achieving a community energy reduction and/or GHG reduction goal. The Smart city project envisages the following three major aspects of energy for the city.

Electrical:

Electricity is supplied to Ajmer through the Kota Power plants, the main grid station is located at Naka Madar. The power supply situation in Ajmer is not very encouraging with T&D Losses and AT&C Losses and frequent load shedding. The total number of existing connections in the city are presented in table below.

Table 6 Category wise connections in Ajmer

Sl.	Category	Number of connections
1	Residential	143253
2	Commercial	28427
3	Industrial	3839
4	Agricultural	1321
5	Street lights	368
6	HT	98
7	MIP	372
	Total	177678

Source: Ajmer Master plan, 2033, ADA

Solar Energy

Under its Smart City plan, Ajmer aims to reduce the dependency on grid based power by harnessing solar energy which is available in abundance in this region. About 5-10% of the demand for walled city is to be met through solar power generation.

Preparation / validation of Solar Masterplan (on the lines of Solar City) and 100% rooftop solar coverage of all government, commercial and institutional buildings and energy certification of all buildings. Provision for incentivizing installation of solar rooftops and gross/net metering based tariff schemes. Creating a regulatory framework for achieving the same and promoting concepts like Renewable Energy Supply Cos. (RESCOs).

Identification of suitable land to be assigned by AMC or the district administration for setting up of an offsite solar farm (along with evacuation infrastructure to the nearest grid substation) to make up for shortfall, if any, in attaining the target of 10% of energy generation through solar and non-renewable energy sources.

Categorization of Different Sectors of the Ajmer City for preparation of Solar city master Plan

This base line of Energy utilization is based on the data on all forms of energy including electrical, petroleum product, coal and biomass from all sectors. We have categorized the Ajmer City in following main sectors as per the MNRE Guidelines.

- I. Residential Sector
- II. Commercial & Institutional Sector
- III. Industrial Sector
- IV. Municipal Sector

Sector wise Energy Utilization of Ajmer City

Residential Sector

Presently the total daily demand for Ajmer city is around 17 MWH with a total of 177678 electric connections as metered energy users as per Ajmer Vidyut Vitran Nigam Limited (AVVNL, Ajmer), the State Electricity Distribution company. Residential survey targets the information about the electrical energy, LPG, petrol diesel, kerosene and biomass consumption in this sector. This is important to assess the potential to increase energy efficiency and to use renewable energy. Residential sector includes all the households in the City, government quarters and apartments. Electricity plays an important role in energy consumption in this sector. LPG, petrol and diesel come second in residential sector. A small quantity of biomass fuel is also being used in poor and peri-urban areas of the City.

Commercial and Institutional Survey

Commercial and Institutional sector includes all offices, shop, bank, shopping malls and complexes, etc. Currently Commercial and Institutional Sector is having 28427 connections as per Ajmer Vidyut Vitran Nigam Limited(Ajmer). The main consumption of this sector is electricity, Non Domestic LPG and diesel in DG sets and petrol in transport. All the data of electricity, LPG, petrol and diesel consumption are being collected. The goal of the survey is to find out the total consumption as well as make an analysis on the characteristics of energy use in Commercial buildings and institutions.

Industrial Sector

Coal, Electricity, Petrol, Diesel, LDO, Furnace Oil are some major sources of the energy in the industries. We are procuring a list of industries in Ajmer City and collection of data of all forms of the energy being used in the sector from various agencies like Rajasthan State Pollution Control Board, Ajmer Chamber of Commerce and Industry, Rajasthan State Industrial Development & Investment Corporation Limited(RIICO), Ajmer Vidyut Vitran Nigam Ltd, Ajmer, District Statistical Office, Ajmer District Industry Centre (DIC). Currently the industrial Sector is having 3839 electricity connection as per Ajmer Vidyut Vitran Nigam Limited(Ajmer).

Municipal Sector

Municipal sector includes water pumping, waste water treatment, and street lighting. Electricity plays a major role of source of energy in this sector. A baseline consumption of the street lighting, public buildings and water pumping will be carried out to assess the energy conservation and renewable energy potential.

Public Health and engineering department PHED

Main work of PHED is water pumping and supply in to Ajmer City. Electricity consumption in this sector will be analysed.

GHG Emission

Greenhouse gases are the gases that trap in the atmosphere and cause increase in atmospheric temperature. We have experienced a great climate change shift in past few decades. GHG are the main reason for Ozone depletion and climate change. We will analyse the sector wise GHG emission by evaluating the source and recommend suitable measures to reduce the emission. This report will also include a comparative study of the GHG emission from different fuels in the various sectors.

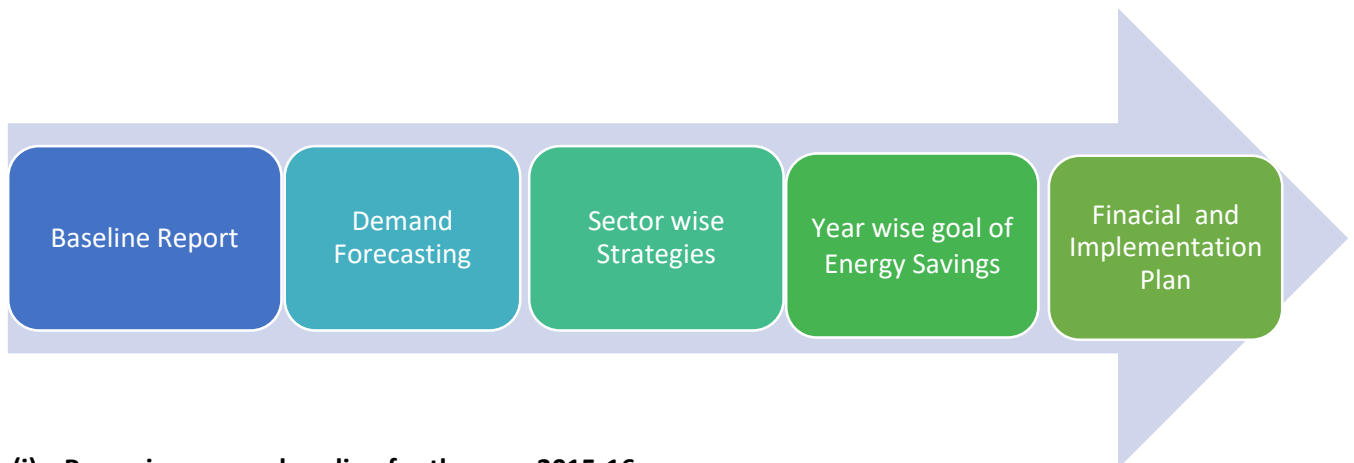
Developing Ajmer as a ‘Solar City’



Ministry of New and Renewable Energy (MNRE), Govt. of India has launched a Scheme, “Development of Solar Cities” under which a total of 60 cities/towns are proposed to be supported for development as “Solar/ Green Cities” during the 11th Plan period. The program aims at minimum 10% reduction in projected demand of conventional energy at the end of five years, which can be achieved from a combination of energy efficiency measures and enhancing supply from renewable energy sources. Out of this, 5% will be from renewable energy source. MNRE has been providing financial support to Ajmer Municipal Corporation for preparing a Master Plan for developing Ajmer as a solar city. Solar city plan has been mandated by MoUD for all the smart cities.

Preparation of Solar City Master Plan for Ajmer city

The solar city master plan preparation process is divided into five steps as presented in figure-6.

Figure 6 Solar city plan work flow**(i) Preparing energy baseline for the year 2015-16**

Energy baseline for the city is a detailed documentation of the existing energy demand and supply sources for the city. Among other things, it consists of sector-wise energy consumption matrix and energy supply mix for the base year. The data is further divided sectorally viz. residential, commercial/institutional, industrial and municipal sector to better understand the energy dynamics.

(ii) Demand forecasting for 2021-22 and 2026-27

This step involves predicting the energy demand for next 5 and 10 year periods. To estimate the demand and growth in energy used in different sectors is based on immediate past trends for each fuel/energy type and future growth plans based upon last 5 years' trends. Based on the past time series data and information on growth plans, growth rate in energy demand for different sectors has been estimated. These growth rates are used for making future projection of energy demand in each sector for year 2021-22 (five year) and 2026-27 (10 year) using suitable forecasting and statistical tools.

(iii) Sector wise strategies

This step involves carrying out techno-economic feasibility of different renewable energy and energy efficiency options for each sector based on techno-economic feasibility for such application to the concerned sectors. The renewable energy resources assessment has been done to identify the potential renewable energy sources for the city. This includes assessment of solar radiation, wind power density and availability, biomass resources and municipal or industrial wastes. A strategy has been prepared for the use of techno economically feasible renewable energy technology options in each sector.

(iv) Year -wise goals of savings

Year wise goals have been set to achieve targeted energy savings from demand side management by energy conservation and efficiency measures in different sectors, and supply side measures based on renewable energy applications.

(v) Action Plan

A five-year action plan has been prepared to achieve the set goals and expected GHG abatements. This includes establishment of solar city cell, capacity building and awareness generation. An indicative

Chapter - 2

Energy Baseline Scenario

The first step in the preparation of the Solar City Master Plan for Ajmer is the preparation of an energy baseline report for the base year 2015. As elucidated in the MNRE guidelines, energy baseline is a detailed documentation of the existing energy consumption scenario for the Ajmer city. It consists of sector-wise energy consumption matrix and energy supply-mix for the base year 2015-16

According to the guidelines, consumption of energy of a city is mainly divided into four sectors, which are residential, commercial & institutional, industrial and municipal sectors. Another major energy consumption sector is transportation sector, which includes petrol and diesel consumption of motor vehicles, but this sector is not considered as a part of solar city master plan because renewable energy interventions in this sector is limited. Energy baseline report is prepared as per the guidelines of solar city master plan. For this purpose, data has been collected from various city development authorities in Ajmer and compiled into an energy baseline report.

2.0 Energy Baseline Scenario of Ajmer City

Energy baseline Scenario is the amount of energy that would be consumed annually in Business as Usual (BAU) scenario. This BAU is entirely dependent upon the historical data, engineering calculations, metered energy consumption in systems, building load model, any conservation measures implemented in the past, statistical regression analysis or a combination of these. This chapter focuses on present energy supply and demand in residential, institutional, commercial and municipal sector with an overall energy consumption scenario for Ajmer city.

2.1. Fuel wise Energy Consumption

Based on the information gathered from the primary and secondary data sources, fuel wise energy consumption is presented here. The main sources of energy are electricity, petrol, diesel, LPG and kerosene.

Electricity:

Electrical consumption data of Ajmer City

The electricity distribution in Ajmer city is administered by the Ajmer Vidyut Vitran Nigam Limited (AVVNL). Basic electricity details of Ajmer city are presented in table-7.

Table 7 Sector wise Electricity consumers in Ajmer city

Sector	2011-12	2012-13	2013-14	2014-15	2015-16
Residential Sector	154572	161525	169371	176699	185313
Commercial & Institutional Sector	41014	42240	43839	45002	46749
Industrial Sector	5102	5417	5847	5672	5854
Municipal Sector	692	767	809	881	1022
Total	201380	209949	219866	228254	238938

Source: AVVNL, Ajmer

Based on the information available, sector wise electricity consumption data is compiled for last 5 years (Table-8). The per capita electricity consumption in Ajmer city has increased from 916 kWh to 1105 kWh/year from 2011 to 2015, a 21% increase in last 5 years.

Table 8 Electricity Consumption in Ajmer city (MWh)

Sector Wise Consumer category	2011-12	2012-13	2013-14	2014-15	2015-16
Residential Sector	213424	222041	246293	264000	271415
Commercial & Institutional Sector	141317	161094	179538	191234	211267
Industrial Sector	125869	139695	141242	143453	140232
Municipal Sector	16482	16513	18182	17543	19296
Total	497091	539343	585254	616231	642210

Source: AVVNL Office, Ajmer

Sectoral trend for the electricity can be seen in Figure-7. Almost all the sectors of the economy have been showing an increasing trend towards use of electricity.

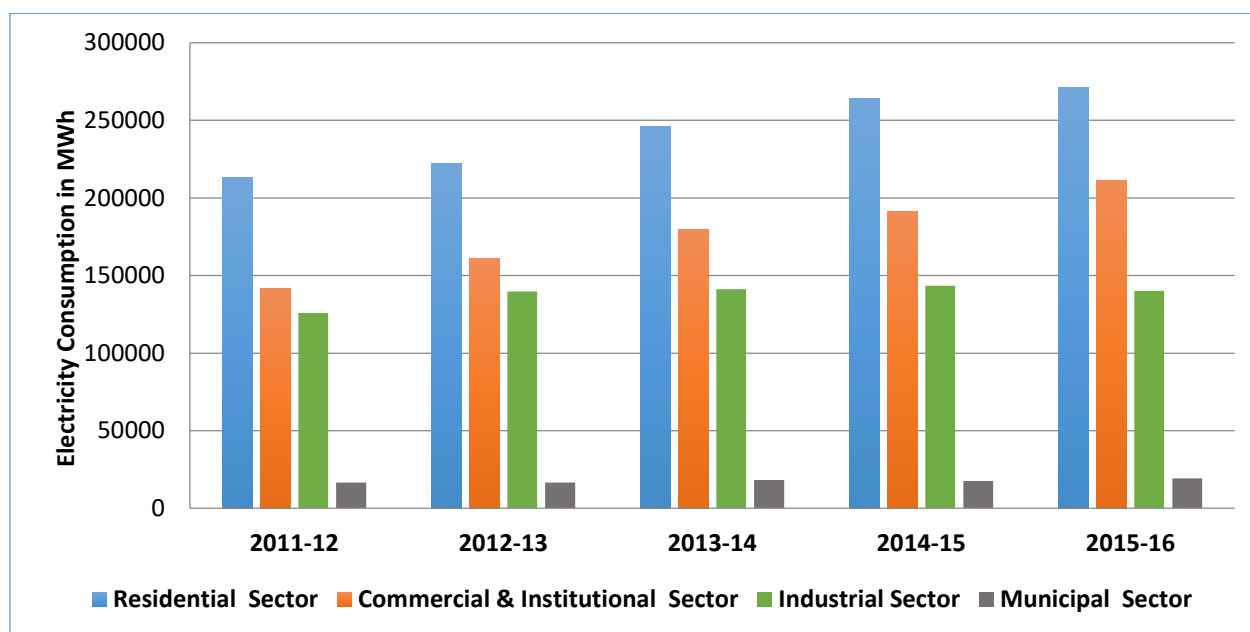
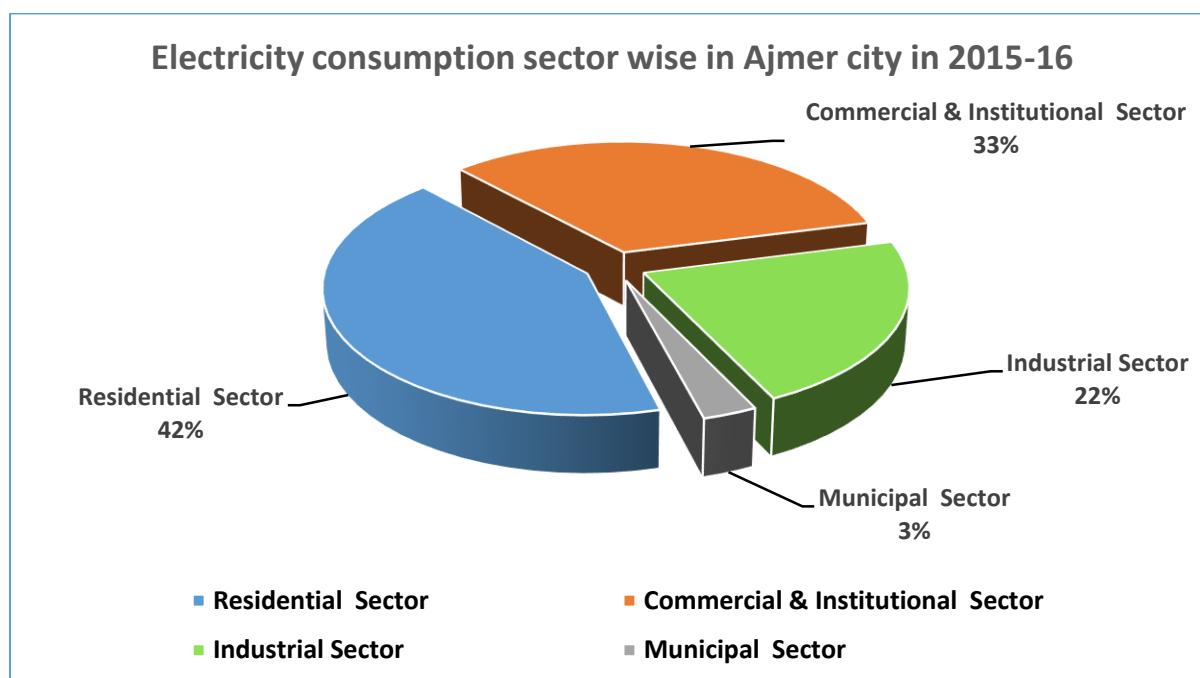


Figure 7 Energy Consumption in last five years in Ajmer city

Figure 8 gives the share of electricity consumption for different sectors. Residential sector dominates (42%) in electricity consumption. During last three years, the residential and commercial & institutional sectors have shown higher growth in electricity consumption as compared to the municipal and industrial sectors.

Figure 8 Share of Electricity Consumption sector wise in Energy Base Year 2015-16

Liquefied Petroleum Gas (LPG)

LPG is basically consumed in household and hotels/restaurants for cooking purposes. Based on the available data, LPG consumption is summarized in Table 9. The data availability for LPG in Ajmer city was a constrain as data was not available hence the data was projected using some available data and IRADe analysis for per capita consumption figures.

Table 9 LPG Consumption in Ajmer City

LPG (in MT)	2011-12	2012-13	2013-14	2014-15	2015-16
Residential	21505	21985	23125	22604	24908
C & I	866	1255	1018	1239	1546
Total	22371	23240	24143	23843	26454

Source: OMC and IRADe Data projection for Ajmer

Petrol

Based on the available data, petrol consumption is summarized in Table 10. Most of the consumption for petrol is in transportation sector.

Table 10 Petrol Consumption in Ajmer City

Petrol (in kL)	2011-12	2012-13	2013-14	2014-15	2015-16
Transportation	39144	39560	40385	44046	46914

Source: IRADe Data projection for Ajmer

Diesel:

Based on the available data, diesel consumption is summarized in Table 11. Most of the consumption would be in transportation, Commercial and Institutional industrial sector. There would also be some diesel consumption in residential/commercial sector for DG sets.

Table 11 Diesel Consumption in Ajmer City

Sector	2011-12	2012-13	2013-14	2014-15	2015-16
C & I	2995	3139	3260	3093	3087
Industry	1168	1224	1271	1206	1204
Transportation	67790	68418	68486	69106	69728
Total	71954	72782	73017	73406	74019

Source: IRADe Data projection for Ajmer

Kerosene:

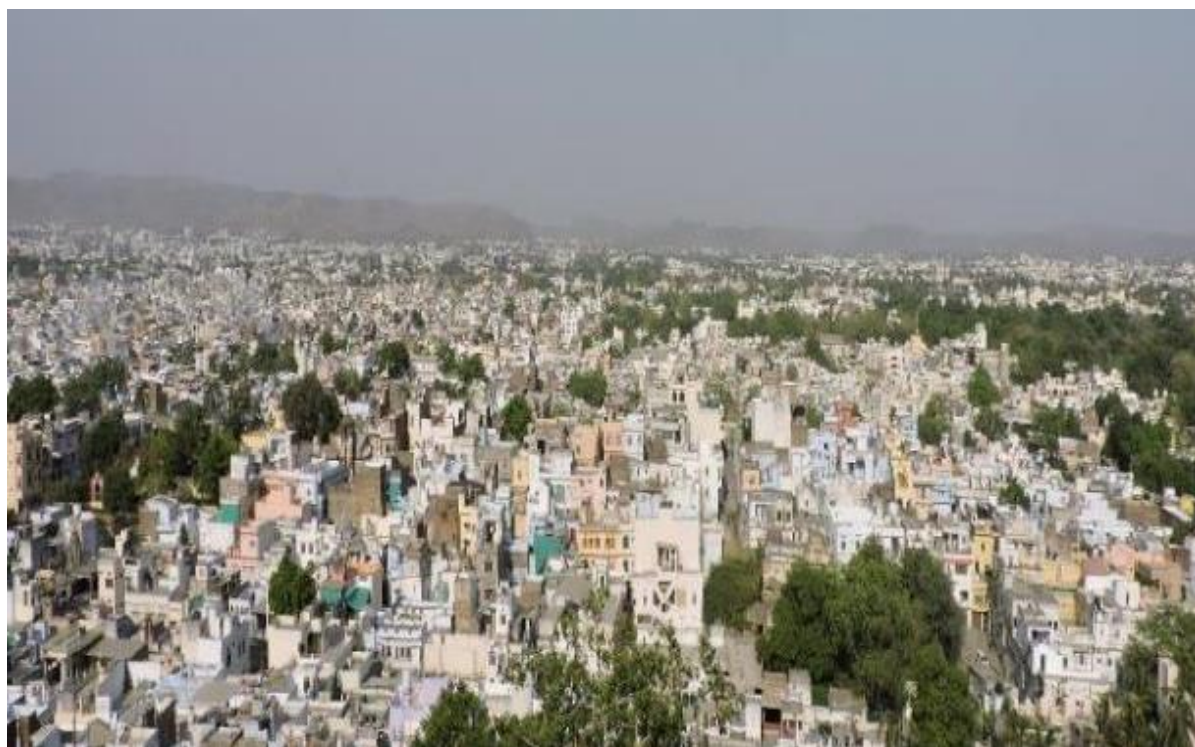
Based on the available data, kerosene consumption is summarized in Table 12. Most of the consumption is in the residential sector for cooking or lighting; however, it might also include the supply to industries which are not falling under AMC area.

Table 12 Kerosene Consumption in Ajmer City

Kerosene (kl)	2011-12	2012-13	2013-14	2014-15	2015-16
Residential	840	856	865	876	606

Source: DSO Office Ajmer

2.2. Energy Consumption in Residential Sector



As stated in the guidelines, in the residential (housing) sector, electricity is the major source of energy for lighting and for powering home appliances (air-conditioning, refrigerators, fans, television, electric geysers, washing machines, water pumps, etc.), whereas LPG and kerosene are used for cooking purposes. Diesel is used for D.G gensets for power back up during power cuts. Data of diesel consumption is not available separately for residential sector. Around 98.1% of households have access to electricity in Ajmer city. Slum Population of Ajmer city is 19.3% which is residing in 82 slums in different parts of the Ajmer city². Total houses under residential use are 123022 units (including only residence and residence cum other use), while the total number of households in Ajmer as per 2011 Census is 109229. Also, average household size is moderate at five persons per family.

Table 13 Energy/Fuel Consumption in Residential Sector

Fuel Type	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	MWh	213424	222041	246293	264000	271415
LPG	MT	21309	22122	22966	22604	24908
Kerosene	kl	840	856	865	876	606

Energy consumption in residential sector is directly related to the number of assets available in each household.

2.3. Commercial and Institutional Sectors Energy Consumption



As per the guidelines, “this sector includes all offices, shops, shopping centre’s, multiplexes, hotels, restaurants, advertisement bill boards, etc. and institutional buildings like hospitals, schools, colleges,

² Competitive Smart Cities in Rajasthan Report, CII-NIUA report

hostels, jails, government offices, etc. The major sources of energy uses are electricity and LPG. In addition, a variety of fossil fuels are used for power back-up, e.g. diesel generators. In some cases, biomass fuels are also used for cooking and water heating.” The Ajmer Discom has classified this under non-domestic usage and mixed load for commercial & institutional sector, as specified in table 14-15. As Ajmer is a tourist destination large number of hotels and restaurant are present in Ajmer city to cater to the tourist inflow during religious and other festival seasons like Pushkar Mela, Birth day of Khwaja Chisti, etc. There are more than 450 hotels in Ajmer city with 10-20 rooms per hotel. Ajmer also has a significant number of educational institutions prominent among them being the Mayo and Regional college. Dargah bazar, Nla Bazar, Madar Gate, Ghee Mandi , Diggi bazar , Agra gate are the main markets in Ajmer city.

Table 14 Government Hospital Building in Ajmer City

1	Allopathic	Name	Nos	Capacity of Bed
1.1	Government	Jawahar Lal Nehru Hospital	1	918
		Govt. Malila Hospital	1	290
		Kamla Nehru Hospital	20	50
		Government Satellite Hospital		50
		Government Aausdhayalaya	12	72
2	Ayurveda			
		Ayurvedic Government Hospital	2	
		Ayurvedic Government Aausdhayalaya	5	
		Total	23	1380

Source: Ajmer Master Plan, 2013-33, ADA

Table 15 Government and Semi government Building and Education Buildings

Category of building	No of Buildings	No of Deputed official 19838
Central Government	34	19838
State Government	139	12311
Semi Government	87	3055
Local Government	49	3877
others	5	1888
Total	314	40969
Institute	Government	Private
Primary school	118	71
Upper primary school	117	147
Secondary school & Higher secondary school	85	160
University	1	

Source: Ajmer Master Plan

Community Hall in Ajmer

There are 7 community halls in Ajmer which are maintained by Ajmer development authority. These buildings help the citizens to come together for some cultural or religious festivals, music shows, etc.

1. Chandravardai Nagar - A Block

2. Chandravarai Nagar - C Block
3. Chatri Yojna
4. Haribhau Upadhyay - Ext.
5. Haribhau Upadhyay - Main
6. Jawahar Rang Manch
7. Vishram Bhawan

Energy consumption in C & I sector

Based upon the data collected the total energy consumption in commercial and institutional category sector is presented in table-16. Electricity, LPG and diesel are the main energy sources used.

Table 16 Energy Consumption in Commercial & Institutional Sector

Fuel Type	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	MWh	141317	161094	179538	191234	211267
LPG	MT	1062	1118	1177	1239	1546
Diesel	kl	2995	3139	3260	3093	3087

Source: AVVNL, OMC's, DSO, Ajmer

2.4 Industrial Sector – Energy Consumption

Industries are necessary for development of the State. It indicates an optimum utilization of available minerals, agriculture, live stock and other resources required for increasing Industrial production, creating additional employment opportunities, eliminating regional imbalances, entrepreneurship and augmenting the financial resources of the state. In Ajmer district 8 medium scale Industries and 17663 small scale & cottage Industries were registered up to March, 2011. The total investment involved was Rs. 92797.54 lakh giving employment opportunities to about 87420 persons. The main Industries of the district are based on textile, food products, leather and leather products, wood products, felspars and quartz grinding, marble, asbestos and cement.

The main MSMEs of Ajmer district are die casting, engineering workshop, bread and biscuit, flour mill parts, re-rolling mills, electronics, etc. HMT Ltd is a large-scale enterprise situated on Beawar Road, Ajmer which manufactures Lathe Machines and machine tools. Another such large-scale industry is the Ajmer Dairy, which produces milk, ghee and butter.

Industrial areas in Ajmer have been developed by RIICO. HMT I and II, Makhupur and Parbatpura are the primary projects accomplished by RIICO. Gegal is another successful project of RIICO which is situated at Ajmer-Kishangarh route at a distance of around 12 km from Ajmer. This includes all types of industries falling within the municipal limits. Besides electricity, other fuels that are used are petroleum products (diesel, natural gas, furnace oil, etc), coal, biomass, etc. On account of its location and availability of better infrastructure facilities, industrial growth is noticeable in Ajmer district and surrounding areas.

Industry at a Glance

Detailed industrial data with respect to number of units, workers employed and turnover is presented in table-17 and 18.

Table 17 Industrial sector at a glance

Sr No	Details	Unit	Particulars
1.	Registered industrial unit	NO.	17663
2.	Total industrial unit	NO.	19221
3.	Registered medium & large unit	NO.	08
4.	Estimated avg. no. of daily worker employed in small scale industries	NO.	87420
5.	Employment in large and medium industries	NO.	3529
6.	No. of industrial area	NO.	30
7.	Turnover of small scale industry	In Lakh	212450
8.	Turnover of medium & large scale industries	In Lakh	231570

Source: DIC, Statistical Abstract, Ajmer

Table 18 Details of existing Micro & Small Enterprises and Artisan Units

Sl.	Industrial Category	No. of units	Employment Nos.
1	Food Products	882	4247
2	Tobacco	78	2601
3	Textile Industry	2685	17820
4	Wool s, silk and synthetic fiber textile	411	2320
5	Joot , Hump , and Masta Textiles	117	377
6	Textile Products	1002	3806
7	Furniture works	996	2968
8	Press , News and Printing	523	3788
9	Leather based	2731	1237
10	Rubber Plastic, Petroleum and coal products	343	1646
11	Chemical and chemical based	342	1749
12	Mineral based	2911	18793
13	Basic Metal & Mix Metal Non-ferrous Metal based	144	1762
14	Machinery and Machine Tools	824	3348
15	Mechanical Instruments based industry	278	1847
16	Electrical Appliances Industries	119	866
17	Transport & Equipment's and Parts	29	374
18	Other industries	2460	13682
19	Medical And Health Service Industry	8	23
20	Private Service Industry	303	1027
21	Repair and maintenance Industry	850	2095
	Total	18036	89993

Source –DIC report Ajmer

The city has a mix of MSME's with mineral based units having a major share for number of units, investments as well as employment.

Large scale industries/public sector undertaking

List of the units in Ajmer & Near by Area

- (1) Hindustan Machine Tools Ltd., Ajmer
- (2) Shree Cement Limited, Beawar.
- (3) R.K. Marbles Ltd. Ajmer
- (4) Costmet Works Pvt. Ltd. Kharva-Masuda

Major Exportable Item

- Engineering goods,
- Mineral based ball Mill, The Emery stone flour mill.
- H.M.T Machines.
- Marble & Granite, Cement.

Energy Consumption in Industrial Sector

The total energy consumption in this sector was compiled and is presented in table-20. As is seen major energy source is electricity in the sector followed by diesel.

Table 19 Energy consumers and Consumption in Industrial Sector

Electricity Consumers in Industry	2011-12	2012-13	2013-14	2014-15	2015-16
Industrial (small)	4043	4357	4157	4214	3814
Industrial (medium)	443	499	488	525	408
Industrial (large)	96	104	106	109	84
Agriculture (nursery)	1140	1025	975	870	444
Agriculture (poultry)	29	28	27	17	21
Total	5847	5672	5854	5847	5672
Electricity Consumption (MWh)					
Industrial (small)	11217	11758	12618	13127	12372
Industrial (medium)	16621	17679	19948	20824	21469
Industrial (large)	94930	106789	104054	104448	99624
Agriculture (nursery)	39	52	44	69	34
Agriculture (poultry)	2947	3049	3425	4554	5020
Total	125869	139695	141242	143453	140232
Diesel kl	1168	1224	1271	1206	1204

2.5 Municipal Sector–Energy Consumption



Under the municipal sector, the major energy consumption sources comprise of street lights and water works. Energy consumption data for these two segments is shown in Table 21, 24. Energy consumption for the Government buildings and facilities falls under the commercial & institutional sector.

Street Lighting details of Ajmer

Street lighting in Ajmer city comes under the Ajmer Municipal Corporation which consisted of 55 municipal wards. ADA, Ajmer and Rajasthan State Industrial Development and Investment Corporation (RIICO), Ajmer also have some street lighting in their area. Details of existing street lights as on base line year 2015 is shown below.

Table 20: Street light details in Ajmer city

Conventional Street Light			
S. No.	Earlier Wattage of Lamp(W)	Quantity	Wattage of existing Street Lighting
1	HPSV-800W	67	800
2	HPSV-400W	8	400
3	HPSV – 150W	20	150
4	TL -96W	1428	96
5	HPSV - 70W	2	70
6	FTL-56W	5450	56
7	FTL - 40W	63	40

8	CFL - 36W	17	36
9	CFL - 28W	22876	28
10	CFL - 20W	59	20
11	CFL -15W	3	15
12	New Pole HPSV – 150W	834	70
13	New Pole HPSV – 70W	743	150
Total		31570	

The total energy consumption in street lights is shown below. Only recently have AMC started to shift GLS bulbs, tube lights, mercury and sodium vapor lamps with LED street lights. And this will result in huge savings on the energy cost.

Table 21: Annual Consumption of Energy in Street lighting in Municipal Sector

Fuel Type	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	MWh	16482	16513	18182	17543	19296

Water Supply in Ajmer City

The main source of drinking water supply in Ajmer city is Bisalpur water project, Foy sagar lake, tube well and hand pumps in and around the city and the tube wells located in Ajmer. Various details of the water supply system in the city is presented below. Ajmer City has 18 Over Head tank which have a capacity of 12895 kl. Beside 23 CWR tanks are also available in Ajmer city for water supply. There are 63495 residential connections and 295 public connections in Ajmer³. City supply is about 115 million liter per day.

Table 22 Water connection details in Ajmer

Particulars	Number of connection	% share of connections
Residential	63495	90.34%
Commercial	5885	8.37%
Government	79	0.11%
Industrial	534	0.76%
Public and Other	295	0.42%
Total	70288	100.00

Source AMP2013-33-AJMER report

The industrial connections include the bulk supply like water to railways, Military settlements, Malls, Industries, etc. There are also a 6 Sulabh toilet complex's within the corporation area of Ajmer.

Electricity consumption details in water supply of Ajmer city

Energy consumption in this sector is presented in table-24. Electricity is the major energy source in this sector.

³ 2013, Ajmer Master Plan report, ADA

Table 23 Consumers and Annual Consumption of Energy in Water works in Municipal Sector

Category	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Consumer numbers						
Water works (small)	242	269	286	324	347	242
Water works (medium)	21	22	22	24	27	21
Water works (large)	6	8	8	9	16	6
Total	269	299	316	357	390	269
Electricity consumption (MWh)						
Water works small	1200	1318	1493	1425	1854	1200
Water works (medium)	1447	2055	2261	1979	2388	1447
Water works (large)	8669	7897	9072	8702	9458	8669
Total	11316	11270	12826	12105	13700	11316

Source: AVVNL

2.6 Transportation Sector–Energy Consumption



Ajmer is a famous tourist city of Rajasthan and tourists come here from across the world and country. Due to this there is a large vehicular traffic flow throughout the year and peaking during holiday and festive seasons. Transport sector is providing employment to local people who run local taxis, buses, intercity ticketing, rickshaws, etc. Under the transportation sector, the major energy

consumption source comprises of bikes, auto rickshaws, tempo, taxis, city buses, trucks, etc. There are over thousand 3 wheelers that ply around the roads of the city that mostly run on diesel.

Table 24 Vehicle Registration data in Ajmer district.

Vehicle type	Cumulative Upto march 2015	During 2014-15
Two Wheeler	465812	27547
Auto rickshaw	5188	177
Passenger	1504	83
Goods carrier	4570	320
Car	37918	2472
Jeeps	12913	1347
Tractors	19922	970
Trailers	1532	0
Taxi/Maxi/Cab	4581	288
Buses	3365	95
Trucks	16923	1065
Others	1217	76
Total	575445	34440

Source: District Statistical handbook, Ajmer, 2015

Based upon data provided by the oil marketing companies (IOCL, BPCL and HPCL) and primary survey the energy consumption of transport sector is presented below.

Table 25 : Energy Consumption in Transport Sector

Fuel Type	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
Petrol	kl	39144	39560	40385	44046	46914
Diesel	kl	67790	68418	68486	69106	69728

Source: IRADe analysis and projections

2.7 Total Energy Consumption of Ajmer City in Energy Base Year 2015-16

Total energy consumption for base year 2015-16 and recent past years were calculated as per MNRE guidelines. The total consumption values were converted to *GWh* using standard energy conversion factors. Diesel has the largest share of energy consumption of total energy consumption of the city with 35% followed by electricity 29%, petrol from transportation sector 20% and LPG consumption in Ajmer city is 16 % of total energy consumption of the city in 2015-16 Energy baseline year. Table 27 and 28 show the energy consumption data and figure-9 shows the share of each fuel in the city.

Table 26 : Total Energy Consumption Fuel wise (Actual Quantities)

Energy/Fuel	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	MWh	497091	539343	585254	616231	642210
LPG	MT	22371	23240	24143	23843	26454
Kerosene	kl	840	856	865	876	606

Petrol	kl	39144	39560	40385	44046	46914
Diesel	kl	71954	72782	73017	73406	74019

Table 27 Total Energy Consumption in GWh terms

Fuel Type	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	497	539	585	616	642
LPG	304	316	328	324	360
Kerosene	9	9	9	9	6
Petrol	380	384	392	427	455
Diesel	770	779	781	785	792
Total	1960	2027	2096	2162	2255

Source: IRADe analysis

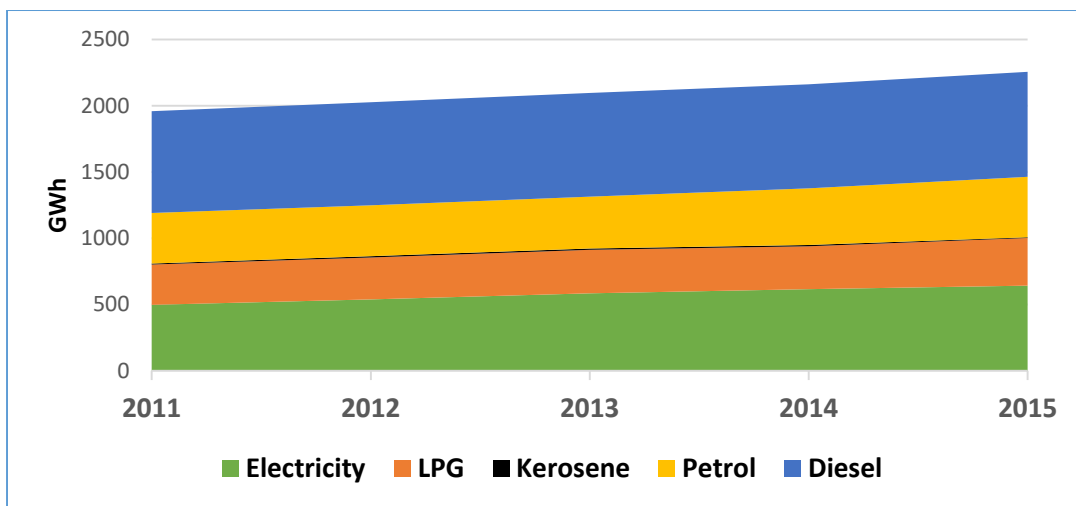


Figure 9 Year Wise trend of Energy consumption in Ajmer City in GWh

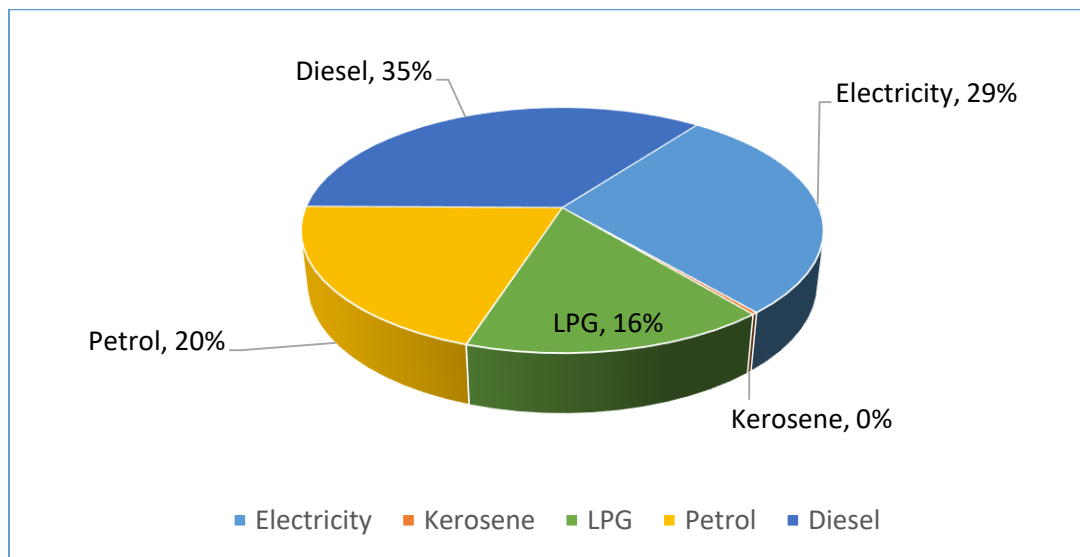


Figure 10 Energy Consumption share in Ajmer for Base Year 2015-16

2.8 Green House Gas Emissions of Ajmer City



Emissions are a direct byproduct of the fossil fuels used by various sectors of the economy, globally Governments are getting concerned about this rising emission trends from all sectors and increasing economic growth is further swelling this. Common city level emissions normally comprise of PM_{2.5}, PM₁₀, NO_x, SO_x, CO₂, CO, CH₄ which are generated due to natural climactic conditions and manmade interventions like power plants, transport fuels, construction sites, etc. This section captures the CO₂ equivalent emissions from all sectors of the economy.

2.8.1 Residential Sector – CO₂ Emission from Different Types of Energy Sources

As can be seen from figure below electricity has maximum share of GHG emissions in residential sector 77% and kerosene has the least share at 0.5% in 2015-16. Although this emission would applicable at the point of electricity generation, but in order to quantify the overall impact for the country the same is presented here.

Table 28: CO₂ Emission from different Energy Sources of Residential Sector in Ajmer city

Year wise GHG's Emissions 000' MT of CO ₂ equivalent in Residential Sector					
Energy source	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	209	218	241	259	266
LPG	66	69	71	70	77
Kerosene	3	3	3	3	2
Total	278	289	315	332	345

Source: IESS 2047, Planning Commission now Niti Aayog, Gol, UNFCCC, for emission factors

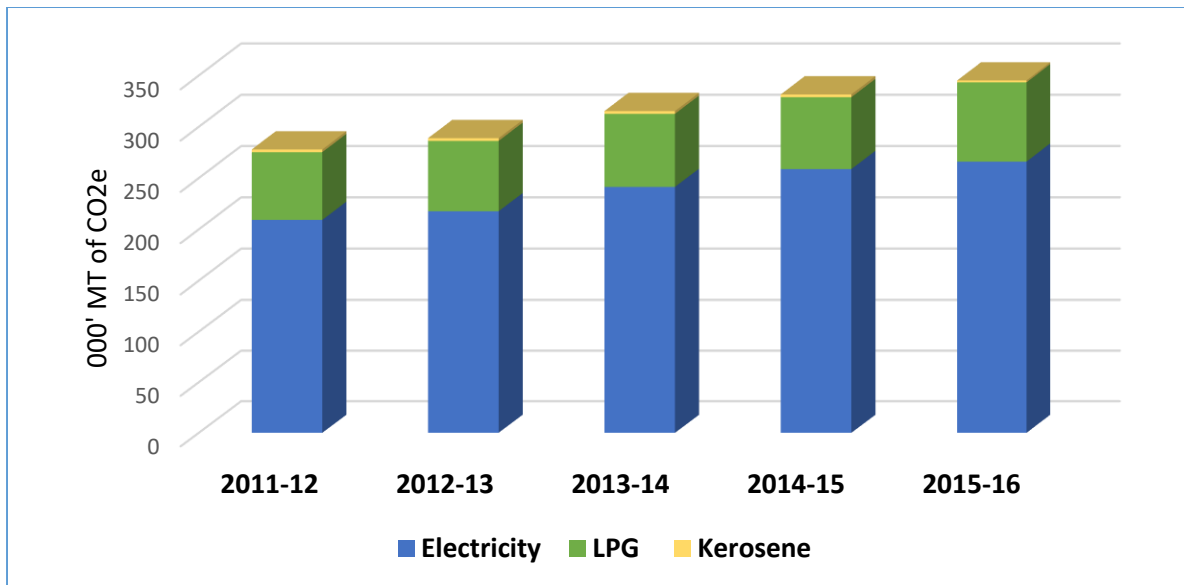


Figure 11: CO₂ Emission from Residential Sector in Ajmer city

2.8.2 C & I Sector – CO₂ Emission from Different Energy Sources

As can be seen from figure below electricity has maximum share of GHG emissions in C&I sector 95% and LPG has the least share at 2%. Here also we need to mention that actual emission from electricity would be at the power plant.

Table 29 : CO₂ Emission from Different type of Energy Sources of C & I Sector

Year wise GHG's Emissions 000' MT of CO ₂ equivalent in C & I Sector					
Energy Source	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	138	158	176	187	207
LPG	3	3	4	4	5
Diesel	7	7	7	7	7
Total	148	168	187	198	219

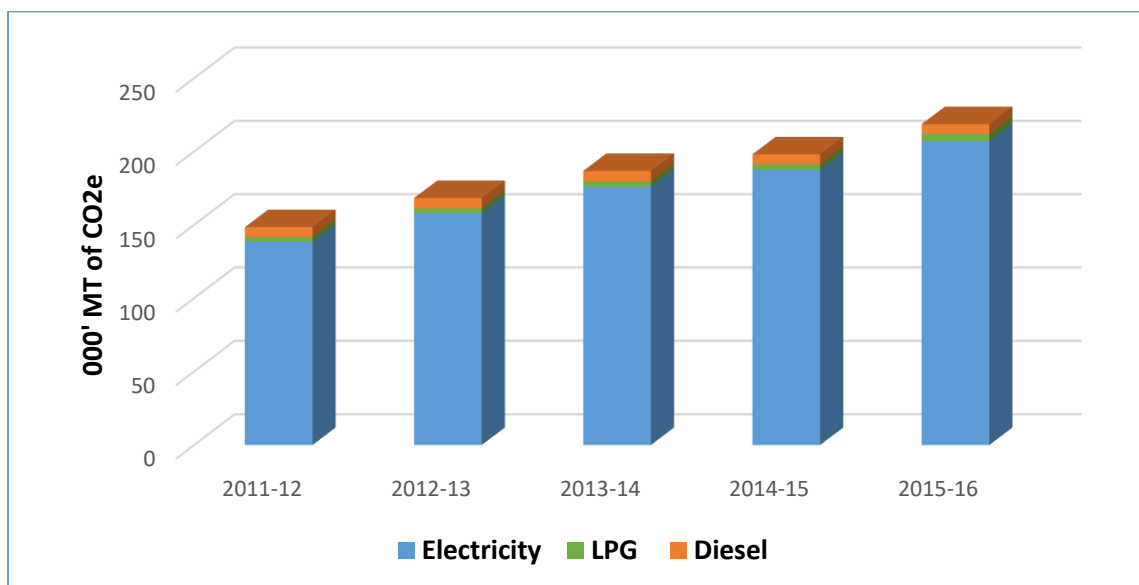


Figure 12: CO₂ emission from C & I Sector in Ajmer city

2.8.3 Industrial Sector –CO₂ Emission from different types of energy sources

As can be seen from table and figure below electricity has maximum share of GHG emissions in industrial sector at 98% followed by diesel with 2%.

Table 30 : CO₂ Emission from Different type of Energy Sources of Industrial Sector

Year wise GHG's Emissions 000' MT of CO ₂ equivalent in Industrial Sector					
Source	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	123	137	138	141	137
Diesel	3	3	3	3	3
Total	126	140	141	143	140

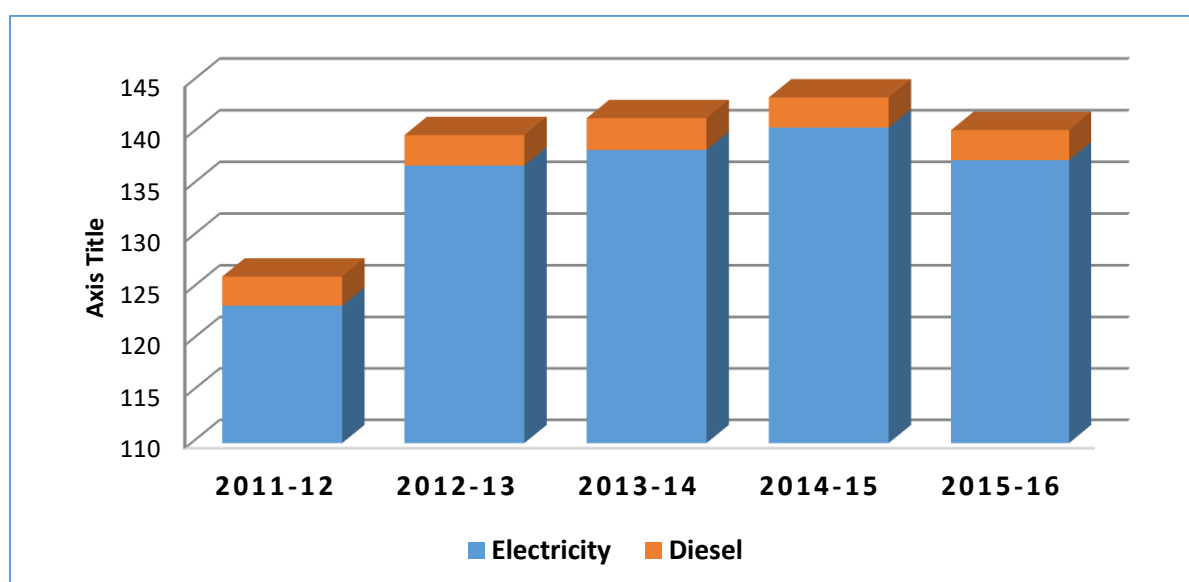


Figure 13: CO₂ emission from Industrial Sector in Ajmer city

2.8.4 Municipal Sector – CO₂ Emission from energy use

Electricity is only the major factor responsible for GHG emissions in Municipal sector.

Table 31: Emissions in Municipal Sector in Ajmer City

Year wise GHG's Emissions 000' MT of CO ₂ equivalent in Municipal Sector					
Source	2011-12	2012-13	2013-14	2014-15	2015-16
Electricity	16	16	18	17	19

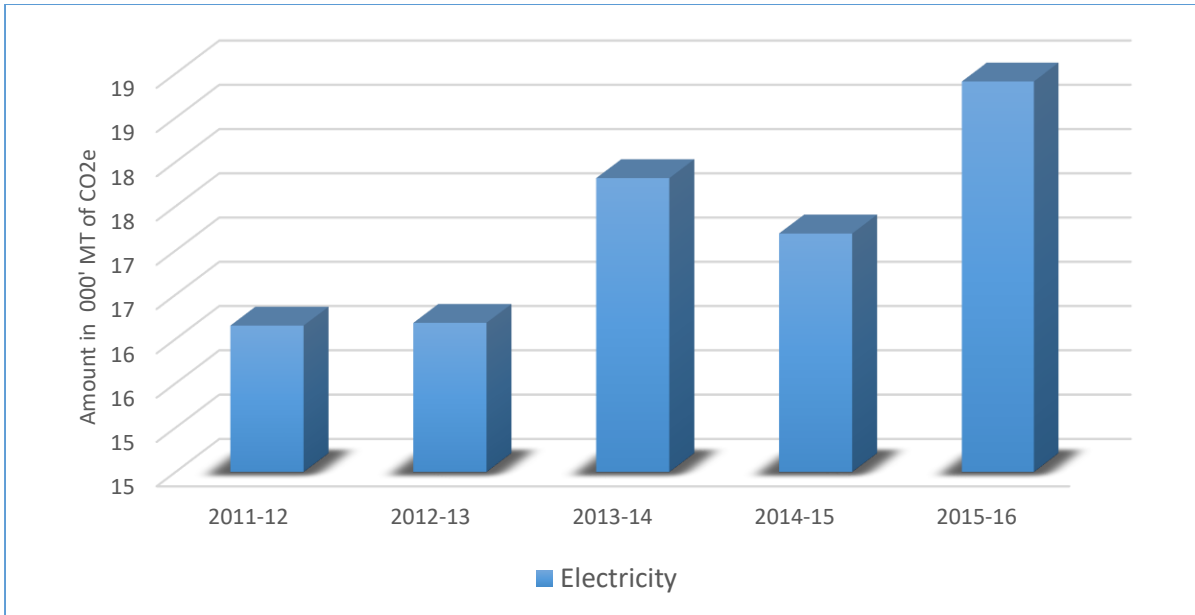


Figure 14: CO2 emission from Municipal Sector

2.8.5 CO₂ Emission from Transportation Sector

Transportation is a major sector for GHG emissions in the Ajmer city. In 2015-16 as can be seen from figure below Diesel has maximum share of GHG emissions in Transportation sector at 54 % and Petrol has 46% share of GHG emissions.

Table 32 : CO2 Emission from Transportation Sector (000' MT)

Fuel	2011-12	2012-13	2013-14	2014-15	2015-16
Petrol	121.4	122.7	125.3	136.6	145.5
Diesel	163.6	165.2	165.3	166.8	168.3
Total	285.1	287.9	290.6	303.5	313.8

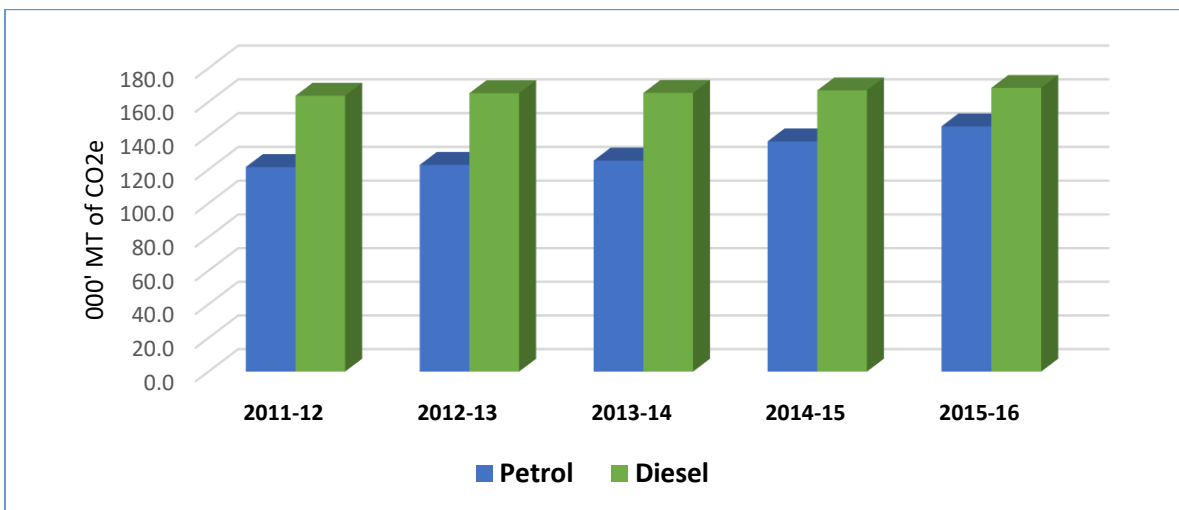


Figure 15 : CO2 Emission trend in last five years in transport in Ajmer

2.8.6 CO₂ Emission from All Sectors

CO₂ emission from all the sectors in energy base year 2015-16 and past year is shown in table 34. Total GHG emissions of Ajmer City in Energy Base Year 2015-16 is 1037 thousand MT of CO₂e of which residential Sector has maximum share of GHG emissions at 33 %, C& I Sector and Industrial both has 21 % and 14 % share of GHG emissions, Transportation Sector has 30 % share of GHG emissions, Municipal Sector has least share of 2 % of GHG emissions.

Table 33 : CO₂ emission from all sector in Ajmer sector

CO ₂ eq Emissions (000' MT of CO ₂)					
Sector	2011-12	2012-13	2013-14	2014-15	2015-16
Residential	277.9	288.9	315.3	331.6	345
C & I	148.4	168.2	186.8	198.1	219
Industrial	126.2	139.9	141.5	143.5	140
Municipal	16.2	16.2	17.8	17.2	19
Transportation	285.1	287.9	290.6	303.5	314
Total	854	901	952	994	1037
Annual Growth rate of GHG emissions		5.6%	5.7%	4.4%	4.3%

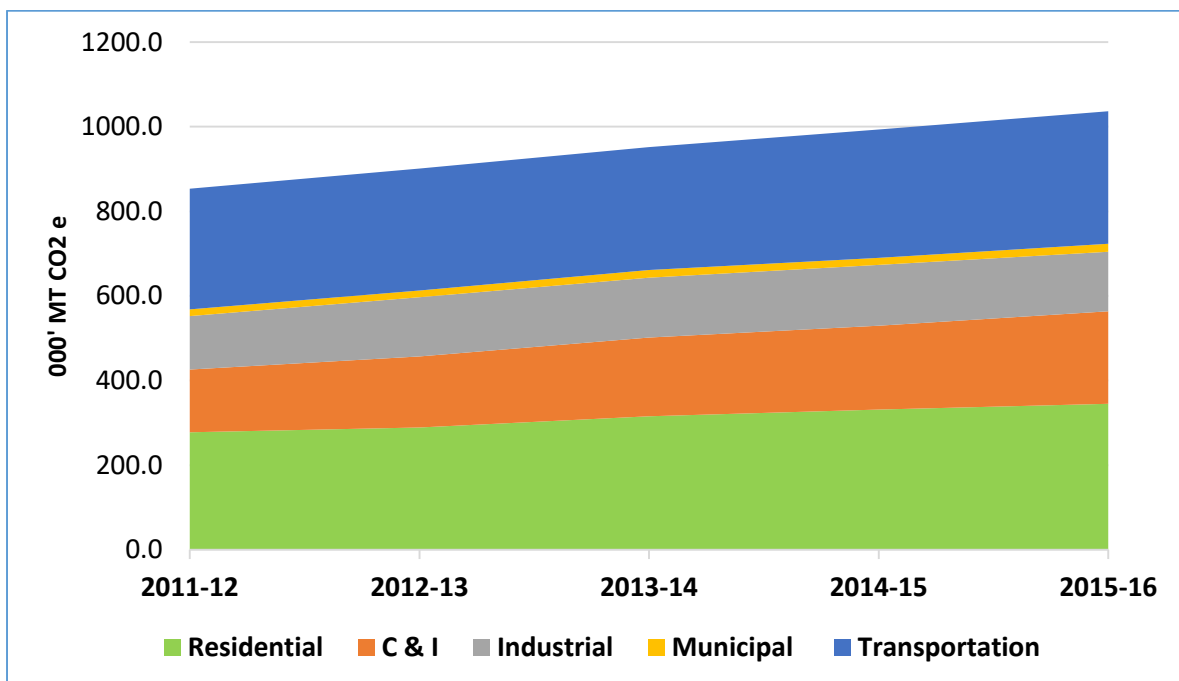


Figure 16 : CO₂ Emission trend in last five years in Ajmer

Fuel wise emissions share is presented in figure 17 below showing maximum share by electricity followed by diesel. It may be noted that electricity emissions would be applicable at the power plant but the end user is indirectly responsible for this emission on account of electricity use.

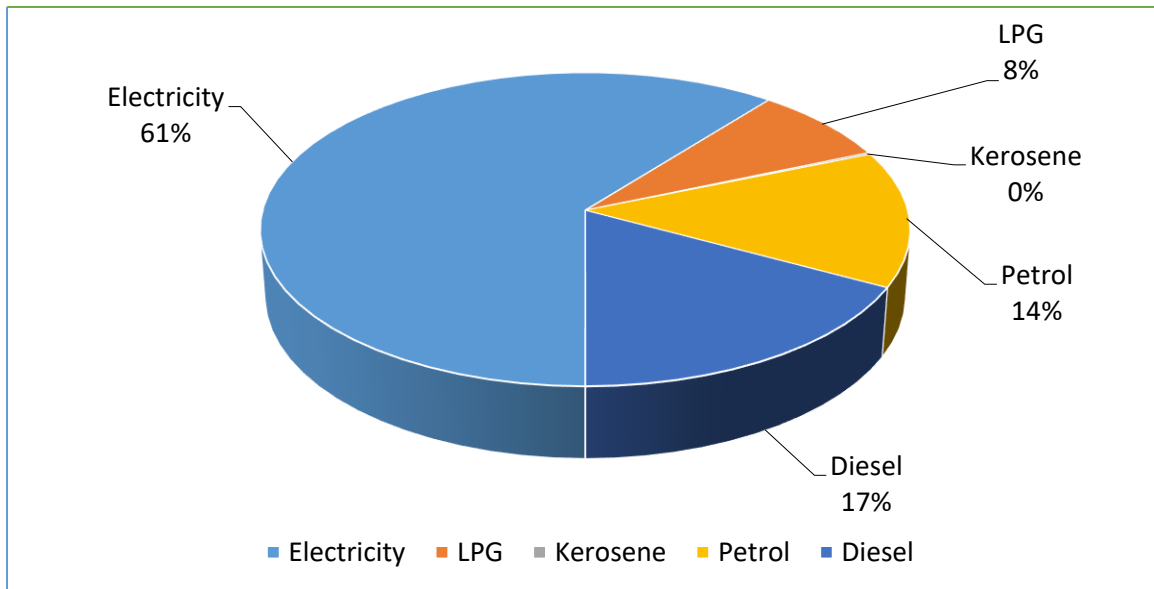


Figure 17 : GHG's emission from different types of fuel in 2015-16

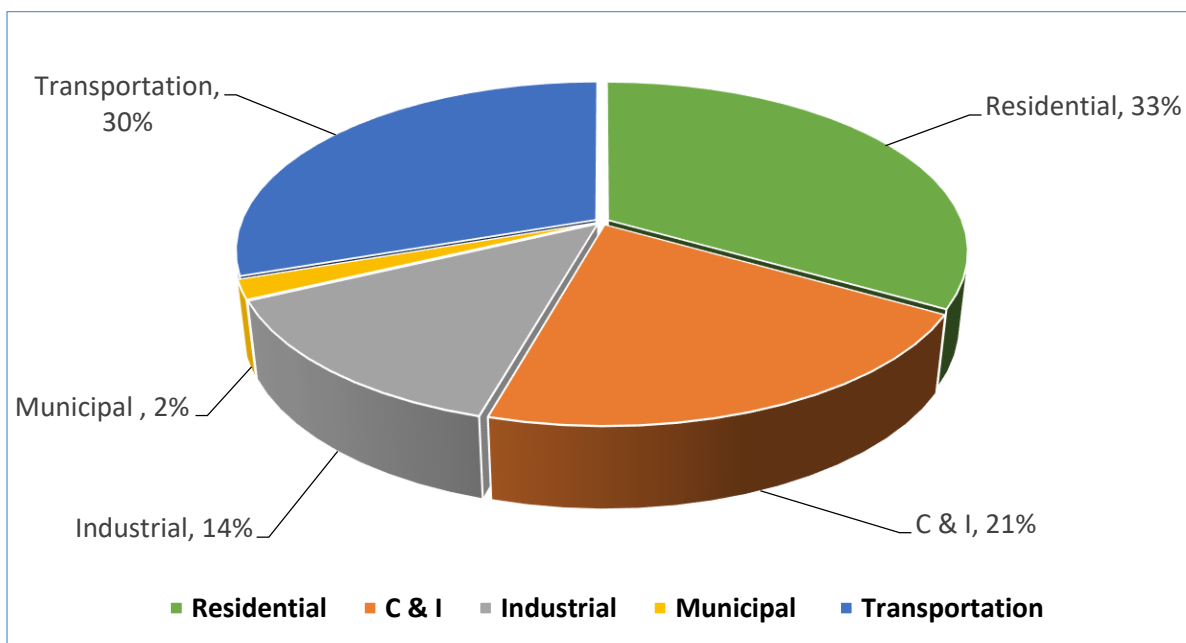


Figure 18: Sector wise % Share of GHG's emission in Ajmer 2015-16

The subsequent chapter will detail the energy demand for the city for next five and ten years.

Chapter - 3

Energy Demand Forecasting

An important factor for assessing the future trajectory of energy use for any region or sector is to analysis the future demands for each fuel and energy source. This chapter forecasts the future energy consumption and demand patterns for Ajmer based on past energy consumption data, baseline energy consumption, population and economic growth rates, etc. Parameters analysed for projection of energy demand comprise of forecasting using regression techniques and best fit curve methods and data co-relation of each variable with population and GDP using Pearsons co-efficient of the two arrays of data sets to plot the forecasted values. GDP, population and transport fuels (petrol and diesel) have shown significant co-relation (0.7-1.0), household fuels have shown less co-relation.

The FORECAST function used comprises of variables (x, known_y's and known_x's) the function then returns the predicted value of the dependent variable (represented in the data by known_y's) for the specific value, x, of the independent variable (represented in the data by known_x's) by using a best fit (least squares) linear regression to predict y values from x values.

If we assume that data pairs are plotted in a scatter plot with x values that are measured on the horizontal axis and with y values that are measured on the vertical axis, FORECAST returns the height of the best fit regression line at the specific value x on the horizontal axis. FORECAST is the value of y that would be predicted based on both the value of x and the regression line (characterized by its slope and intercept that can be found by using SLOPE and INTERCEPT functions). The function also generates the slope equation and R² value to determine the fit.

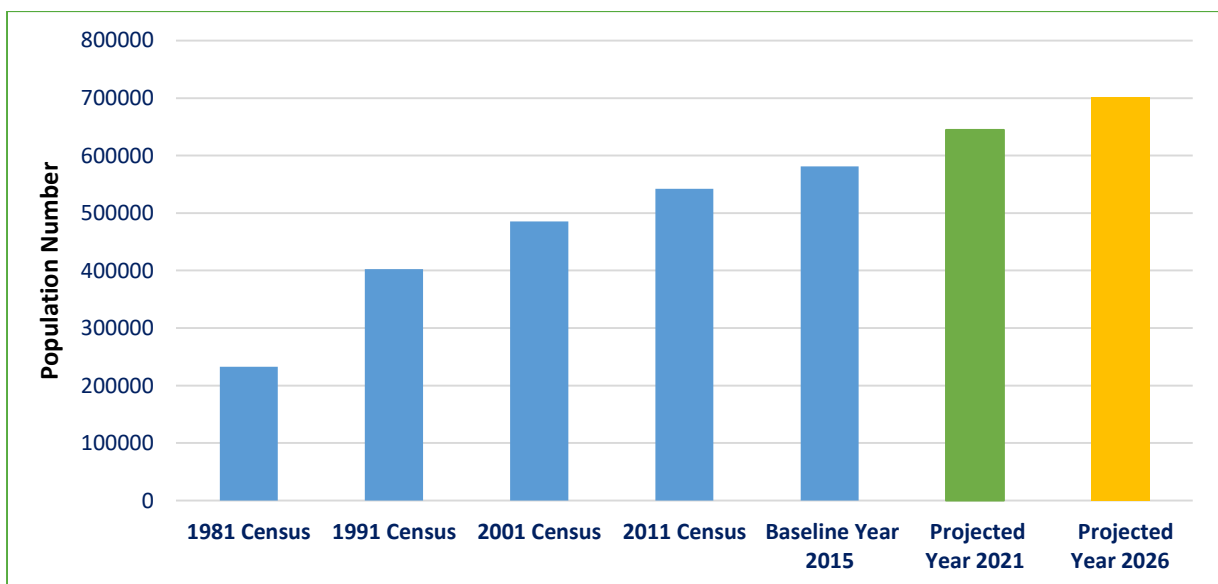
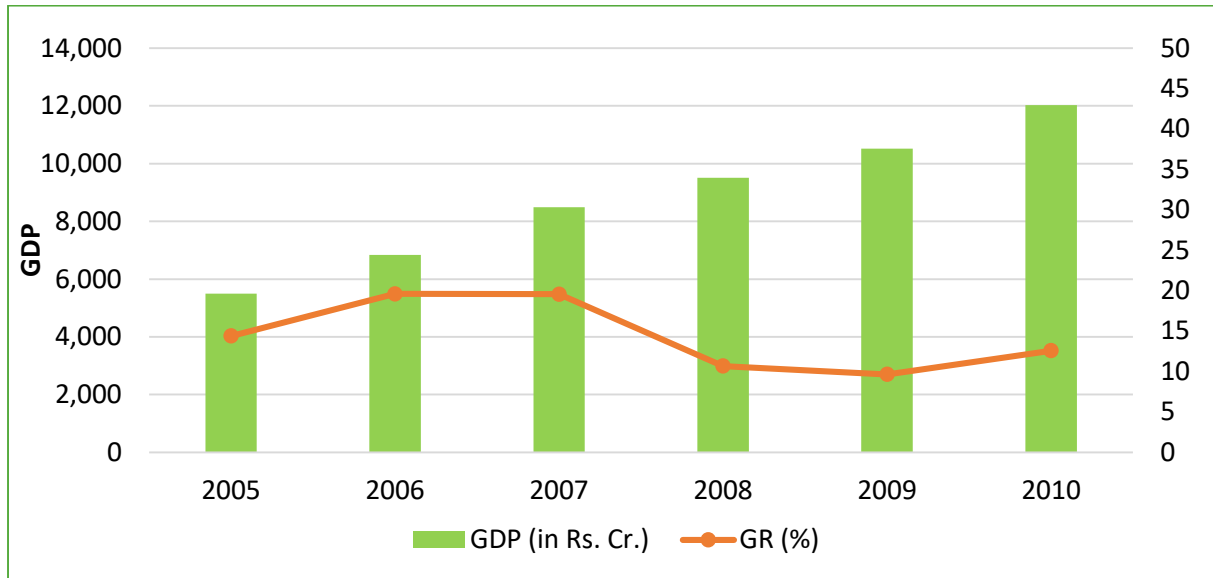


Figure 19: Ajmer City Population Census Data and Projected Population for 2021 & 2026

Population of Ajmer city was 581063 in the energy base line year, which is likely to reach 644427 in 2021 and 702478 in 2031 year under the current trend. Ajmer districts GDP is also analysed and it has been growing at a CAGR of 12.5% during the data period. The figure 19 provides the future population trajectory of the city while figure 20 shows the district GDP and its annual growth rate trend. The

conventional energy demands in the city, based on each of the strategies and variables have been independently been extrapolated and detailed in figure 21.

As seen in all the figures due to small size of the city and more or less linear trend in population and GDP across the time horizon, a similar trend is also seen in the fuel consumption. While all the fuels and energy sources have shown a rising trend in its consumption, kerosene has shown an opposite trend, this is mainly due to the governments intervention to reduce kerosene use as a household fuel.



Source: Data.gov.nic.in

Figure 20 Ajmer District GDP and annual growth rate

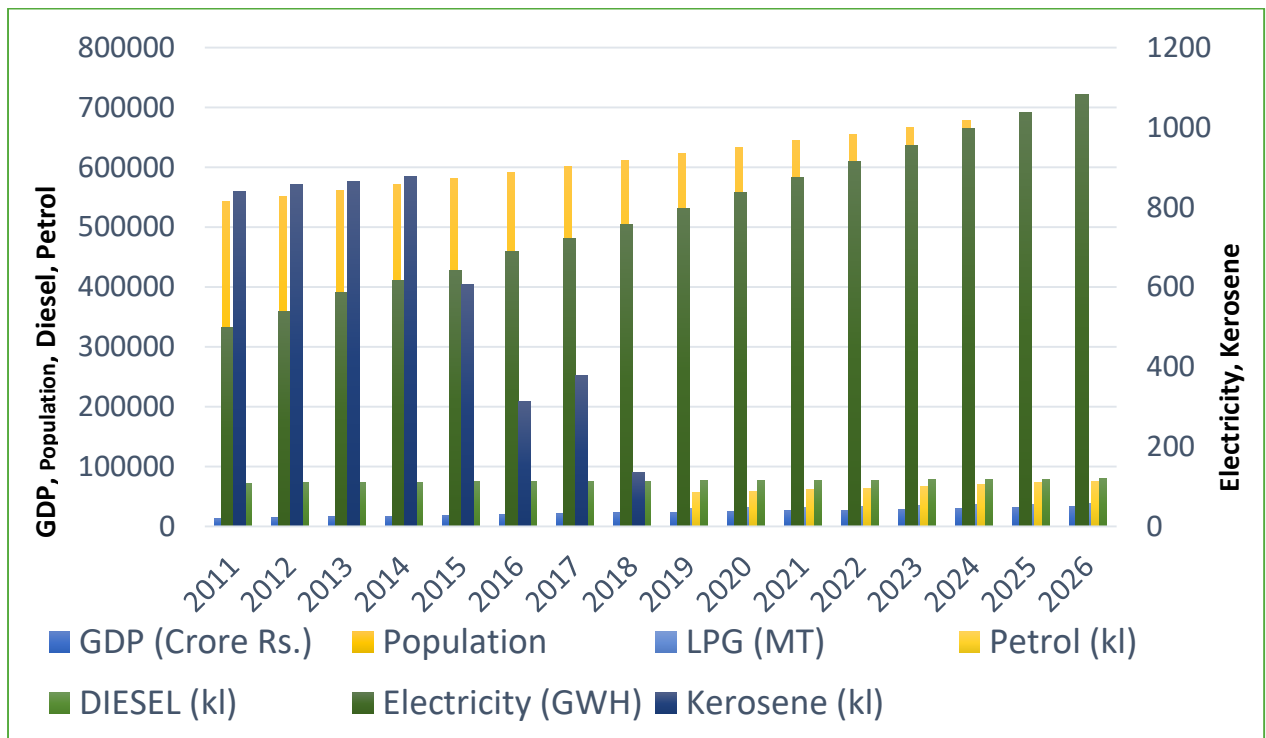


Figure 21 Energy demand projection for Ajmer city

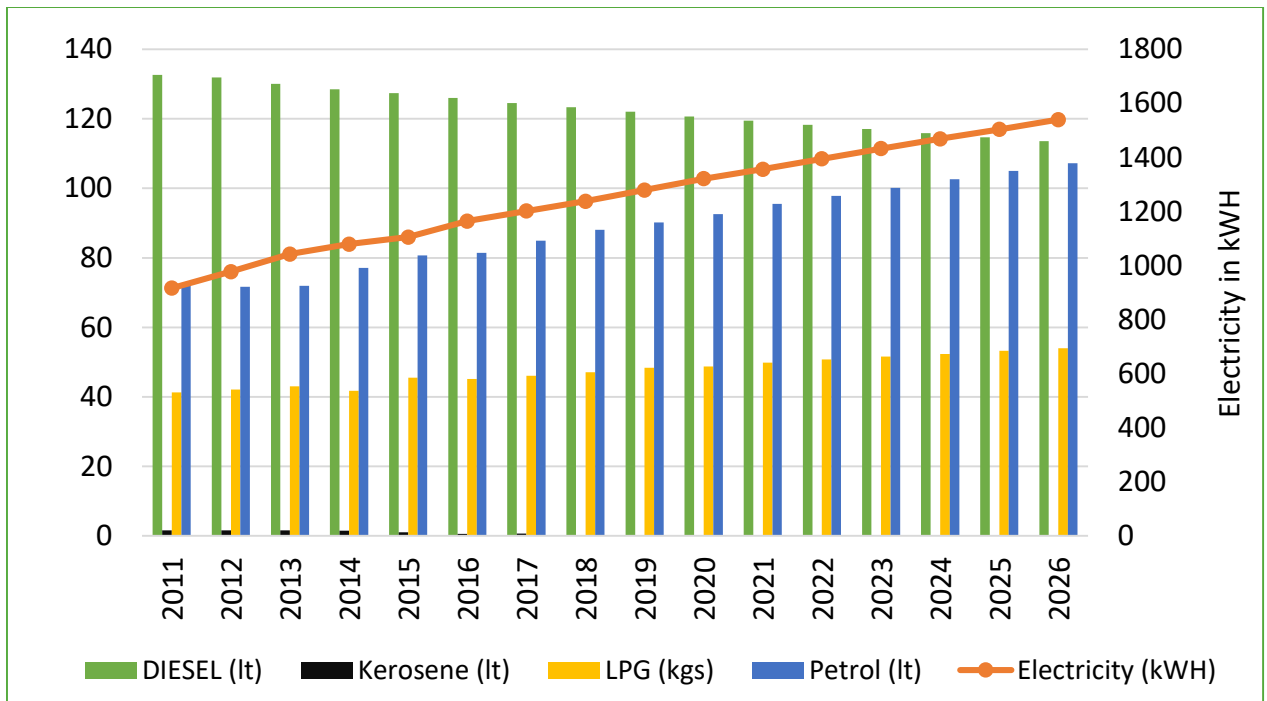


Figure 22 Annual Per capita consumption of energy sources

As is seen in figure 22 the percapita figures give a diverse picture for consumption of each fuel, while electricity goes up from existing 1105 kWh in 2015 to 1540 kWh/yr in 2026 and petrol from 81 lt/yr to 107 lt/yr, LPG from 46 kg/yr to 54 kg/yr from base year to 2026-27. Diesel and kerosene show a reducing trend, mainly due to shift to cleaner forms of cooking, transport and cooking and lighting fuel use.

3.1 Forecasting for the year 2021-22 and 2026-27

The projections for fuel consumption have been done on the basis of past fuel consumption trends of the city. The data was subjected to multiple variable regression with population and GDP as known variables and fuel data as unknown variable. Recent 5-year data was used for energy projection. Per capita income and consumption figures were also calculated to see the trend consistency. Table 34 summarizes projections for the year 2021-22 and 2026-27.

Table 34: Energy Demand Forecast for different fuels

Fuel Type	Unit	Values		
		2015-16	2021-22	2026-27
Electricity	(GWH)	642	874	1082
Kerosene	(kl)	606	0	0
LPG	(MT)	26454	32144	37933
Petrol	(kl)	46914	61557	75328
Diesel	(kl)	74019	76983	79757

Fuel Type	Energy Demand in GWH	
	2021-22	2026-27
Electricity	874	1082
Kerosene	0	0
LPG	437	516
Petrol	597	731
Diesel	824	853
Total	2732	3182

In order to bring all the energy consumption values at a single points the individual data has been converted to GWh (Figure-23). Major fuels are shown in Figure-24.

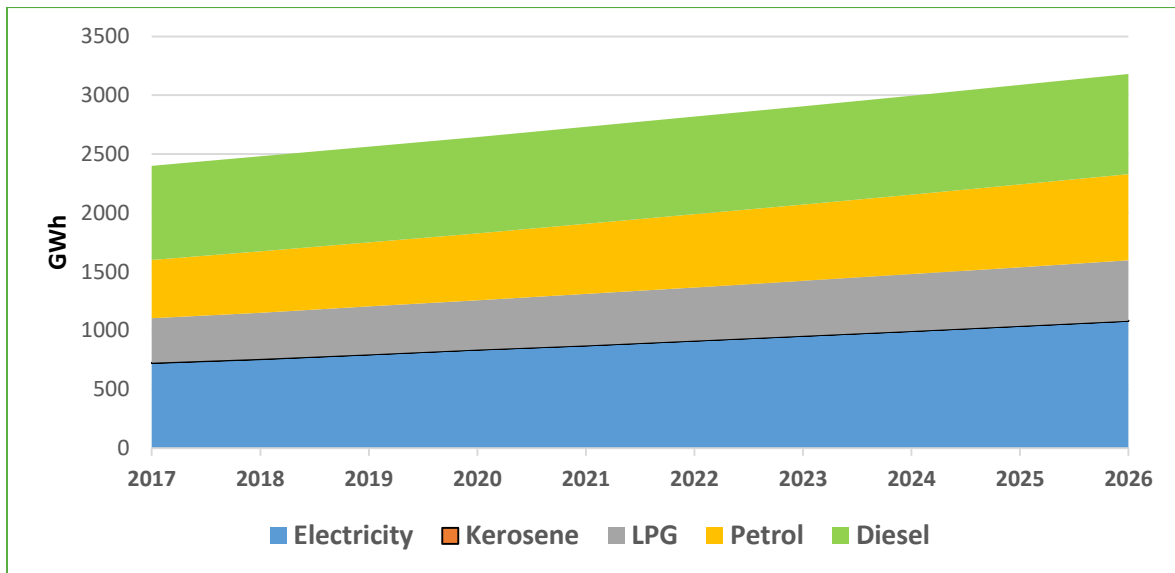


Figure 23: Energy Demand Forecast in GWh

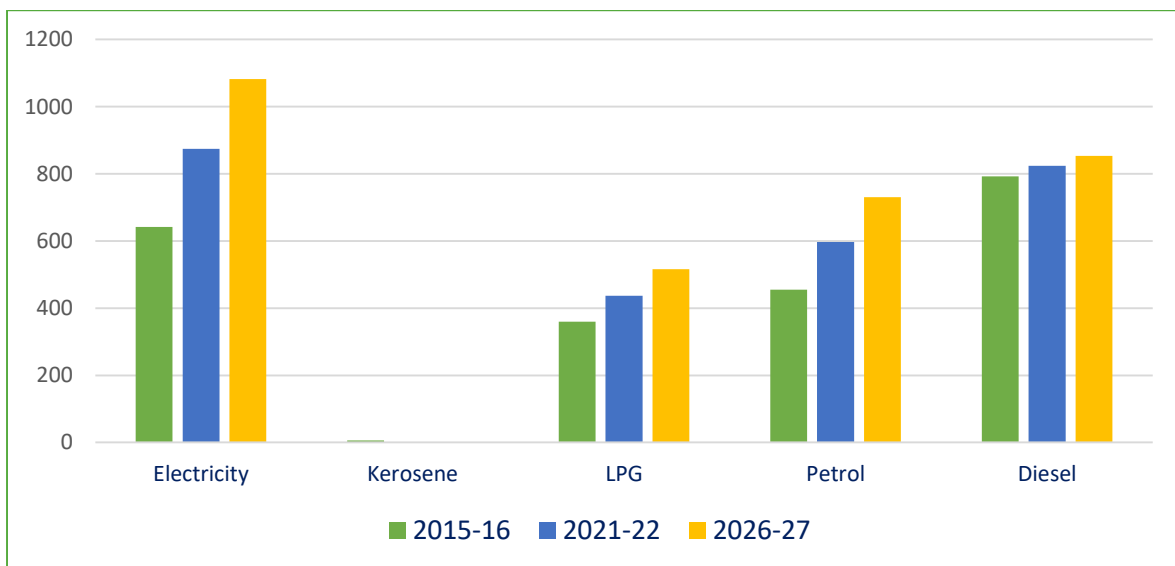


Figure 24: Energy consumption and demand scenario graph in different years

3.2 Goal for the Year 2021-22

For energy reduction and EE targets electricity, LPG and Kerosene have been analysed as they have a direct impact on reduction, diesel use in industry for electricity generation is also considered. Since the transportation sector is not included in this study, petrol and diesel consumption data is not analysed separately for transport sectors. Based on this data, total energy demand for the year 2021-22 and 2026-27 are 1311 GWh and 1598 GWh respectively. Targeted reduction in energy consumption (10% of the total based on past data projection) for the year 2021-22 would be 131 GWh for the first Five Year Plan and 160 GWh in 2026-27.

Table 35: Energy Demand and Energy Demand Reduction Target for Ajmer city

Energy Statistics	2021-22	2026-27
Energy Demand Target in GWh	1311	1598
Target energy demand reduction in GWh @10 % of Total Energy demand	131	160
@ 5 % from Renewable Energy Installation	66	80
@ 5 % from Energy Efficiency Installation	66	80

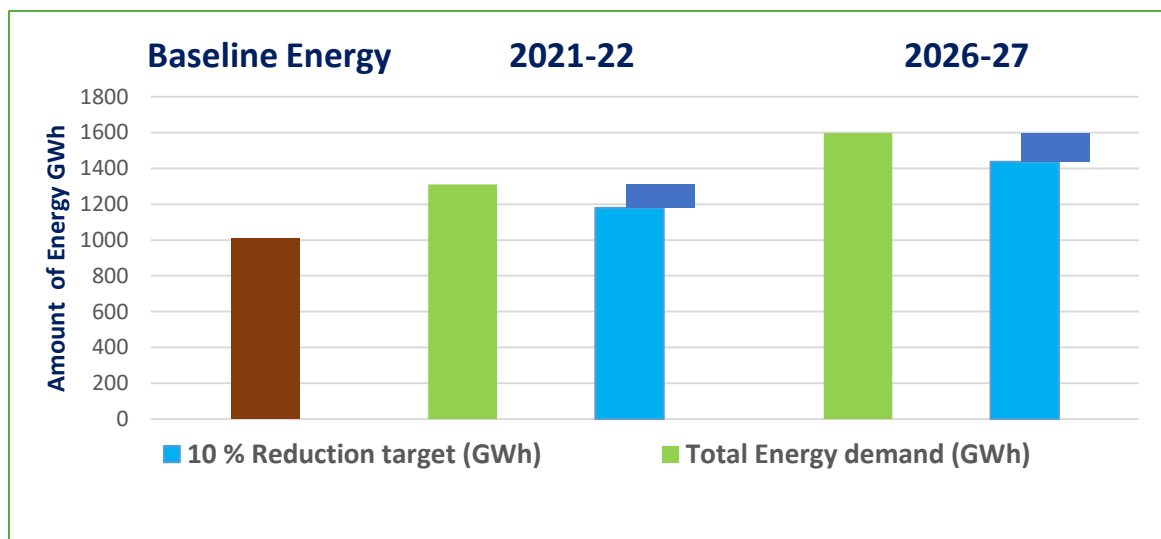


Figure 25: Energy Demand Target and 10 % Energy Reduction Target

Subsequent report chapters will comprise of analyzing the ways and means of achieving these targets through renewable energy and energy efficiency interventions along with resource assessment potentials.

Chapter - 4

Renewable Energy Resource Assessment

Renewable energy resource assessment comprises of identifying the potentials of local energy resources comprising of solar radiation and area potentials, wind power, biomass resources, small hydro and energy recovery potential from municipal solid waste and sewage treatment plant. MNRE has undertaken many studies and reports with respect to potential identifications and the same reports, charts and maps along with other published sources have been referred for identifying local potential. The strategy has been prepared for each sector, identifying most techno-economically viable renewable energy potential, to achieve a reduction of energy consumption of at least 5% from renewable energy resources on completion of the solar city project in the city.

4.1 Solar Energy



Solar energy potential of an area is directly related to the daily global and normal radiation falling over a sq.m. of the surface area and the number of sunny days and sunshine hours per day. Rajasthan state is one of the areas that receives the highest amounts of solar radiation in the country and sunny days are also amongst the highest in the country. This in turn relates to the geographical location of the place to be evaluated.

In case of Ajmer the city's is located at coordinates ranges from $26^{\circ}38'45''$ to $26^{\circ}52'52''$ Latitude North and from $74^{\circ}56'84''$ to $74^{\circ}70'12''$ Longitude East, which receives a good amount of solar radiation as the average annual solar radiation is 5.14 kWh/M²/Day for Ajmer is presented in the Figure-26. Ajmer received the maximum radiation in the months of March to June, being the summer months and least during July-August and December-January being the monsoon and winter months refer Table-37 and figure-27.

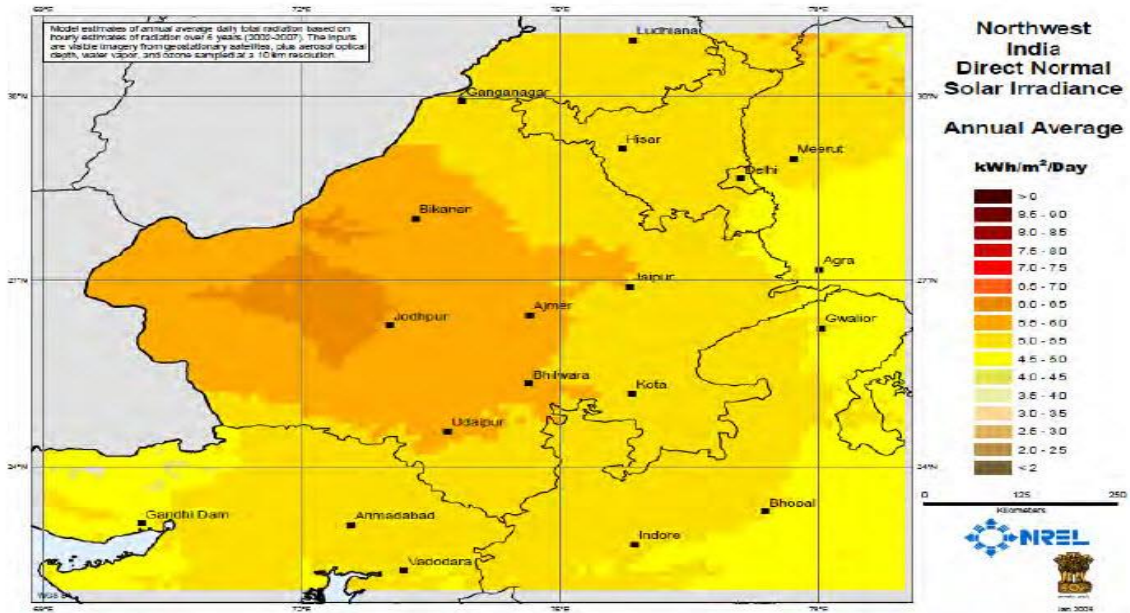
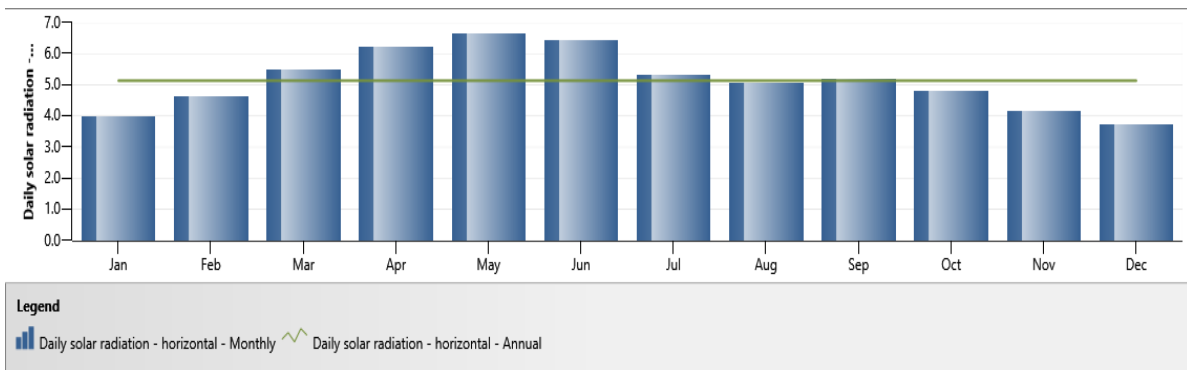


Figure 26 Direct normal solar irradiance over Rajasthan

Table 36 : Solar Radiation Received at Ajmer City

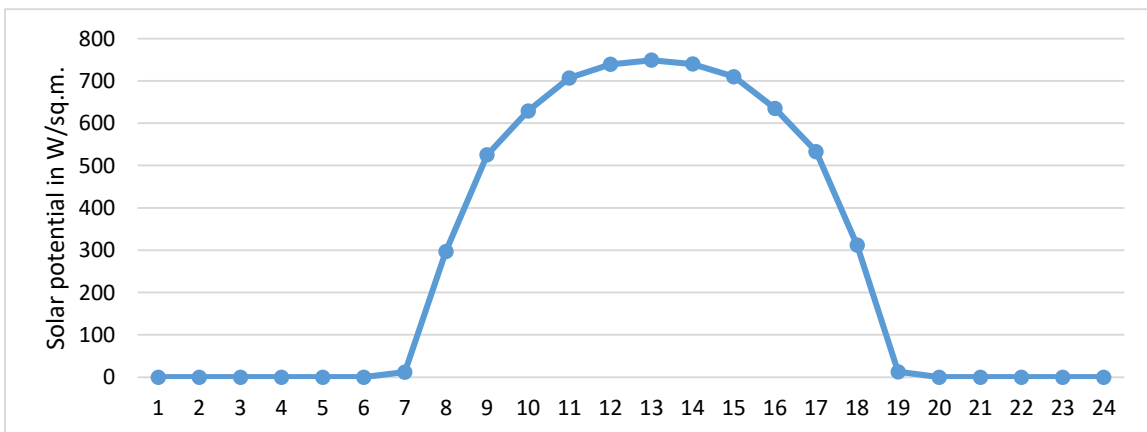
Year	Month/Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	kWh/m ² /d	4.01	4.62	5.48	6.21	6.67	6.46	5.33	5.07	5.18	4.80	4.17	3.72

Source: REC Ret Screen



Other important factors that to be considered are temperature, rainfall and daily movement of the sun for site identification and daily power generation potentials. Figure-27 and 28 present the temperature and a typical one-day solar potential over the region.

Figure 27: Hourly curve of daily solar potential



Solar roof top Potential in Ajmer city

A typical yearly day length of sunlight over the city is shown in figure 29. A typical monthly data for solar insolation and temperature is presented in figure 30.

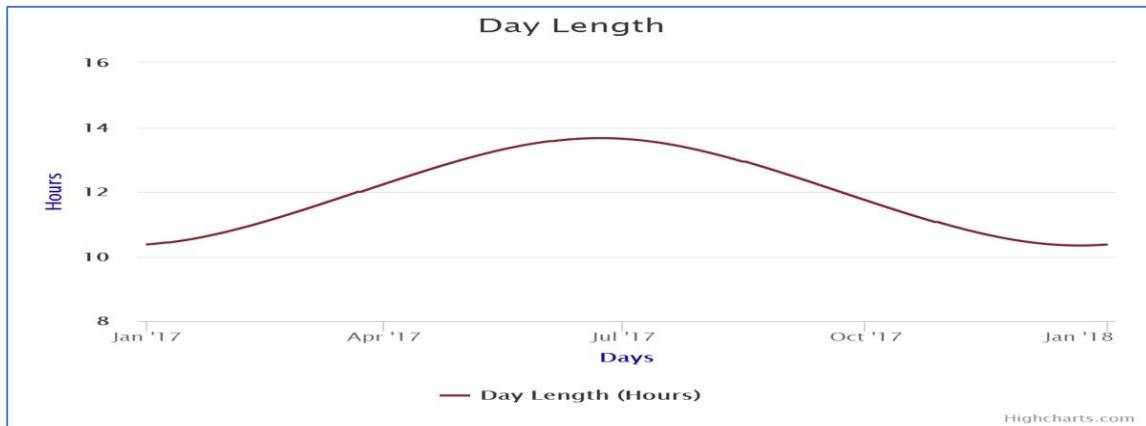


Figure 28 Typical day length chart over Ajmer city for one year

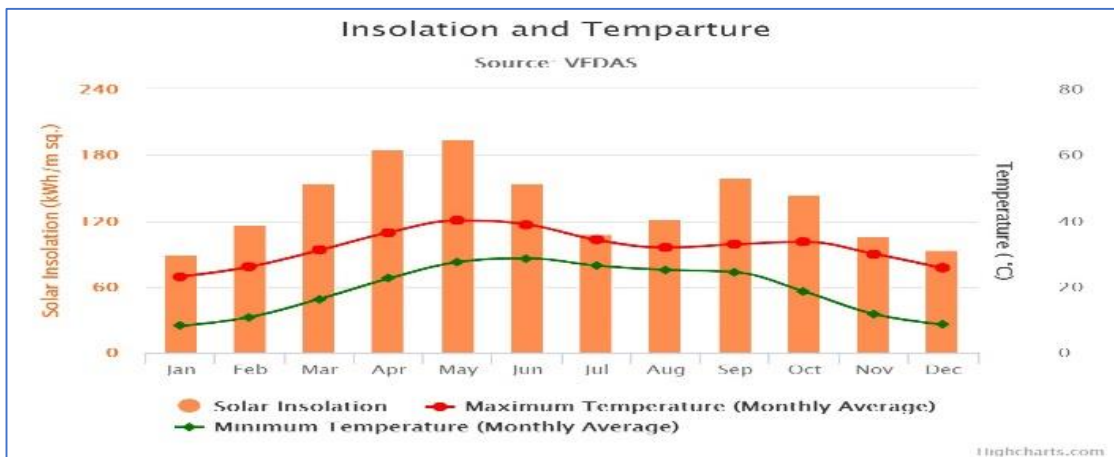


Figure 29 Monthly Solar Insolation and Temperature

Assuming 25% households are available with a spare roof space of 100 sq.ft on the conservative side, with permanent concrete roof structure for installing SPV rooftop power plants of 1KW each. The total power generation potential for roof top works out be 32 MW in the city.

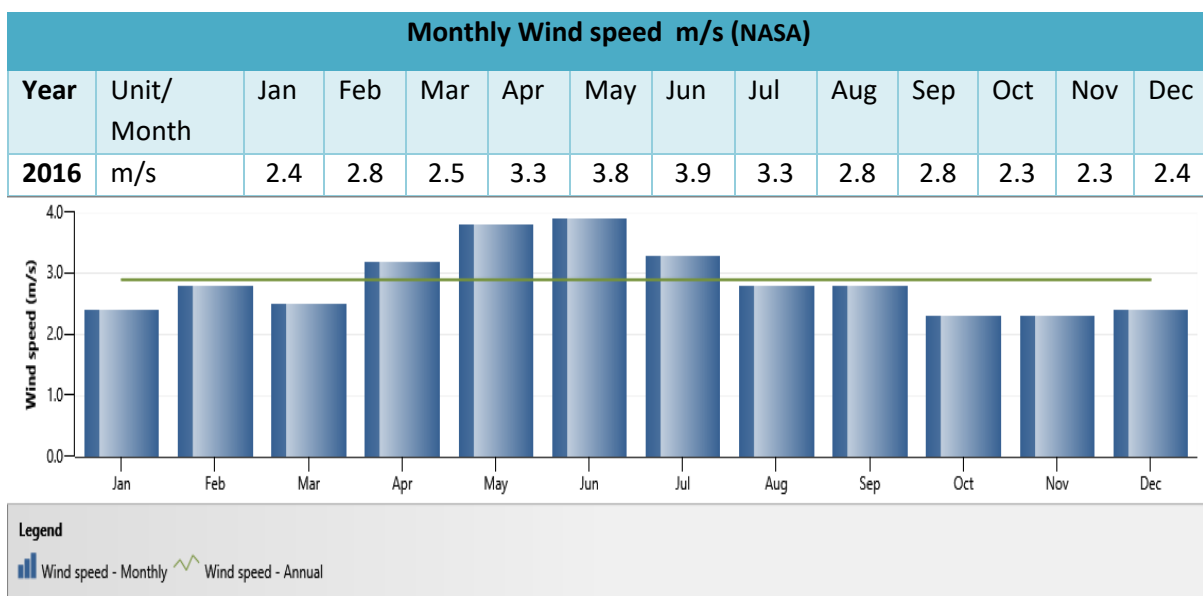
4.2 Wind Energy



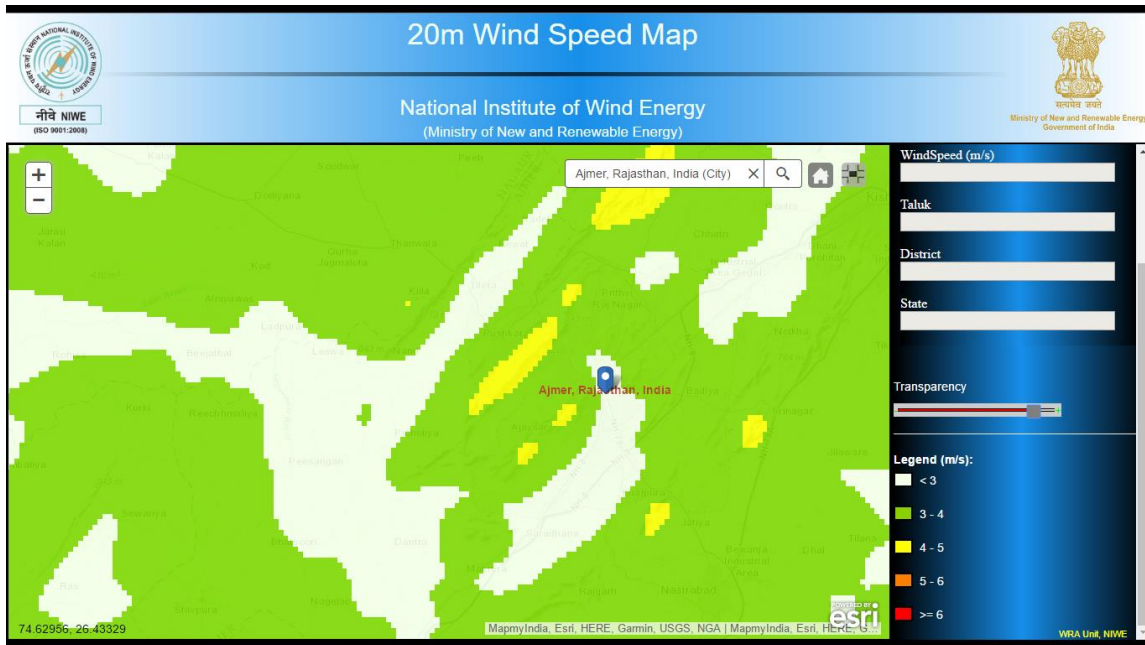
Wind energy has significant potential in Rajasthan state in specific pockets. Rajasthan has 4858 MW potential out of 48561 MW of total wind potential of India, which is nearly 10 % of total wind potential of India. Average annual wind speeds in Ajmer are 2.8-2.9 m/h, which is sufficient for a wind turbine to produce enough electricity to be cost effective. As per the wind data, there seems to be average potential for wind energy in Ajmer, but wind power as an alternate energy source has less opportunity in Ajmer city, a detailed Study is required for the assessment of energy generation potential from wind resource.

Monthly Wind speed data of Ajmer city is mentioned in table 39 and wind speed map is shown in Map-6, the average wind speed at Ajmer are of the range 3m/s. Wind potential is low in the city.

Table 37 Monthly average wind speeds in m/s



Map-6: Wind Speed Map of Ajmer



4.3 Biomass Resource Potential



As per a recent RRECL report on “**Biomass Fuel Assessment Report**” biomass of different districts of Rajasthan, average biomass generation of Ajmer is 5,73,002MT whereas average consumption of generated biomass is 4,21,247 MT. Surplus available biomass for Ajmer district is 1,51,755 MT. Though the potential of power generation for biomass is estimated to be 4-5 MWe for the entire district, However, there is no potential of power generation from biomass within Ajmer city.

Table 38 Biomass generation in Ajmer District

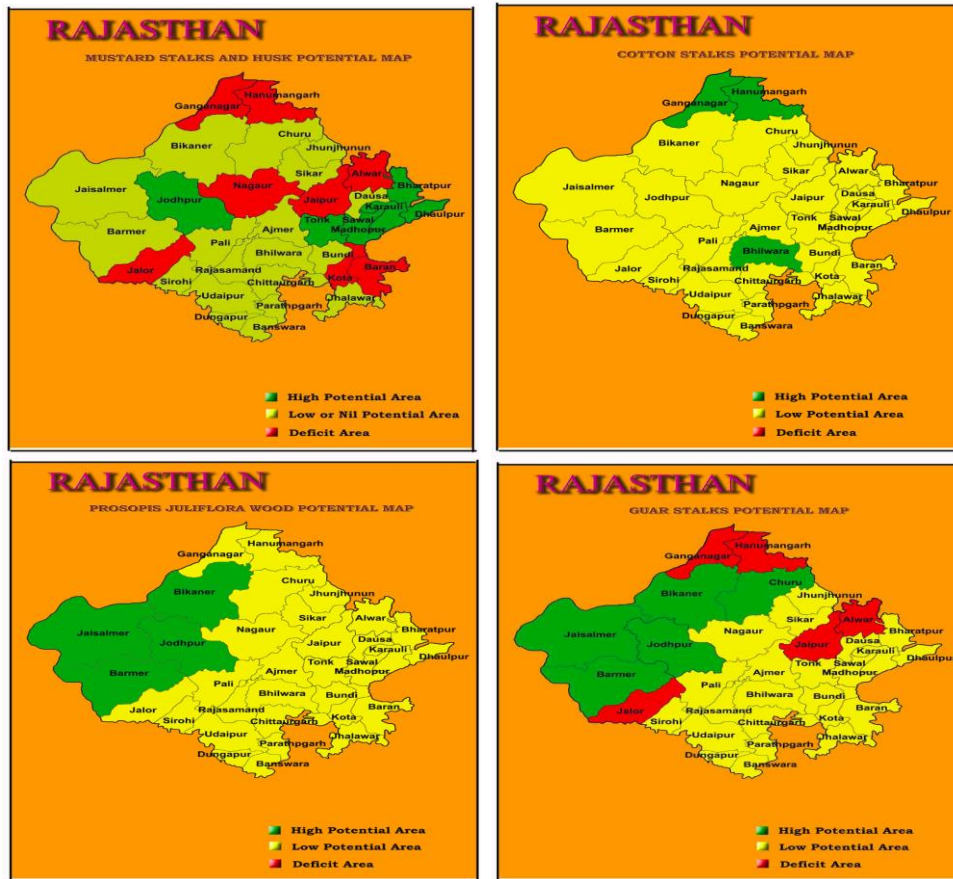
Average biomass generation	573002 MT
Biomass consumption	421247 MT
Surplus Biomass (MT)	151755 MT

Source: RRECL website, Biomass Assessment report

RECL has recently also released a new report on biomass assessment and as can be seen Ajmer district has low potentials of biomass. City biomass potential is very low to negligible.

Figure 30 : Biomass Potential Graph of different District of Rajasthan

Source: Biomass Fuel Supply Study 2015 –RRECL



4.3 Solid Waste Generation

The city on an average generates about 225 metric tons of municipal solid wastes daily average from 2010 to 2016 which includes domestic waste, waste from commercial and institutions and waste on streets. At present the total waste generation is around 250 metric ton per day which is collected and disposed off daily at Makhupura on Ajmer–Nasirabad road in the southern part of the city. IRADe team visited these sites to assess the waste collection, management and disposal aspects. Presently the waste is not segregated and is just dumped on the partial hilly terrain, the valley in which the MSW is dumped is totally filled. There is however a need to scientifically dispose off the MSW with proper techniques like segregation for organic, inorganic (glass, metals, plastics, etc.). Organic waste can be used for composting or power generation through the biomethanation route.



Figure 31 Ajmer waste collection bins, Makhapura dumping site

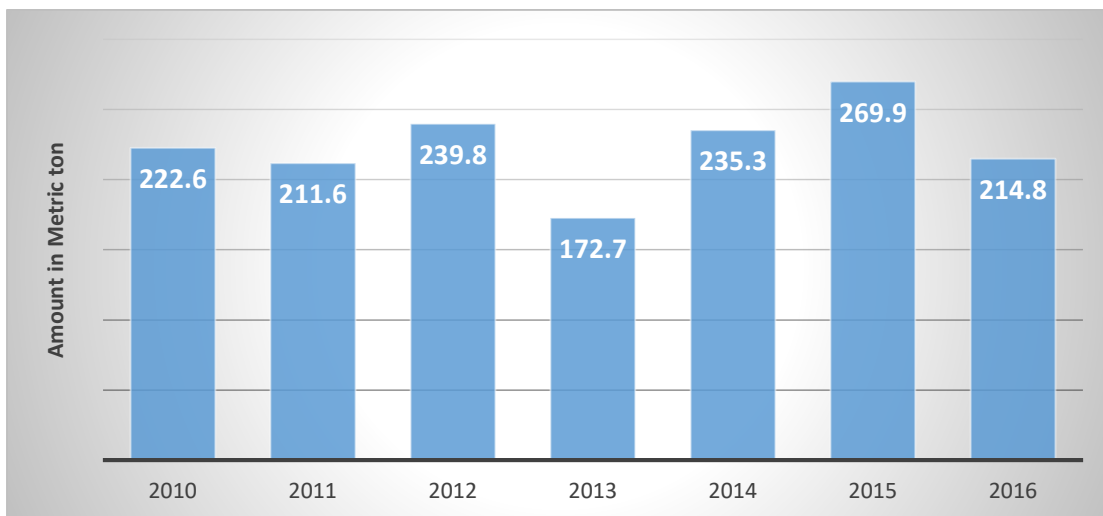


Figure 32 : Municipal Solid Waste Generation Per day in Ajmer City

Source: AMC Data Center

As per the City Sanitation plan (CSP) report of Ajmer the source of solid waste generated in the city are the following.

- Residential and Commercial area
- Slum area
- Vegetable / fruits mobile vans
- Hotel / Restaurants
- Dead bodies of cattle and cattle-dung.
- Construction / Demolition
- Medical establishments
- Industries

Quantity of waste generated is assumed to be 300g. per capita in residential areas. The average solid waste generated per capita per day in various households depending on income levels is given in the following table. Most of the population does not store the waste at source and instead dispose the waste into the municipal bins, streets, open spaces, drains, etc. Segregation of recyclable waste is generally not practiced. Most of the recyclable material is disposed of along with domestic and trade waste. Therefore, recyclable waste is generally found mixed with the garbage on the streets, into the municipal bins and at the dumpsites. Some portion of this waste is picked up by the rag pickers. There is no system of door-to-door collection of waste, except in few housing societies. There has been a significant increase in the generation of municipal solid waste in Ajmer over the last few years.

Essentially the MSW is divided into following categories:

- Biodegradable waste: food and kitchen waste, green waste and paper
- Recyclable material: paper, glass, bottles, cans, and certain plastics
- Inert waste: construction and demolition waste, dirt, rocks and debris
- Composite waste: waste clothing, tetra packs and plastic and
- Domestic hazardous water and toxic waste: medicines, paints, chemicals etc.

Table 39 Typical Municipal Solid Waste Characterization

S. No	Type	Vegetable Markets	Commercial Area	Residential Area		
				LIG	HIG	MIG
1	Compostable	61.9%	44.1%	52.5 %	54.5 %	49.3 %
2	Silt	27%	18.7%	0	0	0
3	Plastic	2.5%	13.3%	14.3 %	18 %	16.7 %
4	Paper	6.1%	8.9%	0	0	0
5	Cloth	1.1%	6.7%	0	0	0
6	Glass	1.4%	8.3%	0	0	0
7	Others	0	0	33.2 %	27.5 %	34 %
Total		100 %	100 %	100 %	100 %	100 %

Assessment of Energy Recovery Potential

A rough assessment of the potential of recovery of energy from MSW from different treatment methods can be made from understanding of its calorific value and organic fraction as shown in Table 43. Since exact details of the calorific value are not available for the city, widely used estimates for municipal solid waste in India have been used. In thermo-chemical conversion, all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output.

Table 40 : Waste to Energy Power Generation Potential from MSW in Ajmer City

Particulars	Value
Total waste quantity :	250 tonnes
Net Calorific Value :	NCV k-cal/kg.
Energy recovery potential (kWh)	$NCV \times 250 \times 1000/860 = 1.16 \times NCV \times 250$
Power Generation Potential (kW)	$1.16 \times NCV \times 250/24 = 0.048 \times NCV \times 250$
Conversion Efficiency	30%
Net Power Generation Potential (kW)	$0.015 \times NCV \times 250$
If NCV	700 kcal/kg., then
Net power generation potential (kW)	$10.2 \times 250 = 2544$ (kW) or 2.54 MW
If Plant Load factor	80%
Power Generation Annually	16.1 Million Unit
GHG Emission Reduction Equivalent CO ₂ MT / Year	14505 MT

As can be seen there is a potential to generate around 2.54 MW of electricity from MSW in the city subject to collection efficiencies and calorific values are attained.

4.4 Liquid Waste to Energy Potential from Sewage

Sewage is the untreated municipal liquid waste requiring treatment in a sewage treatment plant. Sewage contains about 99.9% of water, while the remaining content may be organic or inorganic. Sewage denotes both black water and grey water at the household level, where black water refers to waste water generated in toilets and grey water to the waste water generated in kitchen, bathroom and laundry.

As per Ajmer master plan 2031, 115 MLD water is supplied to Ajmer city of which 80% is converted to Sewage. City sewage generation is increasing with increase of population and tourist activities. Currently Sewage generation of the city is 92 MLD per day, out of which 60 MLD Sewage will be treated through the newly constructed Sewage treatment plants of 60 MLD capacity(40+20).⁴

Accordingly @ 80 lpcd, for the projected population of 6.44 lakhs for year 2021, the sewage produced will be to the tune of 98 MLD and for 2026 it will be 130 MLD.

Sewage treatment plants have the potential to produce methane due to the anaerobic digestion process of the sewage. This methane in turn is used to run gas fueled generating sets to produce electricity. The sludge generated after treatment is used as a fertilizer. A typical 50 MLD treatment plant data is presented here.

⁴ Source: Master Plan 2031, Ajmer

Table 41 : Energy Generation Potential from 50 MLD Sewage Treatment plant

Particulars	Value	Unit
Plant Capacity	50	MLD
Biogas yield	8000	m ³
Electricity (kWh) potential	48000	kW
Capacity of the plant	2000	kW
Conversion Efficiency	33	%
Total Electricity Generated Per Year	5.7816	MU
Plant Load Factor	70	%
Net electrical energy savings potential	4	MU
Emission reduction CO₂ per year	68322	MT

Chapter - 5

Renewable Energy Strategies

Cities around the globe are adopting a shift towards a low-carbon style of growth be it for buildings, lighting, transport, HVAC or any other energy need. A major component of meeting a low carbon lifestyle will result in adopting renewable energy strategies to help in building a more sustainable community by investing in long-term approaches to conserve energy and increase energy from renewable resources. The city can help in encouraging **green tourism** and **green industry** job growth, preventing the rising cost of energy and help in protecting the cities culture and environs and help the nation from dependence on foreign oil. There are three components to this strategy that require intervention namely city operations, city codes and policies, and community involvement.

- ❖ **City Operations:** In this chapter, the goal is to reduce the city's energy demand by 5% percent by 2021-22 through renewable energy.
- ❖ **City Codes, Regulations and Policies:** The aim is to adopt an energy code, that is 5 percent more efficient than the current code, and also to work with the Green Building Council to revise the Green Building Program for inclusion of more mandates and incentives.
- ❖ **Community Involvement:** The objective is to have a fully implemented residential solar rebate program by MNRE and also to provide incentives for residents to take part in home energy audits.

These kinds of efforts will enhance tourism as visitors can “feel good” about coming to a city, that is not only known for world-class serene setup, but also a leader in caring for the environment. Also, investing in renewable energy and energy conservation in Ajmer will help in diversifying the economy and creating opportunities for on-the-job training for skilled labor and local graduates.

Investing in renewable energy and energy conservation will also protect the city from escalating electricity costs. Ajmer, with its abundant solar resources and renewable alternative fuels, can provide leadership by reducing its reliance on foreign oil and non-renewable energy.

Investing in long-term strategies to conserve energy and increase energy from renewable resources requires a new approach to decision-making, which will make Ajmer as a solar city / green city. We must consider long-term savings when making purchases, so that we can help in building a more sustainable community for generations to come.

5.1 Sector Wise Strategies

Solar City will focus on the most appropriate and popular renewable energy projects/systems/devices such as solar PV systems including and building integrated photovoltaic, kitchen waste based plants, solar water heating systems, solar cooking systems, solar steam generating/drying/air heating systems, solar concentrators for process heat applications, solar air-conditioning, solar inverters, power projects based on methane recovery from STPs, MSW, bio-mass gasification based systems, cowdung biogas, wind, etc. This chapter explains in detail the availability of various renewable energy resources in Ajmer city and best possible renewable energy options for various sectors along with their techno economics.

Strategies are prepared as per MNRE guidelines for the following sector

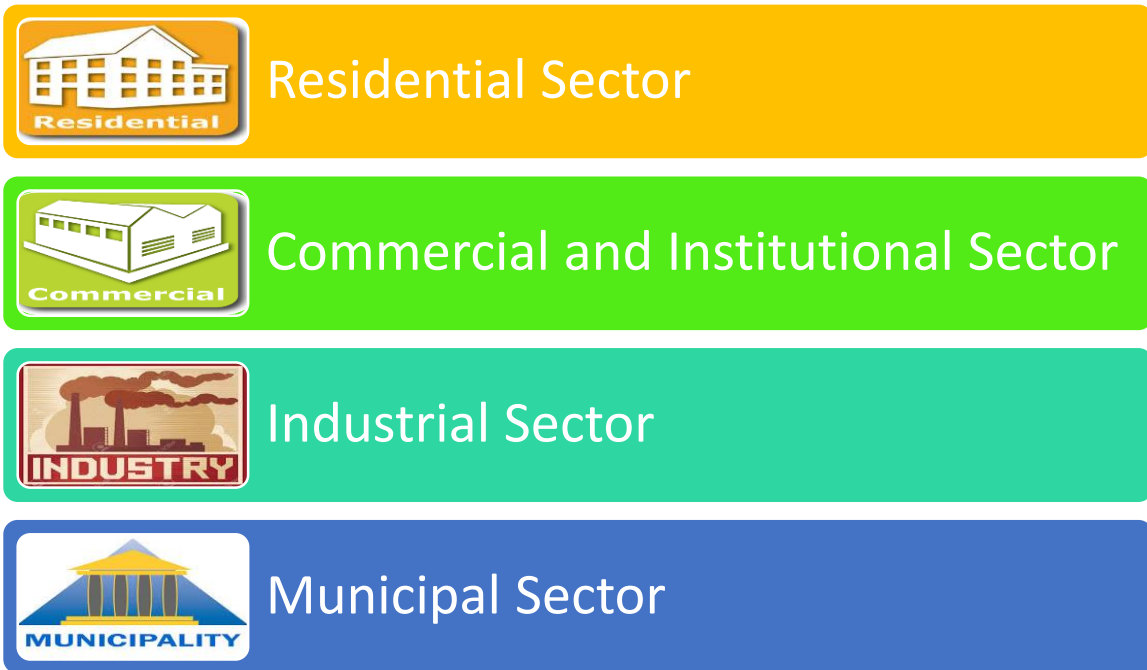


Figure 33 Sectors considered for strategies

5.2 Renewable Energy Strategies for Residential Sector



Residential sector is the major energy consumer of the total energy consumption of the city. This sector consumes 42% of electricity and 33% of energy consumption of the total energy consumption of the city excluding transportation sector which is considered as separate. The current population of the city is 5,81,063 with the current number of household residents at 1,230,22 and the projected population for 2021-22 is 6,44,427. Energy demand and greenhouse gases emission (GHG's) can be reduced from different types of renewable energy approaches in residential sector. Following technologies are suggested, which are technologically proven and approved by the Ministry of New and Renewable Energy.

- Installation of Solar Water Heater Systems
- Installation of Solar Inverter
- installation of Solar Cooker
- Installation of ROOF top Solar Power Plant for replacement of home D.G. sets for power backup or as a roof top standalone power system.

Solar Water Heating System



Solar energy has a great potential to heat up the water. There is abundant radiation available throughout Rajasthan to use solar energy to heat water. Solar water heater is widely being promoted by the Ministry of New and Renewable Energy all over the country as a solar thermal device and make it an integral part of solar city master plan programme for residential, commercial and institutional sector. A 100 litres capacity SWH can replace an electric geyser for residential use and saves nearly 1500 units of electricity yearly. A 100 lpd system (with 2 sq.m of collector area) installed in a home can save 4-6 units of electricity/day depending on the place of installation & hot water use. On an average it could be taken as 5 electricity units/day. Maximum average saving with 300 clear days, therefore, could be taken as 1500 units/year. One system of 100 lpd can replace an electric geyser of 2-3 KW capacity in a home. In 2011, Rajasthan state government has also granted an indirect subsidy to residential users of Solar Water Heaters (SWH). The scheme allows every SWH user to receive a rebate on its electricity bill of INR 0.25 INR/kWh of electricity, capped at a maximum of INR 300 per month – independent of the age of the system. To generate that much of electricity from a coal based power plant around 1.5 tonne of CO₂ year is released in the atmosphere. In Western India expected no. of days of use of hot water per year is around 200 which will result in yearly savings of around 1000 electricity units.

As the city develops under the solar city master plan, solar water heating systems would become mandatory in residential sectors. However, it would take some time by which all households could make a changeover to solar water heating systems (SWHs). In energy assessment report it has been assumed that all existing water heating in the city is from the electricity.

Solar Lantern



Solar lantern can be used as a substitute for kerosene lamp which is responsible for substantial GHG's emissions. Kerosene is a source for lighting in poor families or BPL family. Solar lantern use will result in not only energy saving but also reduction in the direct emission of greenhouse gases from burning of kerosene fuel as well as health co-benefits and fire risk minimization in homes. Solar lantern is a portable device for lighting, available with a 4 Wp with PV module, battery, lamp, and charger. Battery, lamp, and electronics are placed in a suitable housing, made of metal or plastic or fiber glass. Solar lantern is suitable for either indoor or outdoor lighting, as it has a full range of 360 degrees for illumination. Luminaire consists of White Light Emitting Diode (W-LED), a solid state device which emits light when an electric current passes through it. The lantern can provide light for a minimum of three hours daily. Solar Lanterns that follow MNRE specifications cost Rs.1800-2000. Imported models are also available at a lower price. Solar lantern can be purchased from Akshay Urja Shops, dealers/manufacturers of solar cookers, and districts/head offices of State Renewable Energy Development Agencies.

Solar Lantern also provide facility of Mobile Charging that have an in-built USB port for such applications. However, in case of mobile charging, the duty cycle for lighting is to be reduced /adjusted accordingly.

Solar Home Light Systems

Solar home lighting systems are ideal sources for providing indoor illumination in un-electrified households or where electricity supply is inadequate (frequent load shedding areas). A solar home



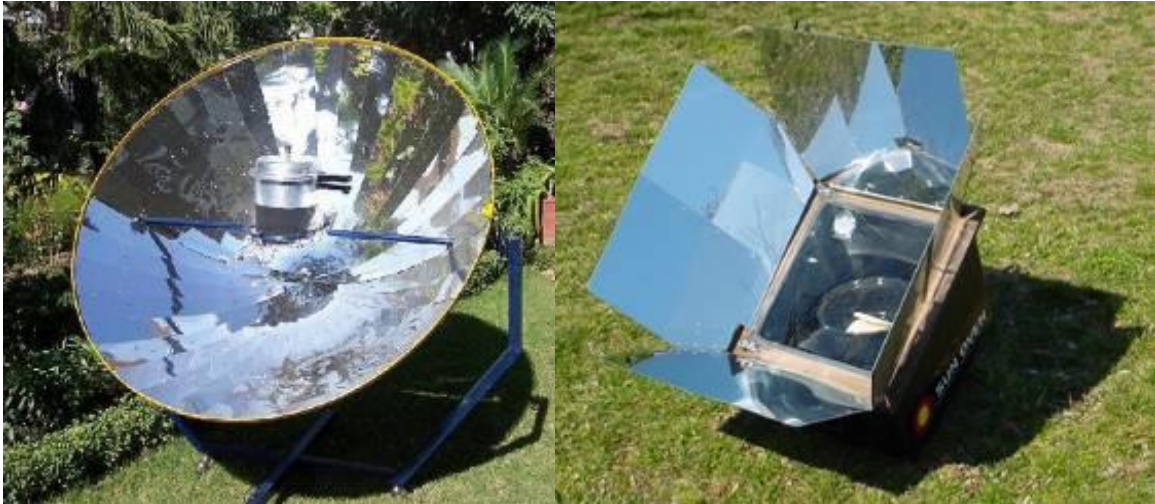
lighting system (SHS) provides a comfortable level of illumination in one or more rooms of a house. The SHS consists of a PV module, control electronics, battery, and luminaire(s). There are several SHS models featuring one, two, or four luminaires based on White Light Emitting Diode (W-LED). The system could also be used to run a small DC fan or a 12-V DC television along with the W-LED Lamps. The system will work for about 4 hours daily, if charged regularly. The Solar Home Lighting systems have been proposed to replace kerosene lamps, new households in Ajmer. A 30 Wp under Solar Home System can replace 3-4 kerosene lamps with 4-5 hours lighting backup hence replacing entire need of kerosene or DG sets use, which is estimated at an average of 20 litres per year per household.

Table 42: Details of LED Home Lighting Systems (7W LED Luminaries)

Category	Spec	Units	Detail
Luminaries	7W LED solar DC home lighting with 8 mtr cable	Nos	2
Battery	12V SMF battery	Ah	20
SPV Module	12V SPV Module	Wp	20
CCU	12V CCU	Amps	5
Cable	1.5 sq.mm / 2.5 sq.mm 2 core copper cable	mts	12.5
Hardware	Module mounting structure, battery box and other accessories	Sets	1
Daily operation	Hours the system can be used with one day of solar charging	hrs	5-6
Autonomy	Hours the system can be used if battery is fully charged	hrs	10-12
Time to fully charge battery	Sunny day with clear sky	days	2.1

Source: MNRE

Solar Cooker



Solar cooker or solar oven is a device, which uses the energy of sunlight to heat or cook food. Advanced technology versions, for example electric ovens powered by solar cells are also available, and have an advantage of being able to work in diffused sun light. The vast majority of the solar cookers presently used are relatively cheap because they do not use fuel and have zero operating cost, solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important. Solar box cooker and dish type solar cooker can be promoted in urban areas. Box type solar cooker is an ideal device for domestic cooking during most of the year, except for the monsoon season and cloudy days. The surface temperature at the bottom of the cooking pot could be as high as 300oC depending upon the weather conditions. Continuous use of a box type solar cooker can save 3-4 domestic LPG cylinders per year. The use of solar cooker to its full capacity may result in savings up to 10 LPG cylinders per year in larger families.

Scope of CSTs & Cost/Fuel savings

Dish solar cookers & Indoor direct cooking systems (Most suitable for N- West, South & Central parts of country where good DNI solar radiation is available)

Scope

- ❖ Individuals, mid day meal schools, tribal areas, Anganwadis, etc. may use for saving LPG or as a green cooking device.

Cost & Fuel savings

- ❖ A dish solar cooker of smaller size can cook food for about 10-12 people and costs around Rs.6,000. It may be able to save around 8-10 LPG cylinders in a year on full use.

Roof Top Solar Power Plant



Roof top Solar Power Plants are helpful in power cut situations or as a new installation, about 5% of residents of Ajmer city uses typically 2-5 kW diesel generator sets during the load shedding hours or use inverters. Solar PV power packs can be used to replace these generator sets with high operating cost through net metering benefits.

Net metering is the process through which households attain a “dual-benefit “by installing a solar power plant on the roof, open space, to generate electricity. Generated power is first used in the building as per the requirement and the surplus power is fed to the grid of utility. A bi-directional meter is installed in the supply line to register import and export of power. Net metering arrangements, thus, combine elements of captive power consumption and exchange of power with the utility. The bill is issued by utility after adjustment of import and export of power.

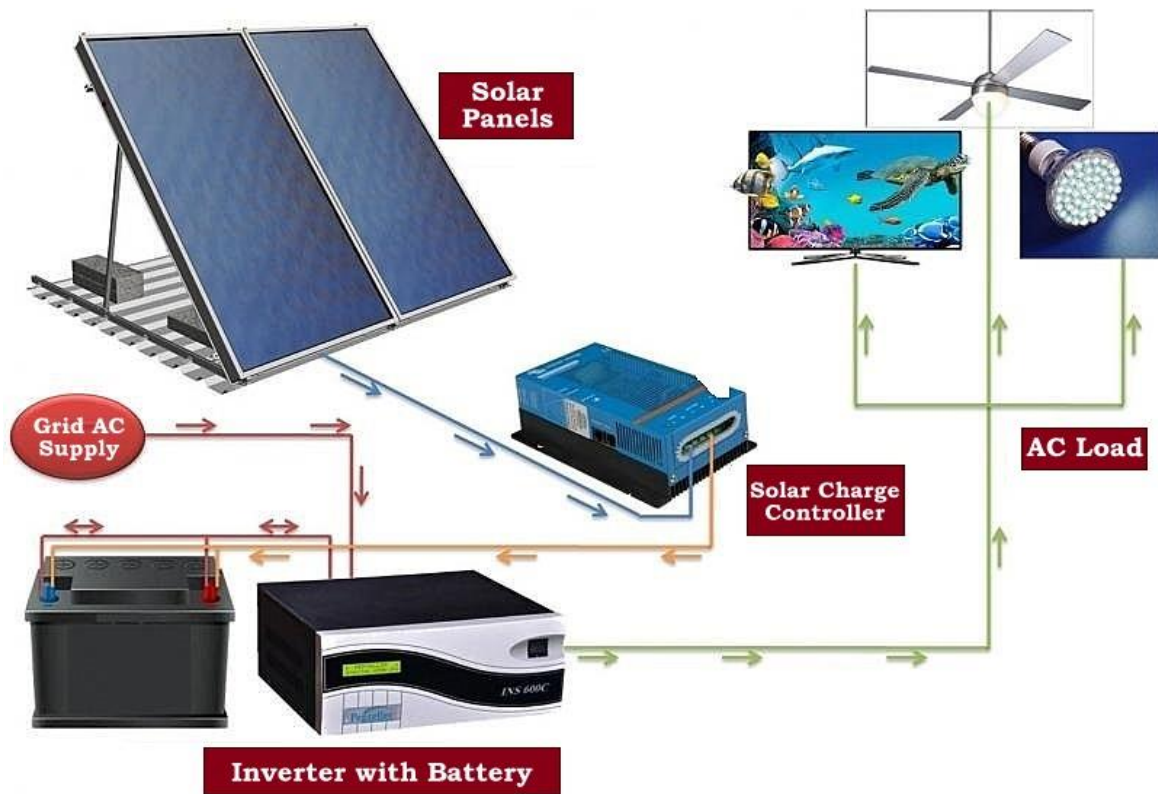
Under Net Metering Policy, all consumers of electricity having minimum sanctioned load of 1.25KW and maximum of 12.50 MW who intend to generate their own electricity and desire to contribute towards environmental protection can install Solar PV plants on Roof-Tops/ Walls/Open area of Individual Households, Industries, Commercial Establishments, Institutions, Residential Complexes, Schools, Colleges, Hospitals, Sheds, Cold Stores, Government and Semi-Government Buildings, etc.

Under Net Metering Policy, Solar PV Power Plants of capacity ranging from 1KW to 10MW can be installed. The maximum capacity of solar power plant to be installed in a building would be 80% of the sanctioned electricity load of that building. But Solar Power Plant of actual required capacity should be installed and capacity be calculated as per formula given below:

- i. Total annual electricity consumption of house/building = xyz kWh = (A)
- ii. Per day electricity consumption = $A/365$ = (B)
- iii. Actual Plant Capacity = $B/4$ = KW

A 1000 Wp and 2000 Wp solar PV power pack has been considered for an average household in Ajmer. For 5-year framework, 5 % households have been taken into consideration to install solar power pack in houses for replacement of DG sets with solar PV systems with a target to save 3735 kilo Liters of diesel per year to reduce GHG to the tune of 14873 metric tons per year.

Solar Inverter



Solar Inverter is a hybrid inverter with inbuilt charge Controller. The Solar Inverter Solar Inverter is a hybrid inverter with inbuilt charge Controller. The Solar Inverter charges the battery from grid and Solar panel both. If solar energy is available then It charges the battery from solar Panel and if Solar is not available, then the inverter charges the battery from Mains/Grid. The main feature is it gives power back up in AC and DC mode. 600 Watt PV Module solar panel compatibility is sufficient for generation of 1.5 to 3 unit per day. It is ideal for running - 2 Ceiling Fan + 3 CFL + 3 Tube light + 1 Television + 1 Laptop/Mobile Charging. Backup time gradually declines as the load on inverter increases. 600 W inverter runs 2 hours on full load while on a 100 watt load at same inverter runs upto 18 Hours.

T- Solar Inverter backup time details

Load	500 W	400 W	300 W	200 W	100 W
Duration	2 hrs 10 min	3 hrs	4 hrs 30 min	7 hrs 30 min	18 hrs 30 min

Summary of Energy Savings from Renewable Energy Installation in Residential Sector

The summary table showing the System wise details of RE System for Residential Sector is presented below. Further tables detail the energy savings accumulated due to these devices, year wise subsidy, year wise budget

Table 43 : System Wise details of RE System for Residential Sector

Sl.	Device or System	Number of Household	Total number of Installation	Cost of System (in Lakh)	Electricity saving per year in MU	Electricity savings per year in Lakh Rs	CO2eq reduction per year in metric ton (MT)
1	Solar Lantern	123022	6151	96	0.03	1.8	27
2	S. Home light		6151	384	0.09	5.1	77
3	SHWS - 100 LPD		1230	221	0.83	50.1	747
4	SHWS - 200 LPD		1230	344	1.66	100.1	1495
5	S.Cooker-Box		615	15	0.41	24.5	365
6	S. Cooker-Dish		615	37	0.61	36.7	548
7	Solar Inverter		1230	369	0.81	49.0	731
8	SPP 1kW		1230	923	2.44	146.9	2192
9	SPP - 2kW		1230	1845	4.87	293.8	4385
10	SPP - 3kW		972	2187	5.77	348.1	5196

SPP- Solar Power Plant(Rooftop SPV) , SWH- Solar Water Heater

Cumulative energy savings targets for each year

The cumulative energy saving targets that would be achieved on account of installation of the renewable energy (RE) devices is summarized in the table no 47. The first year savings would be less as the device procurement and installation would be in the initial phase and would gradually increase and reach its full potential in the fifth year. Second year onwards the figures of energy saving target are cumulative total savings at the end of 5 years would be 17.5 MU.

Table 44 : Year Wise Energy Saving Target from RE System for Residential Sector

Type of Systems	Energy savings in MU or GWh				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Solar Lantern	0.00	0.00	0.01	0.01	0.01
SPV Home light system	0.01	0.01	0.02	0.02	0.03
SHWS - 100 LPD	0.08	0.12	0.17	0.21	0.25
SHWS - 200 LPD	0.17	0.25	0.33	0.42	0.50
Solar Cooker-Box	0.04	0.06	0.08	0.10	0.12
Solar Cooker-Dish	0.06	0.09	0.12	0.15	0.18
Solar Inverter	0.08	0.12	0.16	0.20	0.24
SPV power plant - 1kW	0.24	0.37	0.49	0.61	0.73
SPV power plant - 2kW	0.49	0.73	0.97	1.22	1.46
SPV power plant - 3kW	0.58	0.87	1.15	1.44	1.73
Total Energy savings	1.75	2.63	3.50	4.38	5.25

Summary of Total Budget Estimate Sharing for Renewable Energy System Installation in Residential Sector

Table 45 : RE System Installation & Budget Estimate for Residential Sector

System	Total Installation	Per Item Cost in Rs	Total Cost (Lakh Rs.)	MNRE Share @30% in Lakh Rs.	User share @ 70 % in Lakh	User share @ 100 %in Lakh Rs.
Solar Lantern	6151	1560	96			96
SPV Home light system	6151	6240	384			384
SHWS - 100 LPD	1230	18000	221			221
SHWS - 200 LPD	1230	28000	344			344
Solar Cooker-Box	615	2500	15			15
Solar Cooker-Dish	615	6000	37			37
Solar Inverter	1230	30000	369			369
SPV power plant - 1kW	1230	75000	923	277	646	
SPV power plant - 2kW	1230	150000	1845	554	1292	
SPV power plant - 3kW	972	225000	2187	656	1531	
Total			6422	1486	3468	1467

Summary of Year Wise Budget Estimate Sharing for Renewable Energy System Installation

As is seen in table below the maximum budget in this sector is for solar 3Kw power plant and least is for box type solar cooker.

Table 46 : Year Wise Investment for RE System installation for Residential Sector (Lac Rs.)

Type of System	Total	Year wise Investment				
	Installation Cost in Lac Rs.	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Solar Lantern	96	10	14	19	24	29
SPV Home light system	384	38	58	77	96	115
SHWS - 100 LPD	221	22	33	44	55	66
SHWS - 200 LPD	344	34	52	69	86	103
Solar Cooker-Box	15	2	2	3	4	5
Solar Cooker-Dish	37	4	6	7	9	11
Solar Inverter	369	37	55	74	92	111
SPV power plant - 1kW	923	92	138	185	231	277
SPV power plant - 2kW	1845	185	277	369	461	554
SPV power plant - 3kW	2187	219	328	437	547	656
Total	6422	642	963	1284	1605	1927

5.2 Renewable Energy Strategies for Commercial & Institutional Sector



The commercial and institutional sector is also a large energy-consuming sector in Ajmer. The sector consumes about 29% of total electricity consumed in the city. There are 46749 consumers of electricity in commercial and institutional sector in Ajmer city. The commercial and institutional sector is also a large energy-consuming sector in Ajmer. The sector consumes about 33% of total electricity consumed in the city. This segment consists of commercial establishments such as hotels, restaurants, malls, shopping complexes, educational institutes, medical service facilities, markets, government buildings and others. The main energy load in this sector are lighting, fans, ACs, cooking, water heating and water pumping, During the field visit, it is found that much attention needs to be paid towards the energy efficiency in this sector. There exists a significant potential to provide renewable and energy efficiency in existing educational buildings, hospitals, hotels, Government & private office buildings, restaurants and subsequent reduction of commercial sector energy demand at city level. Total Govt. and Semi Govt. Offices in Ajmer are more than 500. As Ajmer is a tourist destination, there are more than 450 hotel and numerous restaurants in Ajmer. In field survey we found substantial potentials of renewable energy generation in commercial and institutional sector

Strategies for Renewable energy option for Commercial and Institutional sector

Different strategies are prepared for different types of energy consumption. Various solar options are:

- Installation of commercial Solar Water Heater
- Installation of Solar Community Cooker
- Installation of Solar Steam systems for hospitals
- Installation of Roof Top Solar Power plant
- Installation of Solar Dryers

Solar Water Heater

The city has star rated hotels and many budget hotels, dharamshalas, hostels and other commercial accommodations facilities. Major energy requirements, such as hot water and electricity during power cuts, could be met by solar energy. Solar thermal system can be used to generate hot water or steam

for cooking. Solar water heater of different capacities can be installed in hotels, restaurants, hospitals, hostels, etc.

Applications for SWHS in Commercial & Institutional sectors:

- ❖ Pre-feed steam generator boilers
- ❖ Milk dairies for applications such as pasteurization, condensation and cleaning
- ❖ Leather processing industry for drying and tanning
- ❖ Metal finishing industry for degreasing and phosphating
- ❖ Resin emulsification in polymer industry
- ❖ Drying and related processes in pharmaceutical industry
- ❖ Solar drying from air-heating

Other Measures in Commercial and Institutional Sector

Installing HVAC system instead of Window and split AC: Most of the commercial complexes, hotels, and restaurants in the city either use window AC or split ACs. HVAC can be installed in large building premises with central control system.

Enforce and Implement Energy Conservation Building Code: Enforce Energy Conservation Building Code for all applicable buildings. After proper implementation of the ECBC code peak load can be substantially reduced.

Energy Star Rating Program for Commercial Buildings: RRECL, AVVNL and AMC can jointly launch the Star Rating Program for commercials and institutional buildings in the city based on actual performance of the buildings in terms of specific energy usage. This programme would rate office buildings on a 1-5 Star scale with 5 Star labelled buildings being the most efficient. Energy Performance Index (EPI) in kWh / sqm/ year will be considered for rating the building. EPI shall be kWh/sqm/year in terms of purchased & generated electricity divided by built up area in sqm. However the total electricity would not include electricity generated from on-site renewable sources such as solar photovoltaic etc.

Energy Efficient/ Solar Building Architecture:

There should be mandatory provision for upcoming new commercial & Institutional buildings to follow the solar passive architecture. This type of design/ architecture of new commercial buildings would lead to energy conservation benefitting the consumers as well as utility. 10% of the cost of the building with a maximum of Rs.10.0 lakh for each project is available as financial support from MNRE for the Construction of Solar Buildings.

Installation of Building Energy Management Systems (BEMS): A Building Energy Management System (BEMS) is a computer based centralized & integrated control and monitoring system that helps to manage controls and monitor engineering services including cooling, heating, ventilation and air conditioning within a building or group of buildings. Use of a BEMS can reduce total energy costs by 10%.

Initiate Green Building/GRIHA Programme: New commercial building must implement and integrate the various rating program. In Indian scenario GRIHA which has been developed by TERI and adopted by the MNRE is the most relevant and suitable rating system. Although there are other rating systems in place as well namely the LEED and IGBC certification, eco-housing labelling, etc.

Benefits of following GRIHA rating system)

- Up to 30% reduction in energy consumption
- Limited waste generation due to recycling
- Less consumption of water
- Reduced pollution load & liability

Potential Site for Solar Power Plant in Ajmer City

AMC will identify potential Government and institutional buildings for setting up of solar power plants on these with the help implementation agency the state level implementing agency for SPV Rooftop Power Plant.

Summary of Energy Savings targets and Budget for RE Installation in C & I Sector

A detailed table depicting the total installation, economic and fuel savings scenario for the installed devices is presented below.

Table 47 : RE System details for Commercial & Institutional Sector

S.No.	Device Name	Number of Establishment in C & I Sector	Total number of Installation	Cost of System (in Lakh)	Electricity saving per year in MU	Electricity savings per year in Lakh Rs	CO2eq reduction per year in metric ton (MT)
1	SHWS - 500 LPD	457	70	60	0.24	14.3	213
2	SHWS - 1000 LPD	457	35	59	0.23	14.1	210
3	SHWS - 3000 LPD	457	35	116	0.70	42.2	630
4	SHWS - 5000 LPD	457	35	145	1.17	70.3	1049
5	Solar Community Cooker	384	20	9	0.01	0.8	12
6	S. steam generating system	384	10	2	0.01	0.6	9
7	SPP- 1kW	3957	83	62	0.16	9.9	148
8	SPP- 2kW	3957	83	125	0.33	19.8	296
9	SPP- 3kW	3957	38	86	0.23	13.6	204
10	SPP- 5kW	3957	38	114	0.35	21.3	319
11	SPP- 20kW	3957	20	297	0.74	44.4	662
12	SPP- 25kW	3957	20	371	0.92	55.5	828
13	SPP- 30kW	3957	10	223	0.55	33.3	497
14	SPP- 40kW	3957	10	297	0.74	44.4	662
15	SPP- 1 MW	1	1	530	1.86	112.2	1674

SPP- Solar Power Plant (Rooftop SPV), SWH- Solar Water Heater

Cumulative energy savings targets for each year

The cumulative energy saving targets that would be achieved on account of installation of the RE devices is presented below. The first year savings would be less as the device procurement and installation would be in the initial phase and would gradually increase and reach its full potential in the fifth year. Second year onwards the figures are cumulative.

Table 48 : Year Wise Energy Saving Target from RE System for Commercial & Institutional

Typed of Systems	Electricity savings in MU				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
SHWS - 500 LPD	0.02	0.06	0.11	0.17	0.24
SHWS - 1000 LPD	0.02	0.06	0.10	0.16	0.23
SHWS - 3000 LPD	0.07	0.17	0.31	0.49	0.70
SHWS - 5000 LPD	0.12	0.29	0.52	0.82	1.17
Solar Community Cooker	0.00	0.00	0.01	0.01	0.01
S. steam generating system	0.00	0.00	0.00	0.01	0.01
SPP- 1kW	0.02	0.04	0.07	0.12	0.16
SPP- 2kW	0.03	0.08	0.15	0.23	0.33
SPP- 3kW	0.02	0.06	0.10	0.16	0.23
SPP- 5kW	0.04	0.09	0.16	0.25	0.35
SPP- 20kW	0.07	0.18	0.33	0.52	0.74
SPP- 25kW	0.09	0.23	0.41	0.64	0.92
SPP- 30kW	0.06	0.14	0.25	0.39	0.55
SPP- 40kW	0.07	0.18	0.33	0.52	0.74
SPP- 1 MW	1.86	1.86	1.86	1.86	1.86
Total Energy savings	2.50	3.45	4.73	6.32	8.24

Summary of Total Budget Sharing for Renewable Energy System Installation in Commercial & Institutional Sector

Table 49: RE System Installation & Budget for Commercial & Institutional Sector

System	Total Installation	Per System/Device Cost Rs.	Total Cost (Rs. In Lakh)	MNRE Share @ 30 % in Lakh	User share @ 70 %in Lakh	User share @ 100 %in Lakh
SHWS - 500 LPD	70	85000	60	-	-	60
SHWS - 1000 LPD	35	170000	59	-	-	59
SHWS - 3000 LPD	35	336000	116	-	-	116
SHWS - 5000 LPD	35	420000	145	-	-	145
Solar Community Cooker	20	45000	9	-	-	9
S. steam generating system	10	16000	2	-	-	2
SPP- 1kW	83	75000	62	-	-	62
SPP- 2kW	83	150000	125	-	-	125
SPP- 3kW	38	225000	86	-	-	86

SPP- 5kW	38	300000	114	-	-	114
SPP- 20kW	20	1500000	297	-	-	297
SPP- 25kW	20	1875000	371	-	-	371
SPP- 30kW	10	2250000	223	-	-	223
SPP- 40kW	10	3000000	297	-	-	297
SPP- 1 MW	1	53000000	530	-	-	530

Roof top Solar Power plant SPV plants of capacity from 1 kW to 1 MW are recommended for commercial and institutional sector and MNRE does not provide any subsidy on these systems to C&I sector, however we have recommended 20-50 kW plants on institutional buildings. Organisation / Institution under societies registration act 1860 and Indian Trust Act 1882 for eligibility of CFA under Grid connected roof top solar Program where MNRE subsidy is in place at 30%.⁵

Summary of Year Wise Budget Sharing for Renewable Energy System Installation in Commercial & Institutional Sector

Yearly device number for recommendation is taken at 10, 15, 20, 25 and 30 % for the total number of devices so that with increasing capacity building activities gradually the installed number will keep increasing.

Table 50: Year Wise Investment for RE System installation for Commercial & Institutional Sector





Type of System	Total Installation	Year wise Investment in Lakh				
		1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
SHWS - 500 LPD	70	6.0	8.9	11.9	14.9	17.9
SHWS - 1000 LPD	35	5.9	8.8	11.7	14.7	17.6
SHWS - 3000 LPD	35	11.6	17.4	23.2	29.0	34.8
SHWS - 5000 LPD	35	14.5	21.8	29.0	36.3	43.5
Solar Community Cooker	20	0.9	1.4	1.8	2.3	2.7
S. steam generating system	10	0.2	0.2	0.3	0.4	0.5
SPP- 1kW	83	6.2	9.3	12.5	15.6	18.7
SPP- 2kW	83	12.5	18.7	24.9	31.2	37.4
SPP- 3kW	38	8.6	12.8	17.1	21.4	25.7
SPP- 5kW	38	11.4	17.1	22.8	28.6	34.3
SPP- 20kW	20	29.7	44.5	59.4	74.2	89.0
SPP- 25kW	20	37.1	55.6	74.2	92.7	111.3
SPP- 30kW	10	22.3	33.4	44.5	55.6	66.8
SPP- 40kW	10	29.7	44.5	59.4	74.2	89.0
SPP- 1 MW	1	530.0	0.0	0.0	0.0	0.0
Total		726.4	294.6	392.8	491.0	589.2

5.3 Renewable Energy Strategies for Industrial Sector

Various strategies are identified for different types of energy consumption in the industry sector. A major component of which is water heating for process applications through the use of Solar Water Heater. Many other applications are:

- ✚ Installation of Rooftop Solar Power Plant

⁵ Reference :<http://mnre.gov.in/file-manager/UserFiles/Clarification-about-Societies-act-under-Grid-Connected-Rooftop-Programme-for-eligibility-of-CFA.pdf>

-  Installation of Solar Water heater
-  Solar Steam Generating Systems
-  Solar Furnace
-  Solar Dryer

Solar Water Heater

Applications for SWHS in Industries:

- Pre-feed steam generator boilers
- Milk dairies for applications such as pasteurization, condensation and cleaning
- Leather processing industry for drying and tanning



- Metal finishing industry for degreasing and phosphating
- Resin emulsification in polymer industry
- Drying and related processes in pharmaceutical industry
- Solar drying from air-heating

Energy Savings:

For every 1000 liters of water heated at room temperature 25°C to 80°C, approximate energy savings per day are as follows:

Table 51 : Energy Saving Comparison of Different Capacity of Solar Water Heater

Capacity LPD	Total No. of Collectors	Area – 80° C	Elec. Savings (units/day)	Eleec. Savings/yr (@ Rs. 5/Unit)	Savings/Yr (Diesel)
1000	10	35	45	67,500	52,500
2000	20	70	90	135,000	105,000
3000	30	105	135	202,500	157,500
4000	40	140	180	270,000	210,000
5000	50	175	225	337,500	262,500
6000	60	210	270	405,000	315,000
7000	70	245	315	472,500	367,500

8000	80	280	360	540,000	420,000
9000	90	315	405	607,500	472,500
10000	100	350	450	675,000	525,000
15000	150	525	675	1,012,500	787,500
20000	200	700	900	1,350,000	1,050,000
25000	250	875	1125	1,687,500	1,312,500
30000	300	1050	1350	2,025,000	1,575,000

Electricity: 45 Units (kWh) • Gas: 5.5 kg • Diesel: 5.3 litre • Firewood: 31 kgs

Source: MNRE

Other Solar Installation in Industrial Sector

Solar Dryers

Features

- Drying under most hygienic conditions
- No soiling of the material, free from dust
- Quantities from 8 Kgs to large volumes of any material can be dried
- Extra-long life, rugged trays made up of special non-corrosive material
- Special arrangement for drying liquid material without spillage
- Individual tray can be controlled to achieve drying of materials with variable moisture content
- Default temperature gauge is provided to monitor & control the desired temperature
- Controlled moisture is possible
- Colour, taste and texture of material can be maintained as per original material

Natural Thermo Siphon Air Draft Dryers

In this method, the air is taken from the bottom of the flat plate collectors. The air is filtered from a fine mesh to trap any dust, dirt or foreign particles entering the drying process. This air then passes from a heating chamber where the temperature of air is raised to about 60 to 90° C. The heated air then passes over the perforated trays. The material to be dried is kept in the trays. The trays can be either covered with a special heat absorbing lid to protect the material from direct exposure to sunlight or can be kept open as per specific requirements.

Forced Circulation Type Dryers

In this system, the air is heated by passing from flat plate collectors having special heat absorbing selective coating with the final temperature requirement below 90°C. For higher temperature requirement, Scheffler 12.6 M parabolic concentrators with specially designed heat exchangers are used. In this method, the air may be directly or indirectly heated from suitable media.

Roof top Solar Power plant (SPV plants) of capacity from 1 kW to 1 MW are recommended for industrial sector and MNRE does not provide any subsidy on these systems, however we have recommended 5-25 kW plants on industrial buildings.

Summary of energy savings from renewable energy installation in Industrial Sector

Table 52 : RE system details for Industrial sector

Sl.	Device Name	Number of Establishment in Industrial Sector	Total number of Installation	Cost of System (in Lakh)	Electricity saving per year in MU	Electricity savings per year in Lakh Rs	CO2eq reduction per year in metric ton (MT)
1	SHWS - 1000 LPD	485	10	3	0.07	4.1	61
2	SHWS - 3000 LPD	485	10	4	0.20	12.3	184
3	SHWS - 5000 LPD	485	10	4	0.34	20.5	306
4	Solar Community Cooker	485	5	2	0.00	0.2	3
5	Solar steam generating system	485	5	1	0.01	0.3	5
6	SPP - 5kW	485	10	30	0.09	5.7	84
7	SPP - 10kW	485	10	73	0.18	10.9	162
8	SPP - 15kW	485	5	58	0.14	8.6	129
9	SPP- 20kW	485	5	77	0.19	11.5	172
10	SPP - 25kW	485	5	96	0.24	14.4	215

Table 53 : Energy Saving target from RE system installation in Industrial sector

Type of Systems	Annual Electricity Savings (GWh) Cumulative				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
SHWS - 1000 LPD	0.01	0.02	0.03	0.05	0.07
SHWS - 3000 LPD	0.02	0.05	0.09	0.14	0.20
SHWS - 5000 LPD	0.03	0.09	0.15	0.24	0.34
Solar Community Cooker	0.00	0.00	0.00	0.00	0.00
Solar steam generating system	0.00	0.00	0.00	0.00	0.01
SPP - 5kW	0.01	0.02	0.04	0.07	0.09
SPP - 10kW	0.02	0.05	0.08	0.13	0.18
SPP - 15kW	0.01	0.04	0.06	0.10	0.14
SPP- 20kW	0.02	0.05	0.09	0.13	0.19
SPP - 25kW	0.02	0.06	0.11	0.17	0.24
Total Electricity Savings	0.1	0.4	0.7	1.0	1.5

Summary of budget from renewable energy installation in Industrial Sector

Table 54 : RE System Installation & Budget For Industrial Sector

System	Total Installation	Per Item Cost Rs.	Total Cost (Lakh Rs.)	MNRE Share @ 30 % in Lakh	User share @ 70 % in Lakh	User share @ 100 % in Lakh
SHWS - 1000 LPD	10	25000	3	-	-	3
SHWS - 3000 LPD	10	35000	4	-	-	4
SHWS - 5000 LPD	10	35000	4	-	-	4
Solar Community Cooker	5	45000	2	-	-	2

Solar steam generating system	5	16000	1	-	-	1
SPP - 5kW	10	300000	30	-	-	30
SPP - 10kW	10	750000	73	-	-	73
SPP - 15kW	5	1125000	58	-	-	58
SPP- 20kW	5	1500000	77	-	-	77
SPP - 25kW	5	1875000	96	-	-	96

Table 55 : Year Wise Investment for RE System installation for Industrial Sector



Type of System	Total Installation	Year wise Investment in Lakh				
		1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
SHWS - 1000 LPD	10	0.25	0.38	0.50	0.63	0.76
SHWS - 3000 LPD	10	0.35	0.53	0.71	0.88	1.06
SHWS - 5000 LPD	10	0.35	0.53	0.71	0.88	1.06
Solar Community Cooker	5	0.23	0.34	0.46	0.57	0.69
Solar steam generating system	5	0.08	0.12	0.16	0.20	0.24
SPP - 5kW	10	3.03	4.54	6.05	7.57	9.08
SPP - 10kW	10	7.28	10.91	14.55	18.19	21.83
SPP - 15kW	5	5.78	8.68	11.57	14.46	17.35
SPP- 20kW	5	7.71	11.57	15.42	19.28	23.13
SPP - 25kW	5	9.64	14.46	19.28	24.10	28.92
SHWS - 1000 LPD	10	0.25	0.38	0.50	0.63	0.76
Total		34.70	52.06	69.41	86.76	104.11

5.4 Renewable Energy Strategies for Municipal Sector



The municipal sector of the city consumes 3% of total electrical energy in the city. The primary consumption in this sector is from street lights, outdoor lights in parks and monuments, markets, office buildings of the Municipal Corporation, etc. Renewable energy devices are suggested to all categories of consumers depending upon the energy demand. The municipal sector has sufficient opportunity to save energy from installation of different renewable energy sources, which are:

- ✚ Renewable energy strategies for municipal sector lighting system for monuments, street light, traffic light, road safety light, etc.
- ✚ Renewable Energy Strategies for Advertisement hoardings in Ajmer city
- ✚ Renewable Energy Strategies for Parks under Ajmer Municipal Corporation

-  Solar boat Operation in Lakes of Ajmer
-  Solar Powered Rickshaw

Renewable Energy Strategies for Municipal Sector Lighting System for Monuments, Street Light, Traffic Light, Road safety Light etc.

The Ajmer Municipal Corporation has about nearly 32,000 outdoor lights with different wattage, which has been fixed for illumination streets, wards, monuments, etc. The Electrical Department of AMC manages street lights in the city. The table below indicate targets, investment and energy savings potential.

Table 56 : No of Conventional Street Lights Installed in Ajmer city (2014-15)

Conventional Street Light			
S. No.	Earlier Wattage of Lamp(W)	Quantity	Wattage of existing Street Lighting
1	HPSV-800W	67	800
2	HPSV-400W	8	400
3	HPSV – 150W	20	150
4	TL -96W	1428	96
5	HPSV - 70W	2	70
6	FTL-56W	5450	56
7	FTL - 40W	63	40
8	CFL - 36W	17	36
9	CFL - 28W	22876	28
10	CFL - 20W	59	20
11	CFL -15W	3	15
12	New Pole HPSV – 150W	834	70
13	New Pole HPSV – 70W	743	150
Total		31570	

Source: AMC

Solar Street Light



Solar street lights are raised light sources, which are powered by photovoltaic panels, generally mounted on the lighting structure. The photovoltaic panels charge a rechargeable battery, which powers a fluorescent or LED lamp during the night.

Most solar panels turn on and turn off automatically by sensing outdoor light using a light source. Solar street lights are designed to work from out the night. Many can stay lit for more than just one night not if sun in not available for a couple of days. Older models included lamps that were not fluorescent or LED. Solar lights installed in windy regions are generally equipped with flat panels to cope with the winds. Latest designs use wireless technology and fuzzy control theory for battery management.

Solar street lights are generally classified into two types.

Standalone solar street lights

Standalone solar streetlights have photovoltaic panels mounted on the structure. Each street light has its own photovoltaic panels and is independent of the other lamps.

Centrally operated solar street lights

In this type, the photovoltaic panels for a group of streetlights are mounted separately. All the streetlights in a particular group are connected to this central power source.

Comparison of existing street lighting system with the solar street lighting system

- Existing conventional street lighting system are of single bracket or double bracket.
- Each street light may be of HPSV or LPSV.
- The purpose of the street light is to illuminate the road as well as improve visibility of the traffic load.

Now while implementing solar street light system, all the above points are taken into consideration with less consumption. Because solar street lights are of CFL and LED

Benefits of solar street light

- ✚ No fuel is required
- ✚ Minimum maintenance is required
- ✚ Automatically operated
- ✚ No technicians are required
- ✚ Less wiring required

- ✚ Warranty of 25 years for solar module
- ✚ No monthly electricity bill
- ✚ Solar street lights are independent of the utility grid. Hence, the operation costs are minimized.
- ✚ Solar street lights require much less maintenance compared to conventional street lights.
- ✚ Since external wires are eliminated, risk of accidents is minimized

Solar Road Blinkers



Solar road studs are flashing solar cell, powered by LED maintenance-free lighting devices, used in road construction to delineate road edges and centerlines. Embedded in the road surface, they are an electronic improvement on the traditional cat's eyes, in that they may give drivers more than a thirty-second reaction window, compared with about 3 seconds for conventional reflective devices. The intense brightness of the LEDs makes them easily visible at distances of about 900m under favorable conditions. Use of solar road studs reduces the necessity of headlight main beams and the accompanying hazard of dazzling oncoming drivers. They are also more visible in rain and fog conditions where the old type retro reflectors and road markings are problematic. The solar cells charge batteries or capacitors during sunlit hours, over which period the flashing LEDs are turned off by a photo switch.

Solar Traffic Light



Solar traffic lights are signaling devices powered by solar panels positioned at road intersections, pedestrian crossings and other locations to control the flows of traffic. They assign the right of way to road users by the use of lights in standard colors (red - amber/yellow - green), using a universal color code (and a precise sequence to enable comprehension by those who are colour blind). Most of the solar traffic lights have battery back-up for functioning during night.

Solar Boats



Solar boats are electrical boats, with independent, quiet and clean engines, whose batteries store free energy from the sun. On the seas and inland waters as well as along their banks there are only a few connections to public electricity mains. People who live on inland waterway crafts, sailing boats, space stations and houseboats, are dependent on batteries, just as the owners of electrically propelled boats. But batteries sometimes discharge and must be replenished. One of the most elegant solutions for this is solar electricity. Solar modules on a ship can charge the batteries on the spot - cleanly and efficiently with free energy from the sun. In respect to Ajmer is Solar Boat is geared up the tourist attraction and ecofriendly to biota of the lakes. In lake aquatic life gets destroyed due to diesel boat operation. The noise and smoke pollution levels are also considerably reduced.

Table 57 Comparison of Solar Boat with conventional boats

Parameter	20 Passenger Solar boat	20 Pax Conventional boat with Petrol OBM
Initial Cost	35 Lakhs	₹ 20 Lakhs
Running Cost	0.15 Lakhs	₹ 8 Lakhs
Top Speed	11 km/h	11 km/h
Range	50 km	75 km (Depends upon petrol tank)
Noise Levels	<60 db	80-90 db
CO2 Released	0	24,360 kg/year
Weight	5 T (8 T including 6 passenger and effects)	9 T (12 T including passenger and effects)

Table 58: 20 Passenger Solar boat Details

Dimensions	Sun & Energy	Power & Performance	Range
Length – 9 m	Solar panels – 2 kWp	Motor – 2 x 4 kW	Sunny day – 5 hrs
Breadth – 3 m	Poly-crystalline	DC motor	Cloudy day – 4 hrs
Depth – 1.1 m	Battery bank – 9.6 kWh	Inboard propulsion	Night – 2 hrs
Draft – 0.6 m	Solar sealed batteries	Max. speed – 6 knots	@cruising speed

Table 59 : 10 Passenger Solar Boat Details

Dimensions	Sun & Energy	Power & Performance	Range
Length – 6.5 m	Solar panels – 1.25 kWp	Motor – 4 kW	Sunny day – 5 hrs
Breadth – 2.5 m	Poly-crystalline	DC motor	Cloudy day – 4 hrs
Depth – 1.1 m	Battery bank – 9.6 kWh	Inboard propulsion	Night – 2 hrs
Draft – 0.5 m	Solar sealed Batteries	Max. speed – 6 knots	@cruising speed

Solar Advertisement Hoardings System



Solar hoarding is an economically attractive option for advertisement in comparison to conventional hoardings. Target should be made to replace the conventional hoardings with solar hoardings. A solar hoarding light, on the other hand, is extremely affordable, with very low installation costs, and almost negligible maintenance. It will operate automatically (from dusk to dawn).

Only up-front costs are the costs of the system (materials) and the labor to install the system. Within just a few years, the solar hoarding light will have saved enough money to have completely paid for itself. Cost of solar powering a 10x20 feet hoarding is Rs 1 lakh and it can be recovered within two years, whereas a conventional mobile hoarding costs about Rs 3,25,000-3,50,000 a month. Such hoardings can replace conventional hoardings by solar retro-fits replacing consumption of conventional sources of energy. Solar energy can be used for various size of hoardings and the light generated will be equivalent to halogen lamps. Besides conserving good amount of energy, implementation of the technology will add to the demonstration effect of advertisements and be more soothing to eyes.

Table 60 Solar Hoarding technical details

Hoarding Dimensions	Light Source	Solar Panels	Charge Controller	Battery	Backup Source
20' x 10'	90W	250W	10A/24V	150Ah/12V x 2	24Hrs.
40' x 20'	120W	300W	10A/20V	150Ah/12V x 2	24Hrs.

Features:

- Cost Effective – 100% Sun Powered – No Electricity Bills.
- No Power Cable.
- 24 Hrs Uninterrupted Power Supply.

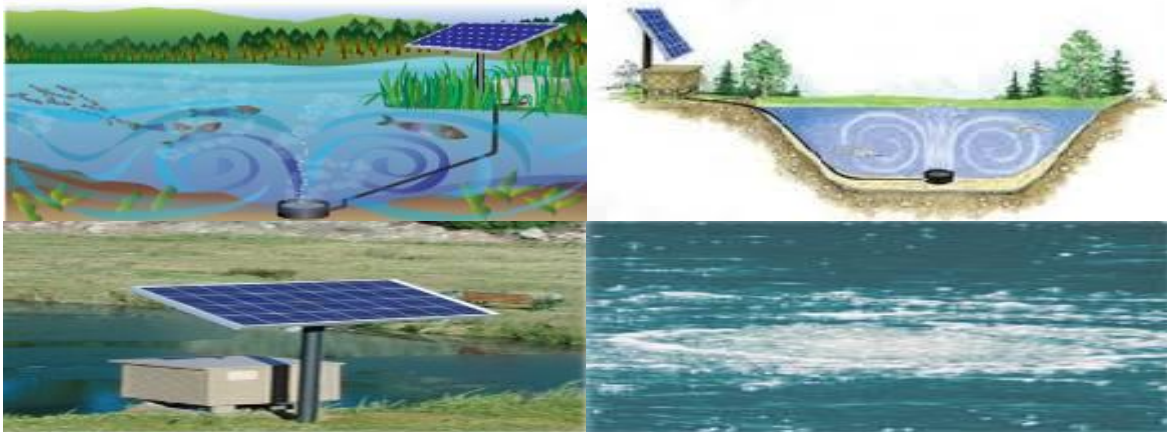
Applications:

- Hoarding Lights.
- Highway Signs.
- Gate and main Entrance Sign.

Solar E Rickshaw

When sunlight falls on solar panels, which are on roof of this rickshaw, solar panels make DC electricity. This DC energy then goes to the batteries via a charge controller so that excess charge is not delivered to the batteries. The batteries get fully charged and power the rickshaw. Solar PV modules charges the batteries while the rickshaw is waiting in traffic. During running condition, a portion of the solar energy along with battery power's the motor. It has twin benefits. The starting load on the batteries are reduced. Batteries do not get deep discharged thus increasing battery life. The rickshaw can easily be charged during night time with a separate solar charging station by simply installing a 1kW Solar power solution.

A normal battery rickshaw has to use conventional form of electricity to charge the batteries. They have to waste 4-5 hours in taking the rickshaw to electric charging station but with solar rickshaw can they can charge batteries on the run from the sun. Ordinary electric rickshaw can only go up to 65-100 km if the battery is fully charged but solar rickshaw increases the efficiency of the vehicle and it can go for a minimum of 85 kms and even more as the charging through solar is always on.

Solar Aeration Pumps

The Solar aeration system is a one-of-a-kind aeration system that is alternative to grid powered aeration (usually fossil fuel). Solar aeration systems are great for both remote installations and environmentally conscience applications. They are for aquatic environments ranging in size from small ornamental ponds to lakes up to 5 acres. These fully automatic systems are designed to run up to 20 hours per day under standard operating conditions. The battery backup system allows them to run like normal under less-than-optimal conditions. Built for both hot and cold climates, no climate is too harsh for Solar aeration systems. Aeration is the process of dissolving oxygen of air to the water for restoring a water body to its healthy state. During this process, the oxygen in the air gets dissolved and raises DO level of water. "Mobile solar power pond aeration system is best alternative to a conventional power from grid or diesel engine pond aeration system. Solar-powered aerator not only reduces algae growth and also increases Dissolve oxygen (DO) levels of the water body but it also has 24-hour auto run time. "A single aerator can help boost aquatic life in a lake spread over three acres. The visible difference in the water body is seen a fortnight after installation as the water becomes translucent and stink caused due to dead fish fades away.

Benefits

- ✚ Improves the esthetics and overall health of ponds and lakes.
- ✚ Targets the "cause" of the problem, rather than just its "symptoms".
- ✚ Eliminates the need for harmful chemicals.
- ✚ Is safe for the environment and animal inhabitants.
- ✚ Reduces maintenance, saving money and time.
- ✚ Improved Water Quality and Clarity.
- ✚ Improved Fish and Water Foul Habitat.
- ✚ Improves the dissolved oxygen in the water.
- ✚ Regulates the pH of the water

Applications

- For aquatic environments ranging in size from small ornamental ponds to lakes.
- Remote installations
- Environmentally beneficial landscaping / aquascaping

Lake Bed Aeration is the introduction of compressed air to a water body. When released at the bottom of a pond or lake, compressed air naturally begins to migrate towards the surface of the water. As air travels up the water column the pressure surrounding the bubbles slowly decreases causing the bubbles to increase in size a slight current begins to develop due to the suction and pumping action of the device. The current draws oxygen-depleted water from the bottom, oxygenates it and transports it to the surface due to aeration. This action protects fish, aquatic organisms and beneficial bacteria from suffocation by breaking down stratified waters while increasing dissolved oxygen levels. Low levels of dissolved oxygen and highly stratified waters can characterize degraded or eutrophic ponds and lakes, where warm, oxygen-rich water is suspended above cool, oxygen-depleted bottom waters.

As anaerobic conditions begin to develop in deeper water, naturally occurring aerobic bacteria can no longer perform beneficial tasks such as waste digestion and water purification. With time, water quality greatly decreases leading to unsightly blooms of algae, the accumulation of aquatic sludge and the build-up of gases such as methane and hydrogen sulfide (which are well know for their offensive odors). Low oxygen levels can also lead to death of fishes and other water animals and plants.

Solar Aeration Pumps includes:

- Solar panel(s)
- Deep cycle gel cell solar batteries
- Brushless DC compressor
- Wiring harness
- Charge control center
- 12/24 volt smart box converter
- Programmable digital timer
- Energy efficient, high volume air compressors
- Attractive 100% recycled plastic cabinet equipped with cooling and sound reduction packages
- Fully-adjustable manifold with safety relief valve and pressure gauge
- Self-cleaning, non-clogging, membrane diffusers
- Complete fittings package
- Installation and maintenance manual

Optional Equipment

- Automatic Solar Tracking System
- Acrylic Flowmeters
- Vandal-Proof Metal Cabinets
- Alpine Self-weighted Feeder Tubing
- Oxygen/Ozone Generation systems

Table 61 Solar Aeration Pumps System Components details

Air Compressor either Rocking Piston, Rotary Vane, High Pressure Piston or Diaphragm	Generates the compressed air
Cooling Fan	Protects the system from overheating
Liquid Filled Pressure Gauge	Monitors system pressure
Pressure Relief Valve	Protects the system from over pressuring
Distribution Manifold	Allows airflow to be adjusted to the diffusers
Electrical Protection	Protects against electrical damage
Inline Check Valves	Prevent water from entering the airline while system is off
Dura Plate or Dura Venturi Diffusers	Air diffusion device, produces the bubbles
Feeder Tubing	Air delivery line, run between aeration system and diffusers

Solar Powered Lake and Pond Aeration System, saves energy and conserves natural ecosystems

Waste to Energy



Energy generation through Municipal Solid Waste

A rough assessment of the potential of recovery of energy from MSW from different treatment methods can be made from knowledge of its calorific value and organic fraction as shown in Table below. Widely used estimates for municipal solid waste in India and Rajasthan have been used. In thermo-chemical conversion, all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output.

Table 62 : Waste to Energy Power Generation Potential from MSW in Ajmer City

Particulars	Value
Total waste quantity	250 tonnes
Net Calorific Value	NCV k-cal/kg.
Energy recovery potential (kWh)	$NCV \times 250 \times 1000/860 = 1.16 \times NCV \times 250$
Power Generation Potential (kW)	$1.16 \times NCV \times 250/24 = 0.048 \times NCV \times 250$
Conversion Efficiency	30%
Net Power Generation Potential (kW)	$0.015 \times NCV \times 250$
If NCV	700 kcal/kg., then
Power generation potential (kW)	$10.2 \times 250 = 2544$ (kW) or 2.54 MW
Plant Load factor	80%
Net Power generation potential (kW)	Say 2.54 MW
Power Generation Annually (@ 330 days)	16.1 MU or GWh
GHG Emission Reduction Equivalent CO ₂ MT / Year	14505

Energy Generation through Sewage Treatment Plant



Google Image of under construction 60 MLD(40+20 MLD) STP at Ajmer

Sewage is the untreated municipal liquid waste requiring treatment in a sewage treatment plant. Sewage contains about 99.9% of water, while the remaining content may be organic or inorganic. Sewage denotes both black water and grey water at the household level, where black water refers to waste water generated in toilets and grey water to the waste water generated in kitchen, bathroom and laundry. The produce of

waste water treatment can be used as a raw material for anaerobic digestion and subsequently for power generation. Sewage generation of the city is around 92 MLD per day. The wastewater (sewage) generation for future has been calculated at 80% of the water demand. The water demand for this purpose has been calculated at the rate of 135 lpcd as per Ajmer master plan for 2031.

Table 63 Sewage generation per day in Ajmer City

Year	Population	Water Demand in MLD	Sewage Generation in MLD
2013	4,68,904	115	92
2021	5,41,219	123	98
2027	6,41,457	130	104

Source: Ajmer Master plan

Accordingly, @ 80 lpcd, for the projected population of 6.44 lakhs for year 2021, the sewage produced will be to the tune of 98 MLD and for 2031 it will be 104 MLD. A very preliminary assessment shows that there is a potential of installing a 2 MW power plant. Currently 60 MLD STP is in construction phase. In addition, 50 MLD STP recommended for Ajmer city for future requirements. A detailed study has to be made for Ajmer to quantify the total sewage generation.

Table 64: Electricity Generation from 50 MLD Sewage Treatment Plant

Sewage Treatment Plant		
System details	Value	Unit
Plant Capacity	50	MLD
Biogas yield	8000	m ³
Electricity (kWh) potential	48000	kW
Capacity of the plant	2000	kW
Conversion Efficiency	33	%
Total Electricity Generated Per Year	5.7816	MU
Plant Load Factor	70	%
Net electrical energy savings potential	4	MU
Emission reduction CO ₂ per year	68322	MT

Solar Car Parking



Solar car parking solution that is an intelligent alternative to rooftop or ground mounted Solar Plant. Solar systems can be installed in any car park, generating solar energy that can be used on-site as well as a charging point for electric cars, and is a perfect way to harness the Sun's Energy to produce green energy.

Summary of Energy Savings from RE Installation in Municipal Sector

Sl.	Device Name	Number of Establishment in Municipal Sector	Total number of Installation	Cost of System (in Lakh)	Electricity saving per year in MU	Amount of Electricity savings per year in Lakh Rs	CO2eq reduction per year in metric ton (MT)
1	Solar E Rickshaw	500	500	575	0.83	49.7	743
2	Solar studs	5000	5000	30	0.20	11.9	178
3	Solar Hoardings	100	100	75	0.00	0.2	2
4	SSL 7 watt LED	100	100	19	0.01	0.4	5
7	Solar traffic LED	150	150	21	0.02	1.4	21
8	SPP 1kW	10	10	8	0.02	1.2	18
9	SPP 2kW	7	7	11	0.03	1.7	25
10	SPP 1 MW	1	1	530	1.86	112.2	1674
11	Waste to Energy(MSW)	1	1	3750	16.12	971.8	15794
12	Waste to Energy(STP)	1	1	2400	5.78	348.6	4163

^Approx.

Table 65 : Year Wise Energy Saving Target from RE System for Municipal Sector

System	Annual Electricity Savings (GWh) Cumulative				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Solar E Rickshaw	1.500	3.750	6.750	10.500	15.000
Solar studs	0.020	0.050	0.089	0.139	0.198
Solar Hoardings	0.003	0.007	0.012	0.019	0.028
SSL 7 watt LED	0.001	0.001	0.003	0.004	0.006
Solar traffic LED	0.002	0.006	0.011	0.017	0.024
SPP 1kW	0.002	0.005	0.009	0.014	0.020
SPP 2kW	0.003	0.007	0.012	0.019	0.028
SPP 1 MW	1.860	1.860	1.860	1.860	1.860
Waste to Energy(MSW)	16.116	16.116	16.116	16.116	16.116
Waste to Energy(STP)	5.782	5.782	5.782	5.782	5.782
Total Energy savings	25.288	27.584	30.644	34.470	39.061

Summary of Year Wise Budget Sharing for RE System Installation in Municipal Sector

Table 66 : Year Wise Investment for RE System Installation for Municipal Sector

Systems	Total devices	Cost of one System in Rs	Total cost in Lakh Rs	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Solar E Rickshaw	500	115000	575	58	86	115	144	173
Solar studs	5000	600	30	3	5	6	8	9
Solar Hoardings	100	75000	75	8	11	15	19	23
SSL 7 watt LED	100	19000	19	2	3	4	5	6
Solar traffic LED	150	14000	21	2	3	4	5	6
SPP 1kW	10	75000	8	1	1	2	2	2
SPP 2kW	7	150000	11	1	2	2	3	3
SPP 1 MW	1	53000000	530	530	0	0	0	0
Waste to Energy (MSW)	1	375000000	3750	3750	0	0	0	0
Waste to Energy(STP)	1	240000000	2400	2400	0	0	0	0

Summary of Total Budget Estimate Sharing for Renewable Energy System Installation

Table 67: RE System Installation & Budget Estimate for Municipal Sector

Budget Estimation for Municipal Sector			
System	Total devices	MNRE Share in Lakh	User share in Lakh
Solar E Rickshaw	500		575
Solar studs	5000		30
Solar Hoardings	100		75
SSL 7 watt LED	100		19
Solar traffic LED	150		21
SPP 1kW	10		8
SPP 2kW	7		11
SPP 1 MW*	1		530
Waste to Energy(MSW)*	1	500	3250
Waste to Energy(STP)*	1	400	2000

(*MNRE Share only for Waste to Energy recovery system)

Chapter - 6

Renewable Energy Pilot Projects

In order to showcase Ajmer as a Solar city many new and innovative projects will have to be implemented along with conventional and proven technological options in renewable energy and energy efficiency. Also projects being implemented under the smart city initiative may also be coupled with these to further improve RE and EE use. Some pilot projects that have been considered to be installed to promote and create awareness of renewable energy and energy efficiency use. MNRE also various schemes in these and sanctions pilot projects for each solar city based on the need and feasibility of RE and EE in the city. A few pilot projects have been prepared for the city in consultation with AMC and SPV smart city officials. These can be implemented on a pilot basis in the city.

6.1 Pilot Projects in Renewable Energy for Ajmer city

For the present draft report the following projects have been recommended for the city. However, some new innovative concepts have also been shared in the report like solar boats, solar e-rickshaws, etc. These along with any new idea or concept could also be taken up and recommended once a detailed discussion on the plan is made with the solar city stakeholder committee. The following projects are recommended in this section.

- Solar Power Plant of 1 MW capacity – AMC, Ajmer
- Solar Power Plant of 1 MW capacity in Mayo College
- State Level Solar Energy Park
- Net metering power project
- SPV power plants on Government institutional buildings
- Energy generation from MSW
- Energy generation from STP waste

Details of these projects have been provided subsequently in this chapter.

Pilot Project Concept Note -1

A 1 MW SPV power plant is recommended for Ajmer City area requiring around 2 ha is considered for the project. The average daily normal incidence (DNI) at the site is 5.05 kW/sq.m/day, peak DNI is in the month of March 7.1 kW/Sqm/day and least is in January. Average Global horizontal Incidence (GHI) at site is 5.63 kW/sq.m/day, peak is in May 7.7 kW/Sqm/day and lowest is 1.1 kW/Sqm/day in January. A typical daily DNI curve at site is presented below. Plant will normally start operation from 7AM to 7PM peaking will be at around 1-2 PM, this would keep varying with months and seasons.

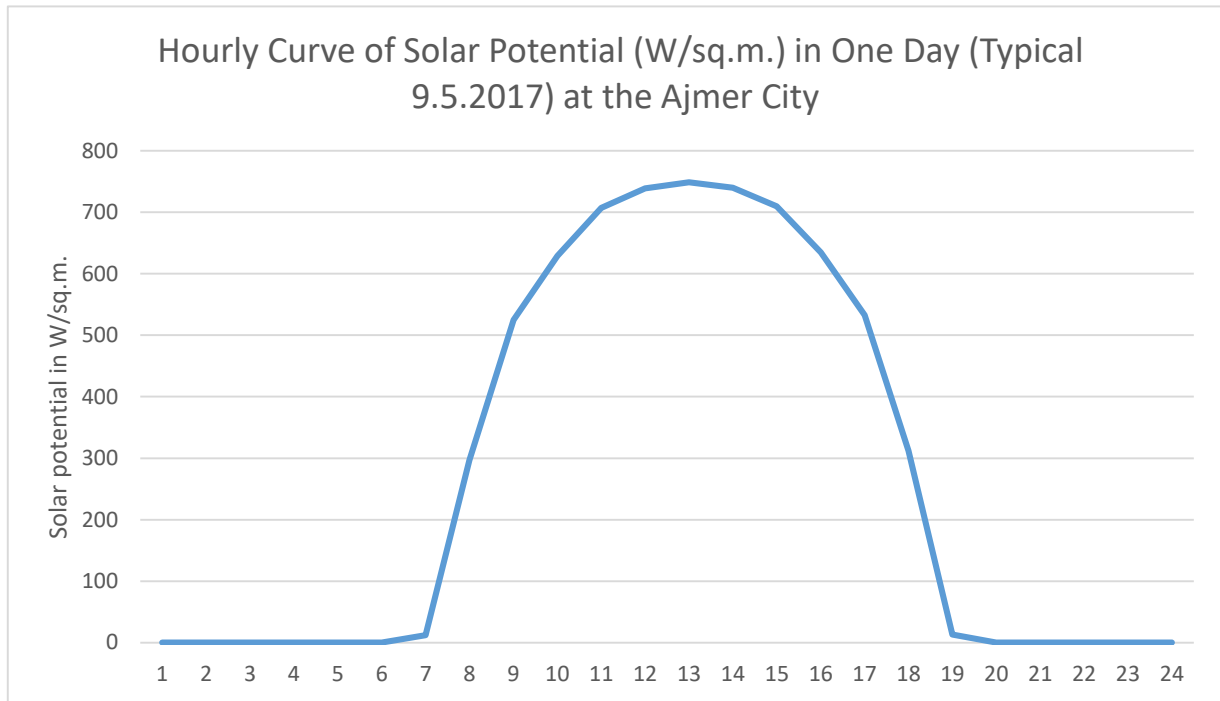


Figure 34 Hourly Curve of Solar radiation

It may be mentioned that actual implementation of the project would be undertaken by an approved MNRE/RRECL Organisation and they would be made aware of the site conditions prior to installing the power plant, detailed site characteristics and potential would have to be worked out separately.

Other aspects to be undertaken by power plant contractor include site slope for panel installation (as recommended slope is 2%, slope stabilization, loose rocks and boulders, water availability, power evacuation, grid availability, design of foundations and structures to take care for wind loads, dust, extreme heat wave, any other natural environmental danger etc. would have to be ensured.

System brief

In grid interaction system, the DC power generated from SPV panels is converted to AC power using power conditioning unit and is fed to the grid either of 33kV/11 KV three phase line depending on the system installed. The grid- interactive SPV power plant works on net metering basis wherein the beneficiary/promoter bills to the utility/DISCOM on net meter reading basis. Ideally, grid interactive systems do not require battery backup.

System cost and economics

As per the latest Central Electricity Regulatory Commission guidelines vide Petition No. 17/SM/2015 date of Order: 23rd March 2016. The benchmark cost for a 1 MW sized solar power plants has been fixed at Rs.530.02 lakh/MW for FY 2016-17 as detailed in table-1 below.

Table 68: Benchmark cost for Solar Power Plant

S.No.	Particulars	Capital Cost norm proposed for FY 2016-17 (Rs. lakhs/MW), for Solar PV projects	% of Total Cost
1	PV Modules	328	62.0%
2	Land Cost	25	5.0%
3	Civil and General Works	35	7.0%
4	Mounting Structures	35	6.6%
5	Power Conditioning Unit	35	6.6%
6	Evacuation Cost up to Inter-connection Point (Cables and Transformers)	44	8.3%
7	Preliminary and Pre-Operative Expenses including IDC and Contingency	28.	5.0%
8	Total Capital Cost	530.	100%

Source: CERC Petition (<http://www.cercind.gov.in/2016/orders/SO17.pdf>)

Table 69: 1 MW Solar Power Plant at Ajmer city

Project Title:	Installation of 1 MW Solar Power Plant at Ajmer City
Project Benefits:	Estimated Annual Electricity Generation 1.65 MU
Capital Cost :	530 Lakh
Land requirement	2 ha.
Implementation Structure:	Project Proponent shall enter into MOU with concerned AVVNL DISCOM for sale/purchase of power.
Tentative Budget	530 Lakh
Time Frame:	2017 to 2018

Pilot Project Concept Note 2
1 MW Solar Power Plant at Mayo College

Table 70 : 1 MW Solar Power Plant at Mayo college

Project Title:	Installation of 1 MW Solar Power Plant at Mayo College
Project Benefits:	Estimated Annual Electricity Generation 1.65 MU
Capital Cost :	530 Lakh
Roof Top Requirement	2 ha.
Implementation Structure:	Project Proponent shall enter into MOU with concerned AVVNL DISCOM for sale/purchase of power.
Tentative Budget	530 Lakh
Time Frame:	2017 to 2018

Pilot Project Concept Note 3

Community Hall, AMC Ajmer Solar Power Pack- 25 kW

Table 71 : Community hall , AMC Ajmer Solar Power Pack- 25 kW

Project Title:	Installation of 25 kW Solar Power Project Community hall , AMC Ajmer
Project Description	25 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.04 MU
Capital Cost :	18.75 Lakh
Roof Top Requirement	250 sq.m.
Implementation Structure:	Project Proponent shall enter into MOU with concerned AVVNL DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
Tentative Budget	18.75 Lakh
Time Frame	2017 to 2018

Pilot Project Concept Note -4**Government Building Solar Power Pack – 20 kW****Table 72 : Government Building Solar Power Pack – 20 kW**

Project Title:	Installation of 20 kW Solar Power Project at Government Building, Ajmer
Project Description	20 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.033 MU
Capital Cost :	15 Lakh
Roof Top Requirement	200 sq.m.
Implementation Structure:	Project Proponent shall enter into MOU with concerned AVVNL DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
Tentative Budget	15 Lakh
Time Frame:	2017-18

Pilot Project Concept Note-5**Government Hospital Building, Ajmer Solar Power Pack- 30 kW****Table 73 : Government Hospital Building, Ajmer Solar Power Pack- 30 kW**

Project Title:	Installation of 30 kW Solar Power Project at Government Hospital Building, Ajmer
Project Description	30 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.049 MU
Capital Cost :	22.5 Lakh
Roof Top Requirement	300 sq.m.
Implementation Structure:	Project Proponent shall enter into MOU with concerned AVVNL DISCOM for sale/purchase of power.
Financing Mechanism	Program to be supported by MNRE under Demonstration Project
Tentative Budget	22.5 Lakh
Time Frame	2017-18

Pilot Project Concept Note- 6
State level Solar Energy Park



Energy Park Scheme

Solar Energy park can be established under Energy Park Scheme under Special Area Demonstration Project (SADP) of MNRE. The Scheme was initiated with the objectives of demonstration of various new and renewable sources of energy technologies and creation of awareness and publicity amongst students, teachers, rural and urban masses about the use and benefits of renewable energy systems and devices



The land for the park of around 2.5 to 3.0 acres of land would be arranged by the concerned organisation/agency for establishment of State level Energy Park either on an ownership basis or through long term MOU with other Government organisation/Universities.

A maximum Central Financial Assistance of up to Rs. 100.00 lakh (Rs. One Crore) would be provided by the Ministry to meet the full cost of procurement and installation of energy systems and devices and minor civil works. The balance civil and other infrastructural cost would be borne by the concerned State/organisation.

Table 74 : Solar Energy Park details

Project Title	Establishment of Solar Energy Park in Ajmer City
Land requirement	2.5 to 3 acre
Cost of Land	Arranged by the concerned organisation/agency
Implementation Structure	Project Proponent shall enter into MOU with concerned Ajmer DISCOM for sale/purchase of power.
Financing Mechanism	Program to be supported by MNRE under Demonstration Project
MNRE contribution	100 lakh – full cost of procurement and installation of energy systems and devices and minor civil works
Organization Contribution	<ol style="list-style-type: none"> 1. Funds for Land Arrangement 2. Funds for Civil work and other infrastructural
Operation & maintenance Expenses	Funds will arrange through self-sustaining basis by levying suitable entry fee
Time Frame	Within one year of Sanctioned of the Project from MNRE

Performa for submission of State Level Energy Park (SLEP) Proposals

Table 75 Solar Energy Park

Form	
1	Name of the State/U.T
2	Name of the State Nodal Agency
3	Name of the district in which the SLEP is proposed
4	SLEP already existing in the State, if any with its address
5	Aims and objectives of the SLEP may be explained clearly)
6	Whether financial assistance for the SLEP Project has been sought from any other funding agency, and if so, give details
7	Infrastructure & other facility available at the Institute for setting of SLEP <ol style="list-style-type: none"> 1. Certificate towards availability of land 2. Undertaking towards meeting the cost of infrastructure development/ civil works 3. Undertaking towards execution of annual maintenance contract of NRSE Systems/ Devices and annual insurance contract 4. Undertaking towards operation & Maintenance with remote monitoring of the NRSE Systems 5. systems on self-sustainable basis including mode of generation of revenue
8	Details of NRSE systems and devices proposed to be installed including their cost and installation cost (may be given separately)
9	Plan for utilizing the energy (if any) generated through the NRSE systems (the use of these systems may be indicated separately) <ol style="list-style-type: none"> (i) Time required for installation of the systems: (ii) Details of availability of matching

Pilot Project Concept Note-7

Waste to Energy at Dumping Site (Electricity Generation from Municipal Solid Waste)

Table 76 Waste To Energy Generation 2.5 MW Power Generation Plant at Dumping Site

Project Title:	2.5 MW Power Generation Plant Project at Makhapura Dumping Site, Ajmer
Project Description	2.5 MW Grid Connected to HT distribution network (11 KVA)
Project Benefits:	Estimated Annual Electricity Generation 16.1 MU
Capital Cost :	15 crore
Land Requirement	Incineration/Gasification/ Pyrolysis plants: 8000 square meter* Anaerobic Digestion Plants: 20000 square meter* Sanitary Landfills (including Gas-to-Energy recovery) : 300000 square meter**
Implementation Structure:	Project Proponent shall enter into MOU with concerned AVVNL DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under CFA Scheme Project
MNRE Share/subsidy	2 crore/MW (5 Crore for the project)
State Share	32.50 crore
Time Frame:	2017-18



MSW dumping site at Makhapura, Ajmer

Chapter - 7

Energy Efficiency Strategies for Ajmer

While renewable energy technologies would provide clean energy, energy efficient strategies and demand side management measures would help in reducing the energy demand. Energy Efficiency (EE) initiatives are the most financially feasible energy saving options in India today. In this report, the EE measures have been thoroughly analyzed for all the four sectors, i.e. residential, commercial, industrial and municipal. The financial and technical analysis is provided for each strategy suggested in all the sectors.

The list of EE and DSM measures suggested for different sectors is given below:

Energy conservation/devices /systems

- LEDs/ CFLs instead of incandescent bulbs / LED traffic lights
- Electronics chokes and fan regulators
- Sensors for automatic on/off of street lights
- Automatic speed regulating fans/motors
- Plugging of leakages in the water supply system and use of efficient pumps and motors
- Energy efficient electrical appliances such as fans, refrigerators, air conditioners, coolers, room heaters, water pumps etc.
- Use of insulating materials and low-energy/energy-efficient building materials e.g. fly ash bricks, hollow bricks, stabilized mud blocks, etc. in building construction
- Any other Energy Efficient/ Energy Conservation device, project being promoted by BEE, Ministry of Power or MNRE



Solar passive architecture in buildings/housing complexes

Major components of solar passive architecture are orientation of building, sun shades, double glazed windows, smart glazing window overhangs, thermal storage wall/roof, roof painting, ventilation, evaporative cooling, day lighting, wind towers, earth air tunneling, construction materials etc. Incorporation of specific components will depend in which climatic zone the building is being constructed.

Green Buildings

The construction of the Green Buildings as per GRIHA Rating, LEED India, ECBC building Code, BEE Star Rating, ECO Housing or other rating systems.

Energy Efficiency Strategies for Residential, Commercial & Institutional, Industrial and Municipal Sector


- ❖ Replace incandescent bulb with LED
 - ❖ Replace fluorescent tube light with LED
 - ❖ LED to replace T12 tube light+ magnetic ballast
 - ❖ Replacement of HPSV with LEDs
 - ❖ Replacement of Energy efficient ceiling fans to replace conventional ceiling fans
 - ❖ Replacement of conventional air-conditioners with energy efficient star rated A.C.s
 - ❖ Replacement of conventional refrigerators with energy efficient star rated refrigerators
 - ❖ Replacement of conventional water pumps with energy efficient water pumps
 - ❖ Sensors for automatic on/off of street lights
 - ❖ Proper Pump-system design (efficient Pump, pumps heads with system heads
 - ❖ Power saver installation in pump house
 - ❖ Plugging of leakages in the water supply system and use of efficient pumps and motors
- Energy Efficiency Measures in WTP

Bureau of Energy Efficiency, Government of India has issued the energy saving guidelines for electrical equipment. Details of energy saving with star rate equipment is listed in figure below:


Table 77 Energy Efficient Star Rated Product details

Star Rated Products


Mandatory for following Products




Frost Free Refrigerators



Tube Lights



Air Conditioners




Distribution Transformers

Energy & Cost Savings for 250 Liters Frost Free refrigerators with different Star ratings							
Star Rating	Energy Consumption (Kwh)	Per Unit Charge (Rs)	Electricity Cost/Yr	Total Savings/ Yr wrt No Star rated	Refrigerator Cost App	Cost difference	Pay Back period (yr)
No Star	1100	4	4400	0	14000	0	0
1	977	4	3908	492	15000	1000	2.03
2	782	4	3128	1272	15500	1500	1.18
3	626	4	2504	1896	16500	2500	1.32
4	501	4	2004	2396	17500	3500	1.46
5	400	4	1600	2800	18500	4500	1.61


Energy and cost saving for 1.5 Tons Windows or Split ACs at different Star ratings							
Star Rating	Minimum	Maximum	Input Power Watt	Units Consumption per day KWh	Per Unit Charges (App) Rs	Electricity Cost/ Month Rs	Cost Savings per year (wrt No Star) Rs
	Energy Efficiency Ratio (EER)	Cooling Capacity Watts					
No Star	2.2	5200	2364	9.45	4	1134	
1	2.3	5200	2261	9.04	4	1084.8	
2	2.5	5200	2080	8.32	4	998.4	
3	2.7	5200	1926	7.7	4	924	
4	2.9	5200	1793	7.17	4	860.4	
5	3.1	5200	1677	6.71	4	805.2	

Note: Assuming 8 hours operation per day for five months: a year


Voluntary for following products




Direct Cool Refrigerator




Industrial Motor




Mono set pump




Open well pump set




Submersible pump set




Gas stove




Storage heater



TV

















Washing machine



Fan

Table 78 Star Rated Energy Efficient Products

Star Rated Products									
 Frost Free Refrigerators (20 brands & 631 models)		 Tube Lights (15 brands & 42 models)		 Air Conditioners (56 brands & 1510 models)		 Distribution Transformers (229 brands & 653 models)			
Refrigerators <ul style="list-style-type: none"> • App cost of 220 Liter Non Star Refrigerator is Rs 15000/- where as cost of 5 Star rated Refrigerator is Rs 23000/- • Annual power consumption of 5 Star, 220 Liter Refrigerator is 720 Units where as ordinary Refrigerator annually consumes power about 1800 units (Assuming 365 days operation in a year) • Annual cost of electricity consumption of Non Star 220 Liter Refrigerator is very high (Rs 7200/-) in comparison to Rs 2880/- for 5 Star 220 Liter Refrigerator • Annually money savings of Rs 4500/- by using 5 Star rated 220 Liter Refrigerator • Payback period of 5 Star rated Refrigerator is app 2-3 years 					Air Conditioners <ul style="list-style-type: none"> • App cost of 1.5 Ton Non Star AC is Rs 21000/- where as cost of 5 Star rated AC is Rs 33000/- • Annual power consumption of 5 Star, 1.5 T AC is 2400 Units where as ordinary AC annually consumes power about 4050 units (Assuming 200 days operation in a year) • Annual cost of electricity consumption of Non Star 1.5 Tons AC is very high (Rs 16200/-) in comparison to Rs 9600/- for 5 Star 1.5 Tons AC. • Annually money savings of Rs 6600/- by using 5 Star rated AC • Payback period of 5 Star rated AC is app 2-3 years 				
 Direct Cool Refrigerator 14 brands & 599 Models	 Industrial Motor 08 brands & 103 models	 Mono set pump 08 brands & 74 models	 Open well pump set 31 brands & 286 models	 Submersible pump set 78 brands & 2930 models	 Gas stove 02 brands & 06 models	 Storage heater 46 brands & 325 models	 TV 07 brands & 250 models	 Washing machine 02 brands & 07 models	 Fan 24 brands & 74 model

7.1 Energy Efficiency in Residential Sector

Residential sector shares large amount of energy consumption in Ajmer city. There are various suggestions to reduce energy demand from energy efficiency that are described below. According to the survey, it is observed that incandescent bulbs are continuously being used by the residential sector, which consumes large amount of electricity. Some Energy Efficient options and calculations are described below:

Replacement of Incandescent Bulb with LED Lights



Conventional incandescent bulbs consume large electricity in the residential sector due to its technology and low initial cost. During the sample survey, it was found that incandescent bulbs are still being used by some households in residential sector. Replacement of incandescent lamps with energy efficient CFL and LED is a feasible option to reduce energy demand in residential sector. There is also scope of replacing the tube lights with CFL or LED's.

Replacement of 40-watt T 12 tube lights and CFL from LED lights



The letter ‘T’ in the lighting industry stands for “tubular”. The number directly following the letter “T” indicates the thickness or diameter of that particular tube in eighths of an inch.

- T12 = twelve eighths of an inch in diameter or one and one-half inches thick
- T8 = eight eighths of an inch in diameter or one inch thick
- T5 = five eighths of an inch in diameter or five eighths of an inch thick

As interest in energy saving technologies has grown and become popularized, these codes have come to designate levels of energy efficiency, instead of merely indicating lamp tube diameter.

Although, these assumptions are generally true, it is important to look at the application and determine the cost benefit of T5 over T8, in order to determine if the increased efficiency of T5 justifies the substantial increase in initial and long-term maintenance costs. Several different factors determine levels of efficiency. Quality of light is measured in CRI (Colour Rendering Index), quantity of light is measured in LPW (Lumens per Watt) and CU (Co-efficiency of utilization.) The numbers being used for CU are general for those used in the low level (12 feet and under) multi-essential environment, so that there can be fluctuations.

The electronic ballast eliminates the need for the fluorescent lamp starter. A conventional tube light T12 (with magnetic ballast consuming 14W) consumes around 54 watts. It can be replaced with T5 tube (28W) with electronic ballast (4W), which will require nearly 32W. Calculation has been done for five years’ energy savings.

T12 40-watt tube light consumes large electricity in the residential sector. During the sample survey, it was recognized that T12 40-watt tube light are being used in majority of the households of residential sector. Replacement of T12 40-watt tube light with energy efficient 15 Watt LED tube is feasible option to reduce energy demand in residential sector.

UJALA scheme

Hon’ble Prime Minister Sh. Narendra Modi described the LED bulb as “Prakash Path” – “way to light”. A simple act of change of one light bulb to LED at South Block Prime Minister's office heralded a movement in the entire country for considering the same change. The initiative is part of the Government of India’s efforts to spread the message of energy efficiency in the country. UJALA scheme aims to promote efficient use of energy at the residential level; enhance the awareness of consumers about the efficacy of using energy efficient appliances and aggregating demand to reduce the high initial costs thus facilitating higher uptake of LED lights by residential users. It may be noted that the scheme was initially labelled DELP (Domestic Efficient Lighting Program) and was relaunched as UJALA.

Every domestic household having a metered connection from their respective Electricity Distribution Company is eligible to get the LED bulbs under the UJALA Scheme. The consumer can purchase the LED on EMI payment (monthly/bimonthly instalments in electricity bill) or on upfront payment by paying the full amount. The consumer needs to carry the following documents to get the UJALA LED bulb:

- 1) For EMI – Copy of latest electricity bill and copy of Government authorized ID proof
- 2) For Upfront - Copy of Government authorized ID proof.

Replacement of Conventional Ceiling Fan with Energy Efficient Ceilings Fan

Energy Efficient Ceilings Fan

BEE 5 star rated ceiling fans are made specially to consume low power for superior performance. It has a special motor that delivers a gentle breeze and performs at 50 Watts of power as against the commercially available fans that consume a minimum of 80 Watts.

BEE 5 star-rated ceiling fans is designed to run continuously, year after year, without heating up or burning out due to low power consumption.

Table 79 Star Rating Index for Ceiling Fans

Star Rating Index for Ceiling Fans	
Star Rating	Service Value for Ceiling Fans
1 Star	≥ 3.2 to < 3.4
2 Star	≥ 3.4 to < 3.6
3 Star	≥ 3.6 to < 3.8
4 Star	≥ 3.8 to < 4.0
5 Star	≥ 4.0



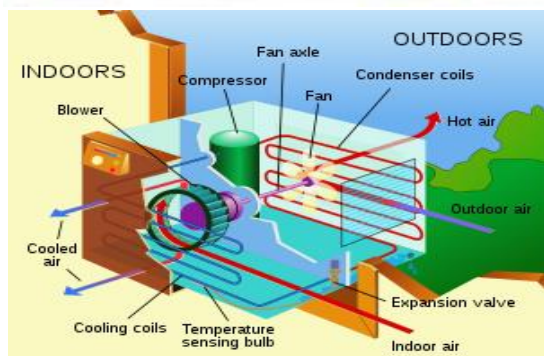
Star Rating	Min. Air Delivery (AD) m3 / min	Input Power in Watts	Service Value (SV) =AD / Power m3 / min / Watt
5 Star	210	52	>=4

Replacement of Conventional Air Conditioner (A.C.) with EE Star Rated A.C.

Air Conditioner

An air conditioner is a home appliance system, or mechanism designed to dehumidify and extract heat from an area. The cooling is done using a simple refrigeration cycle. In construction, a complete system of heating, ventilation and air conditioning is referred to as "HVAC".

For Air conditioners, the star levels are categorized over a band of COP (Co-efficient of Performance) numbers. COP indicates the amount of cooling capacity in watts the A.C. delivers for every watt of electrical energy consumed by it. At present, the COP has to be minimum 2.5 to qualify for 1-Star rating. COP of 3.3 and above falls under 5-Star category. BEE has plans to move up the energy efficiency level continuously in every two years.



Replacement of Conventional Refrigerator with EE Star Rating Refrigerator

Home Refrigerator, often called a “fridge”, has become an essential household appliance. A refrigerator is a cooling appliance that transfers heat from its thermally insulated compartment to the external environment, and thus, cooling the stored food in the compartment. It also normally houses a “freezer”, where temperatures below the freezing point of water are maintained, primarily to make ice and store frozen food. Crisper, which draws inside moisture to keep vegetables and fruits fresh for longer time is normally inbuilt in most of home refrigerators. Two types of home refrigerators are typically available in market. These are:

Direct Cool Refrigerators: These refrigerators are with or without crisper, ice making or frozen food storage compartment. Cooling of food is primarily obtained by natural convection within the refrigerator. However, some refrigerators may have a fan to avoid internal condensation of water but are not claimed as ‘frost free’.



Table 80 Energy and Cost Saving for 180 liters Frost Free Refrigerator with different Star Ratings

Star Rating	Energy Consumption /year	Per Unit price	Electricity Cost Per Year	Total Savings w.r.t. No Star/ Year	Refrigerator Cost	Cost Difference
	Units (kWh)	Prices in Rs				
No Star	1100	5	5500	0	14000	0
1	977	5	4885	615	15000	1000
2	782	5	3910	975	15500	1500
3	626	5	3130	780	16500	2500
4	501	5	2505	625	17500	3500
5	400	5	2000	505	18500	4500

Source: Bureau of Energy Efficiency

Replacement of Conventional Water Pump with EE Star rating Water Pump

Energy efficient pumps also significantly help to reduce the electricity consumption compared to non-rated pumps due to better design of electric motor, water pump design, intake and outlet pipe designs.



7.1.8 Summary of Saving target from EE Installation in Residential Sector

The total energy saved on account of replacement/new installation of energy efficient devices in the city is presented in table 84. 5th years shows the cumulative savings.

Table 81 : Summary of Energy Saving Target through replacement/ new systems of Conventional System with EE System in Residential Sector

Type of System	Electricity savings in MU				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Replacement of T12 Tube light with 15 watt LED	0.3	0.7	1.3	2.0	2.8
Replacement of 23 watt CFL with 12 watt LED	0.1	0.2	0.4	0.6	0.8
Replacement of 18 watt CFL with 9 watt LED	0.1	0.2	0.4	0.7	1.0
Replacement of 15 watt CFL with 7 watt LED	0.2	0.4	0.8	1.2	1.7
Replacement of conventional Ceiling Fan with 5 Star rated Ceiling Fan	0.1	0.3	0.5	0.8	1.2
Replacement of conventional AC with 5 Star EE AC	0.5	1.2	2.2	3.5	5.0
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	1.4	3.5	6.4	9.9	14.1
Replacement of conventional Water Pump with 5 Star EE Water Pump	0.3	0.7	1.2	1.9	2.7
Total Energy savings	2.9	7.3	13.2	20.5	29.3

7.1.9 Summary of Energy Efficient devices Budget for Residential Sector

Table 82: Summary of Energy Efficient System budget in Residential Sector

Device Name	Number of Buildings/ Establish-ments	Total number of Installation	Cost of System (in Lakh)	Electricity saving per year in MU	Electricity savings per year in Lakh Rs	CO2eq reduction per year in metric ton (MT)
15 watt LED tube ilight	123022	24604	39	2.8	169	2522
12 watt LED		24604	36	0.8	48	711
9 watt LED		36907	48	1.0	59	873
7 watt LED		73813	81	1.7	104	1552
5 Star rated Ceiling Fan		6151	74	1.2	73	1091
5 Star EE AC 1.5 ton		3076	953	5.0	300	4475
5 Star EE Refrigerator (200 Ltr)		3076	554	14.1	854	12730
5 Star EE Water Pump		12302	369	2.7	163	2425

Year wise summary of Budget estimate for Energy Efficient Installation in Residential Sector

Table 83 : Summary of Year Wise Budget Estimate of EE System in Residential System

Type of System	Per Item Cost in Rs	Total Installation	Total Budget in Lakh Rs	Year Wise Budget in Lakh Rs.				
				1 Year	2 Year	3 Year	4 Year	5 Year
15 watt LED	160	24604	39	3.9	5.9	7.9	9.8	11.8
12 watt LED	145	24604	36	3.6	5.4	7.1	8.9	10.7
9 watt LED	130	36907	48	4.8	7.2	9.6	12.0	14.4
7 watt LED	110	73813	81	8.1	12.2	16.2	20.3	24.4
Energy Efficient Ceiling Fans	1200	6151	74	7.4	11.1	14.8	18.5	22.1
EE AC	31000	3076	953	95.3	143.0	190.7	238.4	286.0
EE star rated refrigerators	18000	3076	554	55.4	83.0	110.7	138.4	166.1
EE Water Pumps	3000	12302	369	36.9	55.4	73.8	92.3	110.7
Total			2154	215.4	323.1	430.8	538.5	646.2

7.2 Energy Efficiency Strategies in Commercial and Institutional Sector

Commercial and institutional sector of Ajmer shares a significant amount of energy consumption. According to their revenue department, there are more than 4,000 buildings in Ajmer municipal limit in this sector. Energy Efficient options and calculation are described below to reduce energy demand with the following interventions:

- Replacement of 60-watt Bulb with 23 watt LED tube light
- Replacement of T12 Tube light with 15 watt LED tube light
- Replacement of 23 watt CFL with 12 watt LED
- Replacement of 18 watt CFL with 9 watt LED
- Replacement of conventional Ceiling Fan with 5 Star rated Ceiling Fan
- Replacement of conventional AC with 5 Star EE AC
- Replacement of conventional Refrigerator with 5 Star EE Refrigerator
- Replacement of conventional Water Pump with 5 Star EE Water Pump

Energy Saving Target and Investment from Replacement of Conventional System with Energy Efficient System in Commercial and Institutional Sector

Table 84 : Summary of Energy Saving Target Energy Efficient System in C & I Sector

Type of System	Electricity savings in MU				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Replacement of T12 Tube light with 23 watt LED	0.48	1.21	2.17	3.38	4.83
Replacement of T12 Tube light with 15 watt LED tube light	0.51	1.27	2.29	3.56	5.09
Replacement of 23 watt CFL with 12 watt LED	0.11	0.27	0.48	0.75	1.08
Replacement of 18 watt CFL with 9 watt LED	0.06	0.15	0.26	0.41	0.59
Replacement of conventional Ceiling Fan with 5 Star rated Ceiling Fan	0.10	0.24	0.44	0.69	0.98
Replacement of conventional AC with 5 Star EE AC	0.03	0.08	0.15	0.23	0.33
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	0.01	0.02	0.04	0.06	0.08
Replacement of conventional Water Pump with 5 Star EE Water Pump	0.00	0.01	0.02	0.03	0.04
Total Energy savings	1.30	3.25	5.86	9.11	13.02

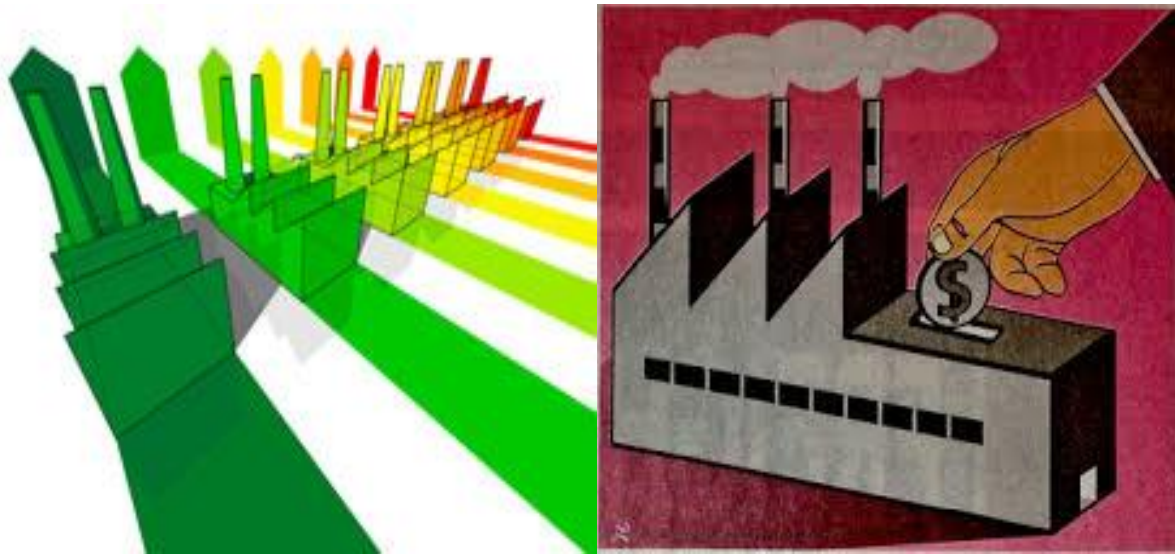
Table 85 : Summary of Energy Efficient System Installation in C & I Sector

Device Name	Number of Buildings/ Establishments	Total number of Installation	Total Cost of System (in Lakh)	Electricity saving per year in MU	Electricity savings per year in Lakh Rs	CO2eq reduction per year in metric ton (MT)
23 watt LED	3957	39570	91	4.8	425	4348
15 watt LED tube light		39570	63	5.1	448	4583
12 watt LED		29678	43	1.1	95	970
9 watt LED		19785	26	0.6	52	529
5 Star rated Ceiling Fan		9893	119	1.0	86	881
5 Star EE AC 1.5 ton		198	61	0.3	29	293
5 Star EE Refrigerator (300 Ltr)		20	5	0.1	7	74
5 Star EE Water Pump		99	3	0.0	3	35

Table 86 Summary of Year Wise Budget Estimate of EE System in C & I Sector

Type of System	Per Item Cost in Rs	Total Installation	Total Budget in Lakh Rs	Year Wise Budget in Lakh Rs.				
				1 Year	2 Year	3 Year	4 Year	5 Year
23 watt LED	230	79140	91	9.1	13.7	18.2	22.8	27.3
15 watt LED	160	79140	63	6.3	9.5	12.7	15.8	19.0
12 watt LED	145	59355	43	4.3	6.5	8.6	10.8	12.9
9 watt LED	130	39570	26	2.6	3.9	5.1	6.4	7.7
EE Ceiling Fans	1200	19785	119	11.9	17.8	23.7	29.7	35.6
EE AC	31000	3957	61	6.1	9.2	12.3	15.3	18.4
EE star rated refrigerators	26000	396	5	0.5	0.8	1.0	1.3	1.5
EE Water Pumps	3000	1979	3	0.3	0.4	0.6	0.7	0.9
Total			411	41.1	61.7	82.2	102.8	123.4

7.3 Energy Efficiency Strategies in Industrial Sector



Ajmer city has more than 4000 registered industrial units having huge energy consumption. Some energy Efficient options and calculations are described below:

- Replacement of 150 watt CFL with 40 watt LED
- Replacement of 100 watt CFL with 30 watt LED
- Replacement of 100-watt Bulb with 23 watt LED
- Replacement of T12 Tube light with 15 watt LED
- Replacement of conventional Ceiling Fan with 5 Star rated Ceiling Fan
- Replacement of conventional AC with 5 Star EE AC
- Replacement of conventional Refrigerator with 5 Star EE Refrigerator
- Replacement of conventional Water Pump with 5 Star EE Water Pump

Summary of Energy Saving Target and Investment from replacement of conventional system with energy efficient system in Industrial Sector

Table 87 : Energy Saving Target from Replacement of Conventional System with EE in Industrial Sector

Type of System	Electricity savings in MU				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Replacement of 150 watt CFL with 40 watt LED	0.22	0.55	0.99	1.54	2.20
Replacement of 100 watt CFL with 30 watt LED	0.11	0.28	0.50	0.78	1.12
Replacement of 100-watt Bulb with 23 watt LED	0.09	0.23	0.42	0.65	0.92
Replacement of T12 Tube light with 15 watt LED	0.03	0.08	0.14	0.22	0.31
Replacement of conventional Ceiling Fan with 5 Star rated Ceiling Fan	0.01	0.04	0.06	0.10	0.14
Replacement of conventional AC with 5 Star EE AC	0.02	0.05	0.09	0.14	0.20
Replacement of conventional Refrigerator with 5	0.00	0.01	0.01	0.01	0.02

Star EE Refrigerator					
Replacement of conventional Water Pump with 5 Star EE Water Pump	0.01	0.01	0.03	0.04	0.06
Total Energy savings	0.50	1.24	2.24	3.49	4.98

Table 88 : Energy Efficient System Installation in Industrial Sector

Device Name	Number of Buildings/ Establishments	Total number of Installation	Cost of System (in Lakh)	Electricity saving per year in MU	Electricity savings per year in Lakh Rs	CO2 eq reduction per year in metric ton (MT)
40 watt LED	485	6063	24	2.2	161	1981
30 watt LED		4850	6	1.1	82	1008
23 watt LED		3638	11	0.9	67	832
15 watt LED		2425	4	0.3	23	281
5 Star rated Ceiling Fan		1455	17	0.1	11	130
5 Star EE AC 1.5 ton		121	38	0.2	15	180
5 Star EE Refrigerator (300 Ltr)		5	1	0.0	1	18
5 Star EE Water Pump		146	12	0.1	4	52

Table 89 : Year Wise Investment of EE System in Industrial Sector

Type of System	Per Item Cost in Rs	Total Installation	Total Budget in Lakh Rs	Year Wise Budget in Lakh Rs.				
				1 Year	2 Year	3 Year	4 Year	5 Year
40 watt LED	400	6063	24	2.4	3.6	4.9	6.1	7.3
30 watt LED	130	4850	6	0.6	0.9	1.3	1.6	1.9
23 watt LED	300	3638	11	1.1	1.6	2.2	2.7	3.3
15 watt LED	160	2425	4	0.4	0.6	0.8	1.0	1.2
Energy Efficient Ceiling Fans	1200	1455	17	1.7	2.6	3.5	4.4	5.2
Energy Efficient AC	31000	121	38	3.8	5.6	7.5	9.4	11.3
Energy Efficient star rated refrigerators	26000	5	1	0.1	0.2	0.3	0.3	0.4
Energy Efficient Water Pumps	8000	146	12	1.2	1.7	2.3	2.9	3.5
Total			113	11.3	17.0	22.7	28.3	34.0

7.4 Energy Efficiency Strategies for Municipal Sector



Municipalities, globally dedicate a significant percentage of their budgets in providing water and street lighting services. In India, these two basic services often represent over 80 per cent of a municipality's total energy expenditures. The opportunities for savings are thus enormous. Municipal sector consumption mainly consists of electricity in street lighting, water pumping and sewerage treatment plant. The Bureau of Energy Efficiency in India has already come out with the Manual for development of Municipal Energy Efficiency Projects. Energy conservation drives in the municipal corporations and councils will become an exemplary initiative for similar activities in the city. As a high visibility and administration center Municipal bodies across India should go ahead in implementing the strategies and replicating the success stories.

The confederation of Indian Industry (CII) estimates that the typical Indian municipal water utility has the potential to improve water pumping system efficiency by 25 per cent. Since many municipal water utilities in India spend over 60 per cent of their budgets on energy for water pumping, the savings could be used to improve service. Similarly, street lighting often represents between 10 and 15 per cent of a typical municipal budget. Various technologies from the Sustainable Cities programme indicate that energy savings of up to 40 per cent are both possible and highly cost effective.

With the smart city concept being implemented in the city the Municipal Corporation should be even further be geared up to promote energy efficiency in all sectors.

Energy Efficiency measures in Street Lighting

Street lighting is one of the major sources of energy consumption in municipal area. A comprehensive survey of street lighting systems has been conducted and meetings with officials responsible for designing, installation, operation and maintenance were held. The Ajmer Municipal Corporation has about nearly 35000 outdoor lights with different wattage, which has been fixed for illumination streets, wards, monuments, etc. The specifications of types of lamps being used

Street Light opportunities:

1. High-efficiency lamps
2. Timer Installation
3. Load management Systems (LMS)

Technical Assessment of Street Lighting Technologies for Energy Efficiency

Lighting components can be based on their functions. They are generally described as structural systems, electrical systems, and optical systems. The items covered include:

All system should be designed to minimize the life-cycle cost, while meeting lighting requirements (e.g., minimum luminance requirements to ensure proper functioning and safety of users). To achieve an effective energy efficient design, it is essential to select the proper lamp/ ballast combination that produces high lumens per watt together with fixtures that meet design requirements and minimizes glare, light trespass and excessive light pollution.

Lamp Technology

The most important element of the illumination system is the light source. It is the principal determinant of the visual quality, cost, and energy efficiency aspects of the illumination system. An electric light source is a device, which transforms electrical energy or power (in watts), into visible electromagnetic radiation, or light (lumens). The rate of converting electrical energy into visible light is called “luminous efficacy” and is measured in lumens per watt. The types of lamps commonly used for street lighting are listed in the following tables.

Table 90: Comparison of Different Capacity of Street Light

Type of Lamp	Luminous Efficacy (lm/W)	Colour Rendering Properties	Lamp life in HRS	Remarks
High Pressure Mercury vapour (MV)	35-65 lm/W	Fair	10,000-15,000	High energy use, poor lamp life
Metal Halide (MH)	70-130 lm/W	Excellent	8,000-12,000	High luminous efficacy, poor lamp life
High Pressure Sodium Vapour (HPSV)	50-150 lm/W	Fair	15,000-24,000	Energy-efficient, poor colour rendering
Low Pressure Sodium Vapour	100-190 lm/W	Very Poor	18,000-24,000	Energy-efficient, very poor colour rendering
Low Pressure Mercury Fluorescent Tubular Lamp (T12 & T8)	30-90 lm/W	Good	5,000-10,000	Poor lamp life, medium energy use, only available in low voltages
Energy-efficient Fluorescent Tubular Lamp (T5)	100-120 lm/W	Very Good	15,000-20,000	Energy-efficient, long lamp life, only available in low voltages
Light Emitting Diode (LED)	70-160 lm/W	Good	40,000-90,000	High-energy savings, low maintenance, long life, no mercury. High investment cost, technology

Energy Efficiency Options for Street Lighting

Ajmer Municipal Corporation is quite active on increasing energy efficiency in street lighting. At the present status all the old street light have been replaced by LED lights. Ajmer Municipal corporation has replaced more than 32000 old lights with new LED lights with different capacities which details are below in table.

Table 91 Street Light details of Ajmer City

Earlier Wattage of Lamp (W)	Total Numbers	Wattage of Earlier Street Lighting	New Installation of LED Light	Total Numbers	Wattage of LED Light
HPSV-400W	251	400	190W	306	190
HPSV – 250W	3149	250	120W	3225	120
HPSV-150W	6582	150	70W	8159	70
HPSV - 70W	2311	70	35W	3565	35
FTL - 40W	18571	40	15W	19745	15

Source: Ajmer Municipal Corporation

E Rickshaw



The Department of Heavy Industries has already formulated a policy for the promotion of electric vehicles in the country and has stipulated a total of 7 million electric vehicles in the country by 2020. In light of which promoting EV's is the right choice of upcoming smart cities. E Rickshaws are three-wheel battery operated vehicles, which are considered as an upgrade to conventional rickshaws, and economically better than auto rickshaws and other fuel variants, these rickshaws, since are battery powered have zero emission, and is often argued to be much better than other rickshaws as they are considered almost pollution free. E rickshaws are now fairly popular amongst Indian rickshaw drivers and has created new

opportunities for people, as they require minimum investment to earn a living. They offer huge returns in less time taken for travel, and are easy to operate and has low maintenance and running cost. A lot of variants are available these days, most of them started as low quality products and were imported from China. These days Indian e rickshaws have been developed offering a higher quality and better services at an equivalent cost. E rickshaws can provide a decent income since the battery charging cost is far lower than any other fuel, new material such as fibreglass has been introduced in them, since the material provides high strength, durability and lighter than metals.

Battery operated electric three-wheelers or e-rickshaws have recently emerged in the public road transport sector in India. The average specific energy consumption of the e-rickshaws has been found to be 53.76 kJ/passenger-km, which is the more efficient among other forms of motorized three-wheeled passenger vehicles. Besides of passenger transportation use of E rickshaw in goods carrier vegetable cart, school cab, etc.

General specifications of E Rickshaw

Overall size :	2850*1040*1850mm
Top Speed (km/h) :	35km/h
Once Charging Mileage :	140km
Grade ability :	15 degree
No. Of Passengers :	6 persons
Charging Voltage :	220v ,50hz
Charging Time :	6-8 hours
Motor :	60v/1000w DC brushless motor
Transmission Mode :	Differential / Shaft
Battery :	12v 120ah lead acid battery (5pcs)
Wheel Size :	front 3.25-16 back 3.25-16

Advantages of e-rickshaws

- 1. Eco – friendly** – E-rickshaws can be the best alternative to petrol or diesel run vehicles as they are operated on battery. These rickshaws do not emit smoke and thus, will not contribute to the increasing air pollution. The batteries which will be used for the functioning of these rickshaws can be effectively recycled and thus, will solve the problem of battery disposal.
- 2. Economical** – E-rickshaws are comparatively cheap and can be easily afforded by a common man. Passengers will have to pay a less transport charge. It is cost effective not only for the consumers but also for the owners. The batteries can be easily recharged from home or from any place that provides a proper voltage.
- 3. Free from noise pollution** – E-rickshaws are free from creating noise pollution as they do not emit any sound. Passengers can have a smooth and comfortable ride.
- 4. Livelihood** – E-rickshaws provide a means of livelihood for the common as well as illiterate people. Without investing much of money, the e-rickshaw drivers can earn a good livelihood.

5. Safety – E-rickshaws involve less risk when compared to the other fuel operating vehicles. They can cause less accident as they are slower and lighter than an auto rickshaw. There is a chance of explosion in the case of fuel operating vehicles.

6. Easy maintenance – As they use electricity, they do not require fuel to operate the engines. E-rickshaws are free from an engine and a gear box and thus, the burden of maintenance is reduced. The motor which is used in these rickshaws is smaller and the battery is placed below it. Hence, maintaining them is quite easier.

Summary of Energy Saving Target and Investment from Replacement of Conventional System with Energy Efficient System in Municipal Sector

Table 92 : Summary of Electricity Saving Target from Replacement of Conventional System with EE System

Type of System	Electricity savings in MU				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
200W LED	1.24	1.24	1.24	1.24	1.24
200W LED	0.05	0.05	0.05	0.05	0.05
72W LED	0.05	0.05	0.05	0.05	0.05
72W LED	1.84	1.84	1.84	1.84	1.84
40W LED	2.47	2.47	2.47	2.47	2.47
40W LED	0.00	0.00	0.00	0.00	0.00
40W LED	0.08	0.08	0.08	0.08	0.08
20W LED	6.06	6.06	6.06	6.06	6.06
20W LED	0.04	0.04	0.04	0.04	0.04
20W LED	0.01	0.01	0.01	0.01	0.01
20W LED	0.47	0.47	0.47	0.47	0.47
15W LED	8.42	8.42	8.42	8.42	8.42
15W LED	0.01	0.01	0.01	0.01	0.01
Total Energy savings	20.73	20.73	20.73	20.73	20.73

Table 93 : Year Wise Investment of EE System in Municipal Sector

Type of System	Per Item Cost in Rs	Total Installation	Total Budget in Lakh Rs	Year Wise Budget in Lakh Rs.				
				1 Year	2 Year	3 Year	4 Year	5 Year
All Street lights replaced by LED under EESL work*		30840		NA				
E Rickshaw	11500	500	57500	58	86	115	144	173
Total				58	86	115	144	173

* Energy Efficient stret lighting already installed by Ajmer Municipal Corporation

Other suggested measures for Energy Efficiency in Municipal Sector

Digital Sensors for Automatic On/Off of Street Lights

Automatic system for street lighting ensures optimum use of electricity only in night and turned off during day time. Manually operated streetlights system consumes more electricity and there is wastage of energy during daytime. Manual control also involves labor costs, energy wastes and poor efficiency; hence, municipal street lights should hasten the process of installing automatic sensors.

Water system efficiency opportunities:

Leak reduction in water supply systems

Pipe re-lining

Capacitor installation

Wastewater reclamation

Installation and harmonization of high efficiency and variable speed pump drives.

Development of public education programmes focusing upon sector wise water use.

Energy Efficiency Measures in Water Pumping

Water pumping is one of the major utility practices, which consume high energy. The energy efficiency initiatives for water pumping in India have been going on for quite some time. BEE in its Manual for Development of Municipal Energy Efficiency Projects states that 25% energy savings can be obtained from initiatives in water systems alone.

Proper water pumping design can bring energy savings in the running and maintenance cost of water pump systems. Careful designing is required to assess the volume of water to be pumped. Fluid piping software can be utilized for designing water pumps in municipal bodies.

Use of Variable Speed/Frequency Drive (VSD/VFD):

Variable speed drive for pump provides significant flexibility and improves the operational efficiency. VSD for centrifugal pumps enables maintaining fixed pressure versus changing flow condition or inverse flow versus pressure. Significant amount of energy can be saved by installing VSD control in the water pumping system instead of throttling, bypassing or other less efficient flow control methods.

Installation of Occupancy Sensor in the Office Buildings

Occupancy sensors can be installed in the municipal office buildings for energy savings. It is the most common device for lighting control used in office and commercial buildings. It saves energy by automatically turning lights ON when a room is occupied and OFF when a room is vacant. Advance occupancy sensors also have option for dimming control, which allows individual workers to adjust lighting levels to their own preferences, and to switch on only a few lights when they work late.

Energy Efficiency Building or Green Building for All Sectors

Residential, public and commercial buildings consume a large amount of energy, mostly for lighting, appliances, space heating and water heating. In order to improve energy efficiency and conserve energy from the concept of solar city, existing and new buildings must be evolved to incorporate energy efficiency and energy conservation measures.

To encourage the best practices in Ajmer, this chapter considers how energy efficiency is incorporated into building codes. Strategies to achieve energy efficient building, according to international practice, will be explained here for the main components of a building, in order to achieve energy efficiency and conservation in the developing solar city of Ajmer. Information on technologies and energy saving methods, outlined in this chapter, aims to assist Ajmer Municipal Corporation to provide tools for innovative design for new and retrofit buildings.

As Ajmer lies in the composite climate, any energy efficient building system must be designed according to this climate. This should also be a major consideration when looking at various practices that are suitable to follow.

- Adopt the National Building Code for building design.
- Incorporate ECBC code for energy efficiency and design.
- Make changes in building bye laws to favor green buildings and design.
- Adopt solar passive architecture
- Promote use of local building materials
- Promote use of traditional knowledge for house design
- Promote the concept of reduce, recycle and reuse (3 R's)

Chapter - 8

Action Plan

The action plan for any solar city is based upon its present energy consumption patterns and the projected energy trends anticipated by that city due to its population and economic growth mainly the GDP. Growing per capita incomes will always lead to increase in energy consumption and the same have to be met through improved energy resources like clean and green energy like renewable energy and reducing the DSM loads through energy efficiency of the entire energy sector.

To fulfill the future energy demands in context of current supply and demand of energy and also continuous shortage of energy resources in Ajmer city, it is necessary to use renewable energy sources and optimize energy conservation, which would thus reduce per capita energy demand and also reduce greenhouse gases GHGs emission. To achieve 10 % energy reduction target up to 2021-22 for Ajmer city, an action plan is needed, which covers energy reduction target for all four sectors including installation of renewable energy techniques and energy efficiency techniques.

8.1 Five Year Strategic Plan to Achieve Goals of Energy Savings

The table 95 summarizes year wise goals for energy savings from installation of different types of renewable energy devices and energy efficiency measures for residential, commercial & institutional, Industrial, and municipal sector. The goal is to achieve 10% reduction in projected total demand of 1311 MU in 2021-22 of conventional energy at the end of five years. The master plan sets a goal of total savings of 131.1 MU with 5% from renewable energy installation and 5% from energy efficiency measures of the total energy demand.

Table 94 Energy Savings in next 5 years period of implementation

Sector	1st year	2nd year	3rd year	4th year	5th year	% of energy savings target
		Cumu lative	Cumu lative	Cumu lative	Cumu lative	
RE for Residential Sector	1.8	4.4	7.9	12.3	17.5	13%
RE for Commercial & Inst. Sector	2.5	3.5	4.7	6.3	8.2	6%
RE for Industrial Sector	0.1	0.4	0.7	1.0	1.5	1%
RE for Municipal Sector	25.3	27.6	30.6	34.5	39.0	30%
Total for RE Energy Savings	29.7	35.8	43.9	54.1	66.3	51%
EE for Residential Sector	2.9	7.3	13.2	20.5	29.3	22%
EE for Commercial Sector	1.3	3.3	5.9	9.1	13.0	10%
EE for Industrial Sector	0.5	1.2	2.2	3.5	5.0	4%
EE for Municipal Sector	20.7	20.7	20.7	20.7	20.7	16%
Total for EE Energy Savings	25.5	32.6	42.0	53.8	68.0	52%
RE and EE Combined Energy Savings	55.1	68.3	85.9	107.9	134.3	102%

8.2 Five Year Budget Estimate Plan

The total budget for achieving the solar city plan targets comes to Rs. 195 crores, maximum investment share of the interventions is in residential sector (44%) and least in industrial sector (2.4%), in case of renewable energy installations while maximum investment share of the interventions is in municipal sector and least in industrial sector, in case of energy efficiency highest share is in residential sector and least is in industrial sector.

Table 95 Renewable Energy Installation Budget

Renewable Energy	Budget Estimate in Lakh Rs.				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Residential Sector	642.2	963.3	1284.3	1605.4	1926.5
C& I Sector	726.4	294.6	392.8	491.0	589.2
Industrial Sector	34.7	52.1	69.4	86.8	104.1
Municipal Sector	6276.8	110.7	147.6	184.5	221.4
Total Target Year Wise	7680.1	1420.6	1894.2	2367.7	2841.2

Table 96 Energy Efficiency Installation Budget

Energy Efficiency	Budget Estimate in Lakh				
	1 st Year	2 nd Year	3 rd Year	4 th Year	5 th Year
Residential Sector	215	323	431	539	646
C& I Sector	41	62	82	103	123
Industrial Sector	11	17	23	28	34
Municipal Sector	58	86	115	144	173
Total Investment Year Wise (in Lakh)	325	488	651	813	976

8.3 Physical Target and Action Plan for Five Years

Different types of renewable energy system will be installed in Ajmer for the development of City as Solar City. Renewable Energy System which will be installed in next five years includes installing solar water heater, solar PV systems, Biogas systems, waste to energy projects and solar cookers. The table below shows the detailed year wise action plan and targets of various strategies (RE & EE). The year wise target has been distributed in such a way that initial year's target is less and it gradually increases till 5th year as the awareness level of the citizens also increase. A list of renewable energy systems/devices and energy efficient devices has been mentioned in the following table.

Renewable Energy Sector Physical Target

Table 97 Renewable Energy Sector Physical target, Budget and Energy saving (Year wise)

	S.No	Installation of System	Total no of systems	Device Cost (000' Rs.)	Total Cost of the Systems (In lakh Rs.)	1 st Year			2 nd Year			3 rd Year			4 th Year			5 th Year			% OF Energy Saving	GHG Emissions reduction (tCO2)
						Numbers of device Install	Budget in lakh Rs.	Energy Savings in MU	Numbers of device Install	Budget in lakh Rs.	Energy Savings in MU	Numbers of device Install	Budget in lakh Rs.	Energy Savings in MU	Numbers of device Install	Budget in lakh Rs.	Energy Savings in MU	Numbers of device Install	Budget in lakh Rs.	Energy Savings in MU		
Residential Sector	1	Solar Lantern	6151	1.56	96	615	10	0.00	923	14	0.01	1230	19	0.01	1538	24	0.02	1845	29	0.03	0.0%	27
	2	S. Home light	6151	6.24	384	615	38	0.01	923	58	0.02	1230	77	0.04	1538	96	0.06	1845	115	0.09	0.1%	77
	3	SHWS - 100 LPD	1230	18	221	123	22	0.08	185	33	0.21	246	44	0.37	308	55	0.58	369	66	0.83	0.6%	747
	4	SHWS - 200 LPD	1230	28	344	123	34	0.17	185	52	0.42	246	69	0.75	308	86	1.16	369	103	1.66	1.3%	1495
	5	S.Cooker-Box	615	2.5	15	62	2	0.04	92	2	0.10	123	3	0.18	154	4	0.28	185	5	0.41	0.3%	365
	6	S. Cooker-Dish	615	6	37	62	4	0.06	92	6	0.15	123	7	0.27	154	9	0.43	185	11	0.61	0.5%	548
	7	Solar Inverter	1230	30	369	123	37	0.08	185	55	0.20	246	74	0.37	308	92	0.57	369	111	0.81	0.6%	731
	8	SPP 1kW	1230	75	923	123	92	0.24	185	138	0.61	246	185	1.10	308	231	1.71	369	277	2.44	1.9%	2192
	9	SPP - 2kW	1230	150	1845	123	185	0.49	185	277	1.22	246	369	2.19	308	461	3.41	369	554	4.87	3.7%	4385
	10	SPP - 3kW	972	225	2187	97	219	0.58	146	328	1.44	194	437	2.60	243	547	4.04	292	656	5.77	4.4%	5196
		Sub-total				642	1.75	3098	963	4.4	4131	1284	7.9	5164	1605	12.3	6197	1927	17.5	13.4%	15763	
Commercial and Institutional Sector	1	SHWS - 500 LPD	70	85	60	7	6	0.02	11	9	0.06	14	12	0.11	18	15	0.17	21	18	0.24	0.2%	213
	2	SHWS - 1000 LPD	35	170	59	3	6	0.02	5	9	0.06	7	12	0.10	9	15	0.16	10	18	0.23	0.2%	210
	3	SHWS - 3000 LPD	35	336	116	3	12	0.07	5	17	0.17	7	23	0.31	9	29	0.49	10	35	0.70	0.5%	630
	4	SHWS - 5000 LPD	35	420	145	3	15	0.12	5	22	0.29	7	29	0.52	9	36	0.82	10	44	1.17	0.9%	1049
	5	Solar Community Cooker	20	45	9	2	1	0.00	3	1	0.00	4	2	0.01	5	2	0.01	6	3	0.01	0.0%	12
	6	S. steam generating system	10	16	2	1	0	0.00	2	0	0.00	2	0	0.00	3	0	0.01	3	0	0.01	0.0%	9
	7	SPP- 1kW	83	75	62	8	6	0.02	12	9	0.04	17	12	0.07	21	16	0.12	25	19	0.16	0.1%	148
	8	SPP- 2kW	83	150	125	8	12	0.03	12	19	0.08	17	25	0.15	21	31	0.23	25	37	0.33	0.3%	296
	9	SPP- 3kW	38	225	86	4	9	0.02	6	13	0.06	8	17	0.10	10	21	0.16	11	26	0.23	0.2%	204
	10	SPP- 5kW	38	300	114	4	11	0.04	6	17	0.09	8	23	0.16	10	29	0.25	11	34	0.35	0.3%	319
	11	SPP- 20kW	20	1500	297	2	30	0.07	3	45	0.18	4	59	0.33	5	74	0.52	6	89	0.74	0.6%	662
	12	SPP- 25kW	20	1875	371	2	37	0.09	3	56	0.23	4	74	0.41	5	93	0.64	6	111	0.92	0.7%	828
	13	SPP- 30kW	10	2250	223	1	22	0.06	1	33	0.14	2	45	0.25	2	56	0.39	3	67	0.55	0.4%	497
	14	SPP- 40kW	10	3000	297	1	30	0.07	1	45	0.18	2	59	0.33	2	74	0.52	3	89	0.74	0.6%	662
	15	SPP- 1 MW	1	53000	530	0	53	1.86	0	0	1.86	0	0	1.86	0	0	1.86	0	0	1.86	1.4%	1674
		Sub-total				249	2	76	295	3	101	393	5	127	491	6	152	589	8	6.3%	7413	
Industrial Sector	1	SHWS - 1000 LPD	10	25	3	1	0.3	0.01	2	0	0.02	2	1	0.03	3	1	0.05	3	1	0.07	0.1%	61
	2	SHWS - 3000 LPD	10	35	4	1	0.4	0.02	2	1	0.05	2	1	0.09	3	1	0.14	3	1	0.20	0.2%	184
	3	SHWS - 5000 LPD	10	35	4	1	0.4	0.03	2	1	0.09	2	1	0.15	3	1	0.24	3	1	0.34	0.3%	306
	4	Solar Community Cooker	5	45	2	1	0.2	0.00	1	0	0.00	1	0	0.00	1	1	0.00	2	1	0.00	0.0%	3
	5	S. steam generating system	5	16	1	1	0.1	0.00	1	0	0.00	1	0	0.00	1	0	0.00	2	0	0.01	0.0%	5
	6	SPP-- 5kW	10	300	30	1	3	0.01	2	5	0.02	2	6	0.04	3	8	0.07	3	9	0.09	0.1%	84
	7	SPP- 10kW	10	750	73	1	7	0.02	1	11	0.05	2	15	0.08	2	18	0.13	3	22	0.18	0.1%	162
	8	SPP- 15kW	5	1125	58	1	6	0.01	1	9	0.04	1	12	0.06	1	14	0.10	2	17	0.14	0.1%	129
	9	SPP- 20kW	5	1500	77	1	8	0.02	1	12	0.05	1	15	0.09	1	19	0.13	2	23	0.19	0.1%	172
	10	SPP- 25kW	5	1875	96	1	10	0.02	1	14	0.06	1	19	0.11	1	24	0.17	2	29	0.18	0.1%	162
		Sub-total				35	0.15	52	0.37	69	0.7	87	1.0	104	1.4	1.1%	1270					
Municipal Sector	1	Solar E Rickshaw	500	115	575	50	58	1.50	75	86	3.75	100	115	6.75	125	144	10.50	150	173	15.00	11.4%	13500
	2	Solar studs	5000	1	30	500	3	0.02	750	5	0.05	1000	6	0.09	1250	8	0.14	1500	9	0.20	0.2%	178
	3	Solar Hoardings	100	75	75	10	8	0.00	15	11	0.00	20	15	0.00	25	19	0.00	30	23	0.00	0.0%	2
	4	SSL 7 watt LED	100	19	19	10	2	0.00	15	3	0.00	20	4	0.00	25	5	0.00	30	6	0.01	0.0%	5
	5	Solar traffic LED	150	14	21	15	2	0.00	23	3	0.01	30	4	0.01	38	5	0.02	45	6	0.02	0.0%	21
	6	SPP-1kW	10	75	8	1	1	0.00	2	1	0.00	2	2	0.01	3	2	0.01	3	2	0.02	0.0%	18
	7	SPP- 2kW	7	150	11	1	1	0.00	1	2	0.01	1	2	0.01	2	3	0.02	2	3	0.03	0.0%	25
	8	SPP- 1 MW	1	53000	530	0	53	1.86	0	0	1.86	0	0	1.86	0	0	1.86	0	0	1.86	1.4%	1674
	9	Waste to Energy(MSW)	1	375000	3750	1	3750.0	16.12	0	0	16.12	0	0	16.12	0	0	16.12	0	0	16.12	12.29%	14505
	10	Waste to Energy(STP)	1	240000	2400	1	2400	5.78	0	0	5.78	0	0	5.78	0	0	5.78	0	0	5.78	4.41%	5203
		Sub-total		6941		6276.8	25.29		111	27.58		148	25		185	34		221	39.04	29.78%	35132	
		Grand Total		16204		7680	30		1421	36		1894	38		2368	54		2841	66	50.49%	59577	

Energy Efficiency Sector Physical Target

Table 98 Energy Efficiency Sector Physical target , Budget and Energy saving (Year wise)

	S. No.	Installation of System	Total no of systems	Device Cost (000' Rs.)	Total Cost of System in Lakh	1 year			2 Year			3 year			4 Year			5 year			% OF Energy Saving	GHG Emissions reduction (tCO2)
						Numbers	Budget	Energy Savings in MU	Numbers	Budget	Energy Savings in MU	Numbers	Budget	Energy Savings in MU	Numbers	Budget	Energy Savings in MU	Numbers	Budget	Energy Savings in MU		
Residential Sector	1	15 watt LED	24604	0.16	39	2460	4	0.3	3691	6	0.7	4921	8	1.3	6151	10	2.0	7381	12	2.8	2%	2522
	2	12 watt LED	24604	0.145	36	2460	4	0.1	3691	5	0.2	4921	7	0.4	6151	9	0.6	7381	11	0.8	1%	711
	3	9 watt LED	36907	0.13	48	3691	5	0.1	5536	7	0.2	7381	10	0.4	9227	12	0.7	11072	14	1.0	1%	873
	4	23 watt LED	73813	0.11	81	7381	8	0.2	11072	12	0.4	14763	16	0.8	18453	20	1.2	22144	24	1.7	1%	1552
	5	EE Ceiling Fans	6151	1.2	74	615	7	0.1	923	11	0.3	1230	15	0.5	1538	18	0.8	1845	22	1.2	1%	1091
	6	EE AC	3076	31	953	308	95	0.5	461	143	1.2	615	191	2.2	769	238	3.5	923	286	5.0	4%	4475
	7	EE star rated refrigerators	3076	18	554	308	55	1.4	461	83	3.5	615	111	6.4	769	138	9.9	923	166	14.1	11%	12730
	8	EE Water Pumps	12302	3	369	1230	37	0.3	1845	55	0.7	2460	74	1.2	3076	92	1.9	3691	111	2.7	2%	2425
		Sub-total			2154		215	3		323	7		431	13		539	21		646	29	22%	26379
Commercial and Institutional	1	15 watt LED	39570	0.23	91	3957	9	0.5	5936	14	1.2	7914	18	2.2	9893	23	3.4	11871	27	4.8	4%	4348
	2	12 watt LED	39570	0.16	63	3957	6	0.5	5936	9	1.3	7914	13	2.3	9893	16	3.6	11871	19	5.1	4%	4583
	3	9 watt LED	29678	0.145	43	2968	4	0.1	4452	6	0.3	5936	9	0.5	7419	11	0.8	8903	13	1.1	1%	970
	4	23 watt LED	19785	0.13	26	1979	3	0.1	2968	4	0.1	3957	5	0.3	4946	6	0.4	5936	8	0.6	0.4%	529
	5	EE Ceiling Fans	9893	1.2	119	989	12	0.1	1484	18	0.2	1979	24	0.4	2473	30	0.7	2968	36	1.0	0.7%	881
	6	EE AC	198	31	61	20	6	0.0	30	9	0.1	40	12	0.1	49	15	0.2	59	18	0.3	0.2%	293
	7	EE star rated refrigerators	20	26	5	2	1	0.0	3	1	0.0	4	1	0.0	5	1	0.1	6	2	0.1	0.1%	74
	8	EE Water Pumps	99	3	3	10	0.3	0.0	15	0.4	0.0	20	0.6	0.0	25	0.7	0.0	30	0.9	0.0	0.0%	35
		Sub-total			411		41	1.3		62	3		82	6		103	9		123	13	9.9%	11714
Industrial Sector	1	15 watt LED	6063	0.4	24	606	2	0.2	909	4	0.6	1213	5	1.0	1516	6	1.5	1819	7	2.2	1.7%	1981
	2	40 watt LED	4850	0.13	6	485	1	0.1	728	1	0.3	970	1	0.5	1213	2	0.8	1455	2	1.1	0.9%	1008
	3	30 watt LED	3638	0.3	11	364	1	0.1	546	2	0.2	728	2	0.4	909	3	0.6	1091	3	0.9	0.7%	832
	4	23 watt LED	2425	0.16	4	243	0	0.0	364	1	0.1	485	1	0.1	606	1	0.2	728	1	0.3	0.2%	281
	5	EE Ceiling Fans	1455	1.2	17	146	2	0.0	218	3	0.0	291	3	0.1	364	4	0.1	437	5	0.1	0.1%	130
	6	EE AC	121	31	38	12	4	0.0	18	6	0.0	24	8	0.1	30	9	0.1	36	11	0.2	0.2%	180
	7	EE star rated refrigerators	5	26	1	0	0.1	0.0	1	0	0.0	1	0	0.0	1	0	0.0	1	0	0.0	0.0%	18
	8	EE Water Pumps	146	8	12	15	1.2	0.0	22	1.7	0.0	29	2.3	0.0	36	2.9	0.0	44	3.5	0.1	0.0%	52
		Sub-total			113		11	0.5		17	1		23	2		28	3		34	5	3.8%	4481
Municipal Sector	1	200W LED	67	1	0	7	0.1	1.2	10	0.1	1.2	13	0.1	1.2	17	0.2	1.2	20	0.2	1.2	0.9%	1117
	2	200W LED	8	1	0	1	0.0	0.0	1	0.0	0.0	2	0.0	0.0	2	0.0	0.0	2	0.0	0.0	0.0%	44
	3	72W LED	20	1	0	2	0.0	0.0	3	0.0	0.0	4	0.0	0.0	5	0.1	0.0	6	0.1	0.0	0.0%	43
	4	72W LED	763	1	0	76	0.8	1.8	114	1.1	1.8	153	1.5	1.8	191	1.9	1.8	229	2.3	1.8	1.4%	1654
	5	40W LED	1428	1	0	143	1.4	2.5	214	2.1	2.5	286	2.9	2.5	357	3.6	2.5	428	4.3	2.5	1.9%	2222
	6	40W LED	2	1	0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.0	0.0	1	0.0	0.0	0.0%	2
	7	40W LED	87	1	0	9	0.1	0.1	13	0.1	0.1	17	0.2	0.1	22	0.2	0.1	26	0.3	0.1	0.1%	73
	8	20W LED	5450	1	0	545	5.5	6.1	818	8.2	6.1	1090	10.9	6.1	1363	13.6	6.1	1635	16.4	6.1	4.6%	5453
	9	20W LED	63	1	0	6	0.1	0.0	9	0.1	0.0	13	0.1	0.0	16	0.2	0.0	19	0.2	0.0	0.0%	35
	10	20W LED	17	1	0	2	0.0	0.0	3	0.0	0.0	3	0.0	0.0	4	0.0	0.0	5	0.1	0.0	0.0%	8
	11	20W LED	1890	1	0	189	1.9	0.5	284	2.8	0.5	378	3.8	0.5	473	4.7	0.5	567	5.7	0.5	0.4%	420
	12	15W LED	20986	1	0	2099	21.0	8.4	3148	31.5	8.4	4197	42.0	8.4	5247	52.5	8.4	6296	63.0	8.4	6.4%	7582
	13	15W LED	59	1	0	6	0.1	0.0	9	0.1	0.0	12	0.1	0.0	15	0.1	0.0	18	0.2	0.0	0.0%	8
	14	E Rikshaw	500	115	1	50	57.5	0.0	75	86.3	0.0	100	115.0	0.0	125	143.8	0.0	150	172.5	0.0	0.0%	0
		Sub-total			1		88.3	20.7		132.5	20.7		176.7	20.7		220.9	20.7		265.0	20.7	15.8%	18661
		Grand Total			3254		356.2			534.3	32.6		712.4	42.0		890.5	53.8		1068.6	68.0	51.9%	61235

8.4 Capacity Building and Awareness Programs

In order to inculcate the energy conservation techniques in the common architecture, it is essential that all the practitioners be properly trained in renewable energy efficient or Green architecture. Ajmer Municipal Corporation may organize a series of training programs for the planners, architectures, electrical, HVAC and lighting Consultants and engineers involved in the building sector. These courses, tailor made to suit different levels, must be imparted to all the professionals in public as well as in private sector.

Specific training programmes need to be designed for front line workers, technicians and supervisory roles for effective monitoring of energy demand.

All members of Solar City Cell should be trained on RE and EE by MNRE and BEE on various PPP models. Public awareness and education is imperative for Municipal Corporation to change the public from sustained awareness campaigns and communicate the benefits of energy conservation and renewable energy to different users groups, including local elected representatives.

A key component of the awareness campaign would be to capture school children's attention towards energy efficient and clean future. Thus, the campaign for the school children will include the following elements.

- Inter School essay and drawing competitions
- Inter School quizzes
- Workshops and seminars
- Exhibitions and demonstrations
- Field Trips

Ajmer Municipal Corporation can also initiate awareness campaigns along with electricity department to generate a public response on energy conservation like door to door campaign, newsletters, etc.

To meet the growing energy needs of Ajmer, optimizing energy conservation and resource efficiency is needed, which would thus reduce per capita electricity demanded and would minimize the need for new generation's reduced greenhouse gases and other pollutants, thereby, addressing the environmental concerns.

As a matter of priority, in order to develop Ajmer as a solar city, the principal government agencies should be committed to:

- ❖ Discussing critical energy issues jointly from open meeting
- ❖ Sharing of information and analyses to minimize duplication and maximize a common understanding for decision making.
- ❖ Continuing progress in meeting the environmental goals and standards, including minimizing the impact on local and global environment.

8.5 Financial Requirement for Ajmer Solar City Master Plan and Sharing of Funds

The total indicative budget for the development of Ajmer as a Solar City is estimated to be Rs. 194.60 crores, from renewable energy as well as energy efficient system installation, and some renewable energy pilot projects, which will be invested over the 5 years of implementation period for solar city development programme. The total proposed budget will be shared by the MNRE and User. MNRE share will be sector and device dependant as per latest CFA and rest part will be invested by the private users or end user for Renewable energy systems where as 100 % system installation cost will be borne by users for energy efficient system installation. The budget for implementation of RE strategy and EE strategy is estimated to be Rs. 162 crore and Rs.32.5 crores respectively. Budget for establishment of the Solar City Cell and awareness and publicity is estimated to be Rs.50 Lakhs. While budget for RE strategy will be shared amongst MNRE, state/city and private users, private investors will primarily drive EE activities.

Table 99 : Sharing of Budget for development of Ajmer City as Solar City

S.No.	Budget	Budget in Crore Rs. for 5 Years
1	MNRE Share	21.26
2	User Share	173.32
	Total Budget	194.60

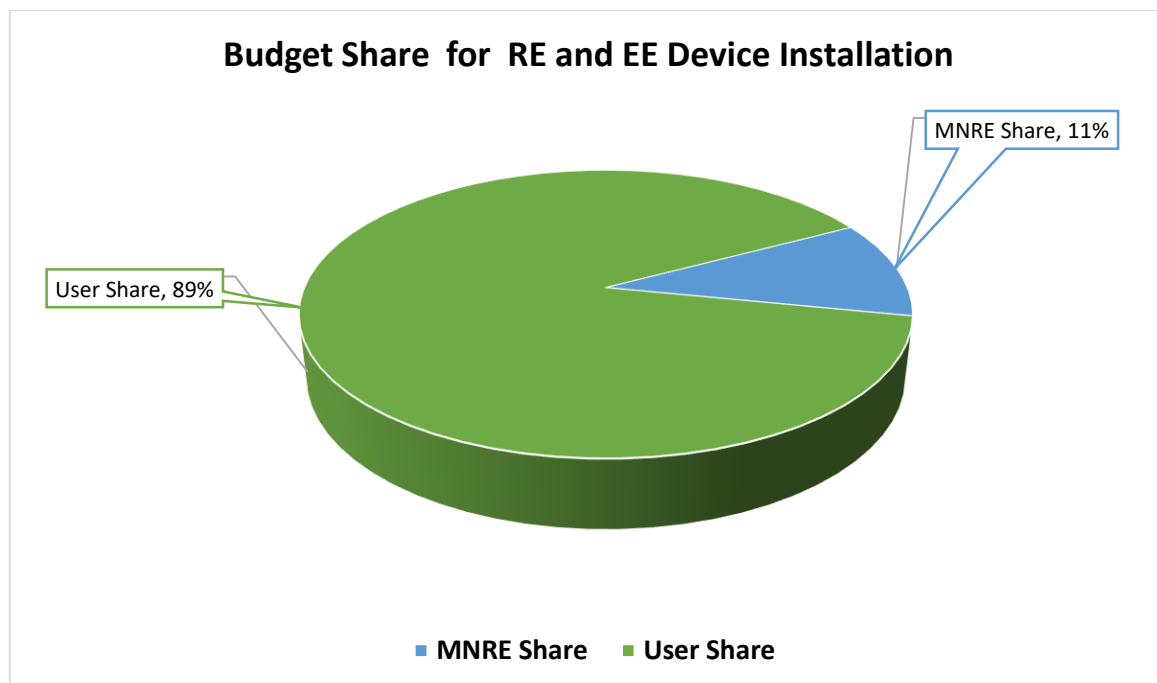


Figure 35 Budget Share

8.6 Budget Expenditure and Activity Plan

MNRE has provisions for various activities and sub-activities under its solar city scheme and the same has to be implemented by the corporation to qualify for solar city. Besides this loan and subsidies as applicable for other schemes like solar power plants can also be tapped into. Loan from IREDA and designated banks can also be processed.

Budgeted Expenditure and Activity Plan for Ajmer Solar City Master Plan												
	Activity Heads	Budgeted Amount	Time Line (Funds requirements at the beginning and end of each Half Year Period) (in months)									
			6	12	18	24	30	36	42	48	54	60
1	Setting up of Solar Cell and its functioning	10,00,000										
1.1	Setting up of office infrastructure	2,00,000	3,00,000	-	-	-	-	-	-	-	-	-
1.2	EE/RE/CDM awareness through technology interpretation centre	3,00,000	-	2,00,000	-	-	-	-	-	-	-	-
1.3	Capacity building for Solar City Committee members	3,00,000	2,00,000	1,00,000	-	-	-	-	-	-	-	-
1.4	Case study tour	2,00,000	2,00,000	-	-	-	-	-	-	-	-	-
2	Appointment of technical advisor	10,00,000										
2.1	Assistance in structuring, implementation, monitoring and supervision of the proposed projects in the master Plan	10,00,000	2,00,000	2,00,000		3,00,000	-	3,00,000	-	-	-	-
2.2	Assistance in capacity building of the community for day to day operations & maintenance											
2.3	Assistance in dev of innovative financial mechanism for funding the projects											
2.4	Assistance in various workshops to be organized by Solar Cell											
3	Promotional & Awareness Activities	20,00,000										

3.1	Organizing various workshops for capacity building for officials, locals, students, NGOs, societies etc.	12,00,000	2,00,000	2,00,000	2,00,000	2,00,000	2,00,000	2,00,000	-	-	-	-
3.2	Media & Publicity for various awareness campaign	8,00,000	2,00,000		2,00,000		2,00,000	2,00,000	-		-	-
4	Preparation of solar city master plan	10,00,000		10,00,000								
Column Total in Rupees		50,00,000	1300000	1700000	400000	500000	400000	700000			-	-

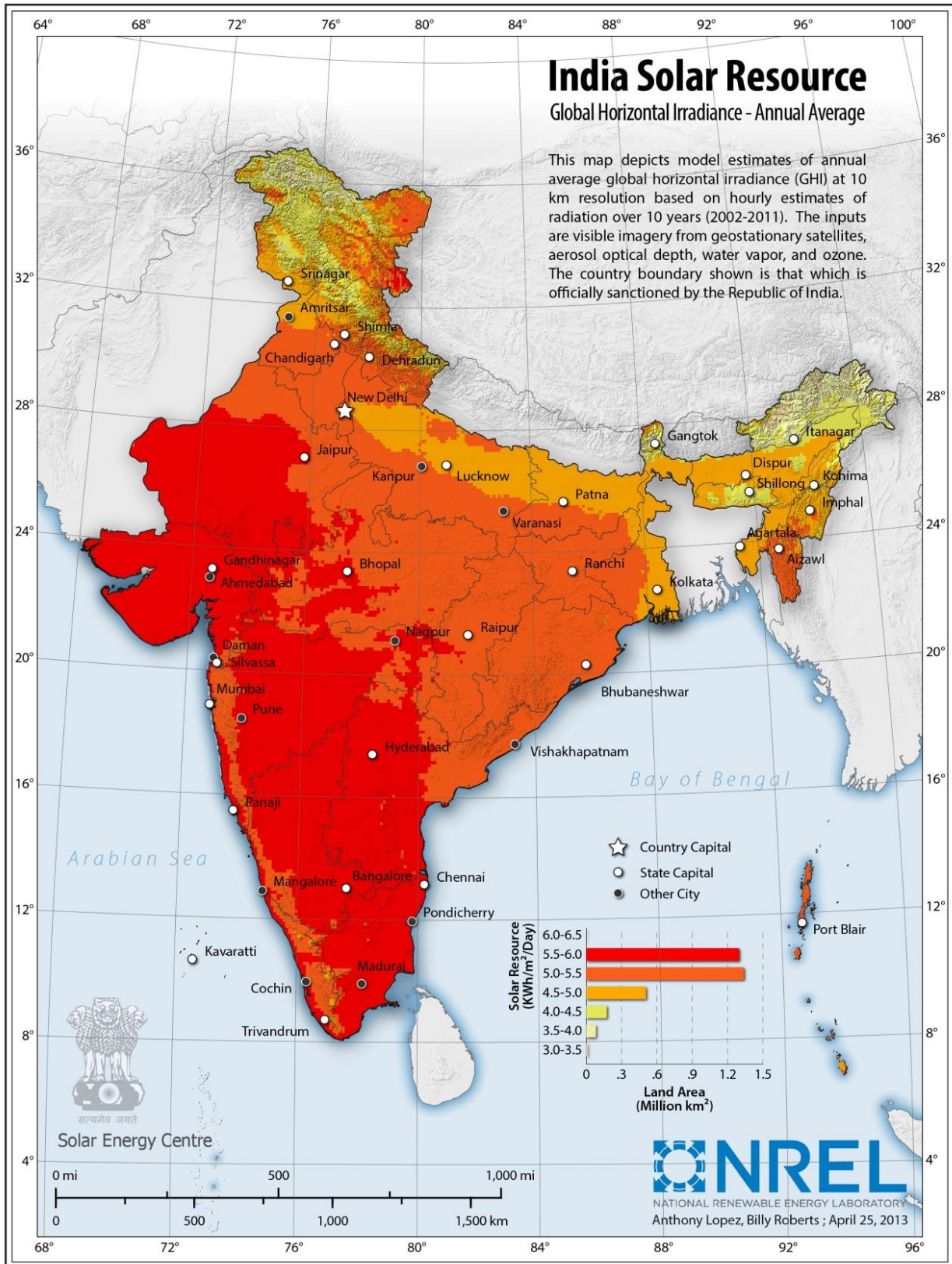
8.7 Implementation Plan

Implementation of the strategies suggested in the master plan requires a multilateral collaboration from all the stakeholders and key government agencies. To achieve the reduction targets, key implementation points have been summarized below.

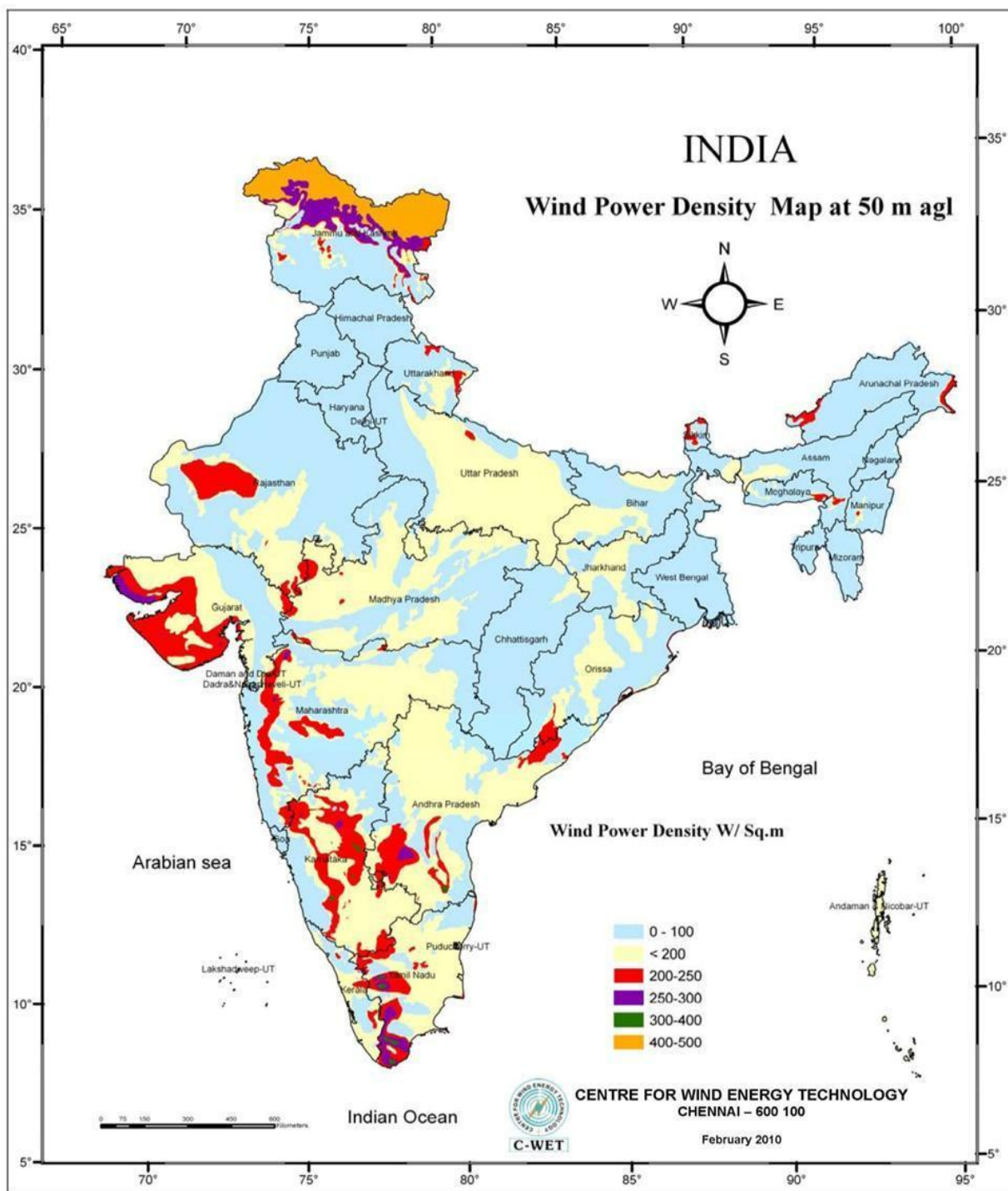
1. The established Solar City Cell shall take a lead role as a facilitator in the implementation of the master plan. An empowered committee may also be set up to provide guidance to the Solar City Cell and resolve administrative and financial bottlenecks in the implementation of the master plan.
2. There is a provision for availing grant-in-aid provided by Bureau of Energy Efficiency (BEE) to design a few pilot energy efficient buildings in the city in accordance with Energy Conservation Building Code (ECBC). The Solar City Cell may take advantage of the grant-in-aid for energy consultancy as well as incremental cost of construction for a few buildings.
3. The Solar City Cell may work:
 - ✓ To get ECBC notified immediately
 - ✓ To ensure that the building by- laws are changed in accordance with it.
 - ✓ To ensure that all the upcoming non-residential buildings are brought under the ambit of ECBC and to incorporate the relevant green building elements.
 - ✓ To ensure that the major new commercial and government buildings are GRIHA certified.
4. In collaboration with the CFL manufacturing and distribution companies, distribution of quality CFLs to its consumers at concessional prices or on easy payment terms can be worked out. For instance, in Delhi, BSES had promoted CFL from “Buy one get one free CFL offer”.
5. Building bye-laws shall be amended for making use of solar water heating systems mandatory in certain category of buildings. AMC may take the initiative in this direction.
6. The Solar City Cell may initiate a dialogue with Ajmer Vidhut Vitran Nigam Limited and Ajmer Discom for introducing rebate on electricity tariff for the domestic consumers, which employ solar devices.
7. Rigorous publicity campaign, training programme and business meets may be organized for various stake holders, e.g. architects, engineers, builders & developers, financial institutions, NGOs, technical institutions, manufactures/suppliers, etc. so as to involve them actively in meeting the objective of solar city.

8. The Solar City Cell may start a sustained campaign from print media, radio and television.
9. The Ministry has been promoting the establishment of Akshay Urja shops in major cities of the country with a view to make solar energy products easily available and to provide after sales repair and maintenance services. The Solar City Cell may work in close conjunction with Akshay Urja shops in disseminating information about various solar products.
10. Solar City Cell along with Rajasthan Renewable Energy Corporation Limited (RREC), power utilities and educational institutions may launch awareness generation campaign on EE and RE to engage the public on a sustained manner.
11. Solar City Cell may work closely with associations of local traders and manufacturers to propagate use of star rated electrical appliances.
12. For commercial and institutional buildings, adoption of energy efficient appliances can be encouraged from Energy Services Company (ESCOs) route.
13. As Industrial Sector is the high energy consuming sector in Ajmer, AMC may enhance the present scheme for promoting energy audits in the industrial sector.
14. It is also important to generate funds from State Government and other funding organizations necessary for achieving the objective of making the city as a “Solar City”.
15. Rebate in property tax from Municipal Corporations and Municipalities and in electricity tariff though Utilities/ Electricity Boards may be provided to the users of solar water heaters, especially in domestic sector.
16. Government Order with regard to construction of energy efficient solar buildings can be issued at least in Government and public sectors in accordance with ECBC: 2006
17. National Rating System for construction of energy efficient Green Buildings particularly in commercial and institutional buildings shall be promoted.
18. MSW Rules 2000 notified by MoEF shall be complied and projects of suitable capacity for generating energy from the waste collected from the city/ town may be set up.

Annexure 1: Solar Radiation Map of India



Annexure 2: Wind Power Density Map of India



Annexure 3: Web link of important web pages

Description	Web link
Ministry of New and Renewable Energy	http://www.mnre.gov.in
List of Manufacturers and Dealers of Energy Technologies	http://www.mnre.gov.in/information/manufacturersindustrial
Central Electricity Regulatory Commission	http://www.cercind.gov.in
Rajasthan Renewable Energy corporation Limited Regulatory Commission	http://www.rrecl.com
The Indian Renewable Energy Development Agency IREDA	http://www.ireda.gov.in
Centre for Wind Energy Technology (C-WET)	http://www.cwet.tn.nic.in
Strategic Plan For New And Renewable Energy Sector For The Period 2011-17, of MNRE	http://mnre.gov.in/file-manager/UserFiles/strategic_plan_mnre_2011_17.pdf
Jawaharlal Nehru NationalSolar Mission (JNNSM):Schemes and Documents	http://www.mnre.gov.in/solar-mission/jnnsmission/introduction-2
AMC	www.Ajmermc.org
MoUD	www.moud.gov.in
Smart City link	Smartcities.gov.in

Annexure-4: Conditions required for a Solar City for availing the funds of MNRE

- i. The City has created a **Solar City Cell** and constituted the **Stakeholders Committee**. A copy of the notifications for creation of Solar City Cell and Stakeholders Committee to be submitted.
- ii. Action initiated/taken to amend building bye-laws for making the use of solar water heating systems mandatory in certain category of buildings.
- iii. Action initiated/taken to provide rebate in property tax from Municipal Corporations/ Municipalities or in electricity tariff through Utilities/ Electricity Boards to the users of solar water heaters especially in domestic sector.
- iv. Action initiated/taken to promote National Rating System for construction of energy efficient Green Buildings in particular to commercial and institutional buildings. The city has issued G.O as regards to construction of Green buildings in compliance with approved National Rating Systems like GRIHA particularly in Government/PSUs buildings.
- v. As per MSW Rules notified by the MoEF, the city has initiated/taken actions for proper MSW management and for setting up set up projects of suitable capacity for generating energy from the waste collected from the city/town.
- vi. The city has initiated actions in amending/has amended the byelaws or makes new byelaws for promoting the renewable energy options for avoiding use of diesel and petrol gen-sets in markets, public places, schools, offices etc.
- vii. Action initiated/taken for reduction of electricity consumption in street light/garden lights, traffic lights, blinkers, hoardings etc. and in schools, commercial buildings, offices, institutional buildings and other establishments by using energy conservation & renewable energy devices.
- viii. The Municipal Corporation/ Municipality/SNA have established at least one Akshay Urja Shop alongwith the repair and maintenance facilities either in their campus or at some prominent place in the City.
- ix. The Master Plan has been prepared and the installation of at least 2 to 3 Major Projects of Renewable Energy have taken place/ sanctioned/commenced.

Annexure-5: Renewable Energy and Energy conservation projects/system/devices for Solar Cities

Solar City will focus on the limited and popular renewable energy projects/systems/devices such as solar PV systems including and building integrated photovoltaic, kitchen waste based plants, solar water heating systems, solar cooking systems, solar steam generating/drying/air heating systems, solar concentrators for process heat applications, solar air-conditioning, power projects on methane recovery from STPs, bio-mass gasification based systems, biogas, wind etc.

Energy conservation/devices/systems

- I. LEDs/ CFLs instead of incandescent bulbs
- II. LED traffic lights
- III. Electronics chokes and fan regulators
- IV. Sensors for automatic on/off of street lights

Automatic speed regulating fans/motors

- I. Plugging of leakages in the water supply system and use of efficient pumps and motors
- II. Energy efficient electrical appliances such as fans, refrigerators, air conditioners, coolers, room heaters, water pumps etc.
- III. Use of insulating materials and low-energy/energy-efficient building materials e.g. fly ash bricks, hollow bricks, stabilized mud blocks, etc. in building construction
- IV. Any other Energy Efficient/ Energy Conservation device, project being promoted by BEE, Ministry of Power or MNRE

Solar passive architecture in buildings/housing complexes

Major components of solar passive architecture are orientation of building, sun shades, double glazed windows, smart glazing window overhangs, thermal storage wall/roof, roof painting, ventilation, evaporative cooling, day lighting, wind towers, earth air tunneling, construction materials etc. Incorporation of specific components will depend in which climatic zone the building is being constructed.

Green Buildings

The construction of the Green Buildings as per GRIHA Rating, LEED India, ECBC building Code, BEE Star Rating, ECHO Housing or other rating systems.

Annexure-6: Indicative measures to be taken by City Council /Administration for developing their city / town as ‘Solar City’

1. To create a “Solar City Cell” with in the City Administration/ Council which will be fully responsible for city planning and implementation of projects towards making it a “Solar City”?
2. To conduct energy auditing of Govt./Public sector buildings, water pumping and street lightings in the city at regular interval and take necessary steps towards conservation of electricity. Other establishments also to be encouraged for the same.
3. To reduce electricity consumption in street light/garden lights, traffic lights, blinkers hoardings etc. by using energy conservation & renewable energy devices.
4. To amend building bye-laws for making the use of solar water heating systems mandatory in certain category of buildings.
5. To provide rebate in property tax from Municipal Corporations/ Municipalities & in electricity tariff through Utilities/ Electricity Boards to the users of solar water heaters especially in domestic sector.
6. To issue G.O as regards to construction of energy efficient solar buildings at least in Govt. /Public sectors in accordance with ECBC :2006 and follow up its implementation rigorously.
7. To comply to MSW Rules 2000 notified by the MoEF and set up projects of suitable capacity for generating energy from the waste collected from the city/town.
8. To organize rigorous publicity, and also the training programmer’s/ business meets for various stake holders e.g. architects, engineers, builders & developers, financial institutions, NGOs, technical institutions, manufactures/suppliers, RWAs etc. so as to involve them actively in meeting the objective of solar city.
9. To generate necessary funds from State Govt. and other funding organizations for achieving the objective of making the city as “Solar City”. Benefits of the schemes of Govt. of India will also be taken in meeting the objectives.
10. To achieve targets set by the City Council/Administration for reducing consumption of electricity from renewable energy and energy conservation devices during five years of implementations for developing their city as Solar City.

Annexure-7: Indicative actions towards a ‘Solar City’

1. City has created/notified a “Solar City Cell” and a Stakeholder’s Committee” with in the City Administration/ Council which will be fully responsible for city planning and implementation of projects towards making it a “Solar City”?
2. The Master Plan of the Solar City has been prepared.
3. City has amended building bye-laws for making the use of solar water heating systems mandatory in certain category of buildings.
4. City is providing rebate in property tax from Municipal Corporations/ Municipalities & in electricity tariff through Utilities/ Electricity Boards to the users of solar water heaters especially in domestic sector.
5. City is conducting energy auditing of Govt./Public sector buildings, water pumping and street lightings in the city at regular interval and is taking necessary steps towards conservation of electricity.
6. City has taken steps to reduce electricity consumption in street light/garden lights, traffic lights, blinkers, solar studs, hoardings etc. by using renewable energy devices and energy conservation.
7. City has issued a G.O as regards to construction of energy efficient solar/green buildings at least in Govt./Public sectors in accordance with ECBC or any rating system and is following up its implementation rigorously.
8. City is complying with MSW Rules 2003 notified by the MoEF. City has set up or is setting up projects of suitable capacity for generating energy from the waste collected from the city/town.
9. The city has the facility of sewage treatment possibly with energy generating system.
10. The city has at least one or more Akshay Urja Shop or Sales and Service center for Renewable Energy systems and devices.