Jodhpur Solar City Master Plan

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Final Report

Jodhpur Solar City Master Plan

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ABBREVIATIONS AND ACRONYMS

AC	Air Conditioner
BEE	Bureau of Energy Efficiency
CDM	Clean Development Mechanism
CERC	Central Electricity Regulatory Commission
CFA	Central Financial Assistance
CFL	Compact Fluorescent Light
CO_2	Carbon Dioxide
DG	Diesel Generator Sets
DISCOM	Distribution Company
EE	Energy Efficiency
GHG	Green House Gases
GWh	Giiga watt hour
HH	House Hold
HPSV	High Pressure Sodium Vapour
Hrs/day	Hours per Day
HVAC	Heating, Ventilation and Air Conditioning
IRADe	Integrated Research and Action for Development
IREDA	Indian Renewable Energy Development Agency
JMC	Jodhpur 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
MWe	Mega Watt Equivalent
MWh	Mega watt hour
NASA	National Aeronautical Space Administration
O&M	Operations and Maintenance
R&D	Research and Development
RE	Renewable Energy
RET	Renewable Energy Technology
SNA	State Nodal Agency
SL	Solar Lantern
SSL	Solar Street Light
SHL	Solar Home Light
SPP	Solar Power Plant
SPV	Solar Photo Voltaic
Sqm	Square Metre
STP	Sewage Treatment Plant
SWH	Solar Water Heater
SWM	Solid Waste Management

Executive Summary

India is a developing country and it is in the phase of rapid industrialization. With this continuous development, there is a huge demand for energy. In India, largest source of energy is coal (conventional source), which is the cause of large scale emission of Greenhouse Gas (GHG) in various sectors. With the view to reduce dependence on conventional sources of energy to meet the increasing demand, Solar City programme has been initiated by the Ministry of New and Renewable Energy (MNRE), Government of India (GoI).

The main focus of India's Eleventh Five Year Plan was to reduce the increasing energy demand and reducing dependence on fossil fuels across different sectors in the fast urbanizing cities in the country. With an increase in population and economic activities, urban areas are facing tremendous energy crisis. In Jodhpur City, the population is expected to rise to 11.6 million by the end of 2017-18 and 12.7 million by the end of 2022-23; whereas the gross energy demand excluding transportation sector is expected to increase by 6.17% per year to reach a value of 3995 Million Units of Energy (kWh) by 2017-18 and 5303 Million Units of Energy Demand (kWh) 2022-23.

As has been the case with the wide-scale introduction of renewable energy technologies and energy efficiency measures across the country, Jodhpur Municipal Corporation (JMC) has taken the initiative to develop it as a Solar City. Solar City programme strives to integrate efforts in Energy Efficiency (EE) across different energy consuming sectors in the city and utilization of available Renewable Energy (RE) resources such as solar energy, wind energy, biomass, and municipal wastes to meet the reduction targets as per the guidelines provided by MNRE**.**

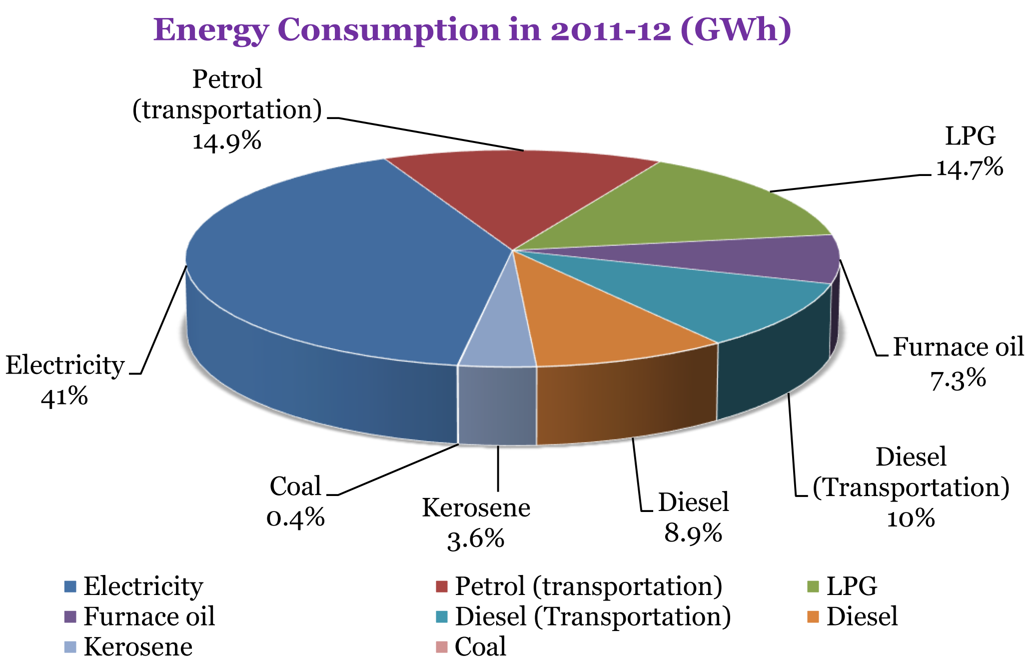
The study "Development of Solar City Master Plan" has benefitted from the active participation of Jodhpur Municipal Corporation, Rajasthan Renewable Energy Corporation Limited, power and energy distribution companies, industry associations, builders associations, educational institutions, and energy supply agencies in the city. The project includes study of four different sectors, namely, municipal, commercial and institutional, residential and industrial. However, as an additional study as advised by the JMC, baseline energy consumption in the transportation sector has also been included in the report. The key components of the study comprised of:

(1) Baseline (2011-12) energy assessment and demand forecasting for the year 2017-18 and 2022-23.
(2) Energy planning and sector-wise strategy for meeting 10% reduction target through RE and EE.
(3) Budget estimation for achieving the reduction targets.
(4) Implementation plan, awareness generation and capacity building.

During the baseline year for the city, the maximum energy consumption was in the form of electricity followed by coal, LPG, petrol, diesel, Furnace Oil and kerosene in order. The consumption trend for all the fuels and sources of energy has been increasing during the past five years.

Baseline Energy Consumption 2011-12 and Projected Energy demand for the year 2017-18 & 2022-23

Sector	Energy Consumption in GWh	Projected Energy Demand in GWh	
	2011-12	2017-18	2022-23
Residential	827	1125	1665
C & I	374	674	888
Industrial	737	868	1128
Municipal	107	186	289
Transportation	677	1142	1332
Total	**2722**	**3995**	**5302**

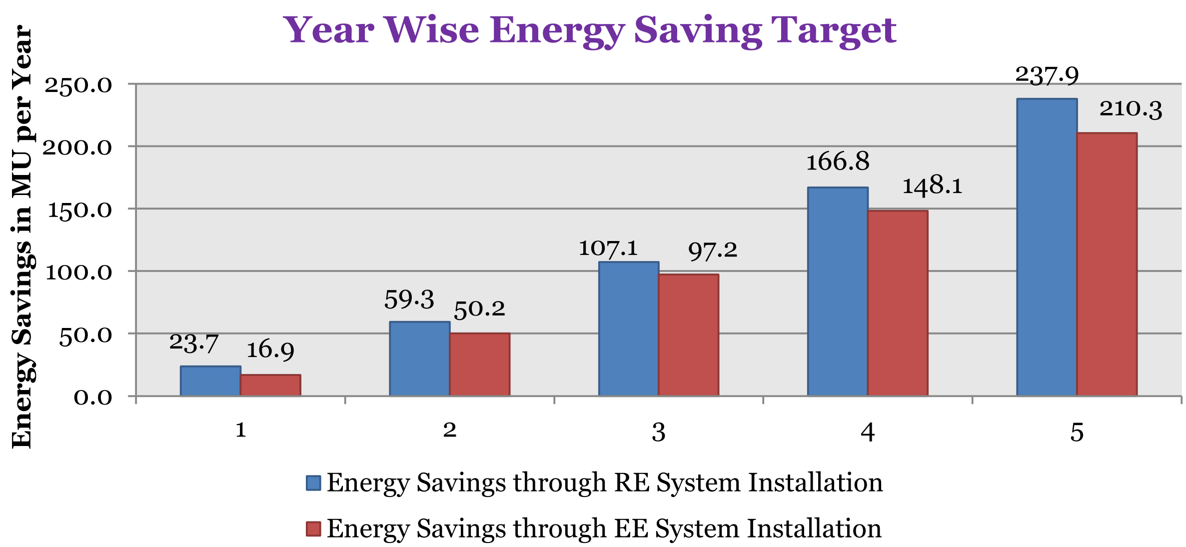


Electricity has the largest proportion in the energy consumption, accounting for 41% of the energy supply, with LPG at 14.7 %, petrol at 14.9%, diesel at 18.9%, kerosene at 3.6% and Coal at 0.4%.

Different sectors are expected to see different growth rates. The annual growth rate of energy consumption of residential sector is around 6.57 % after 2011-12, whereas, commercial & Institutional Sector, Industrial, municipal, transportation sector are expected to see an annual growth of energy consumption by 6.57 %, 8.67 %, 5.46 % and 5.05 % respectively.

As mandated in the solar city programme, the target is 10% reduction of energy demand at the end of five years. Projected energy demand at the end of next five year (2017-18) for Jodhpur City is estimated to be 3995 GWH. As per guidelines of "Development of Solar City Master Plan", minimum of 10% reduction is projected in energy demand of conventional energy at the end of five years through a combination of enhancing supply from renewable energy sources in the city and energy efficiency measures. Energy demand reduction target is to be achieved through installation of renewable energy system and energy efficient system in the four sectors as per the guidelines of Solar city master plan. Total energy demand reduction target is 399.5 GWh, which will be achieved through installation of RE System and EE System. Installation of RE System and EE System has been distributed year wise across the forthcoming five years from 2013-14 to 2017-18, in the proportion of 10 % in first year, 15 % in second year, 20% in third year, 25 % in fourth year and 30 % in fifth year of demand respectively. Based on the analysis of potential for supply side augmentation through RE and demand side measures through EE, following targets are proposed for different sectors in order to develop Jodhpur as a "Solar City".

Renewable energy	**Sector Wise Yearly Energy saving target for First commitment period 2017-18 in MU**					
	1st Year	**2nd Year Cumulative**	**3rd Year Cumulative**	**4th Year Cumulative**	**5th Year Cumulative**	**% of target**
Residential Sector	13.8	34.5	62.2	96.7	138.2	34.6%
C & I Sector	5.3	13.4	24.1	37.6	53.6	13.4%
Industrial Sector	3.1	7.9	14.4	22.6	32.0	8.0%
Municipal Sector	1.4	3.5	6.4	9.9	14.1	3.5%
Total Renewable Energy Saving Target	23.7	59.3	107.1	166.8	237.9	59.6%
Energy Efficiency in %	**1st Year**	**2nd Year Cumulative**	**3rd Year Cumulative**	**4th Year Cumulative**	**5th Year Cumulative**	**% of target**
Residential Sector	6.9	20.6	34.4	57.3	84.7	21.2%
C& I Sector	6.6	16.5	29.7	42.4	61.4	15.4%
Industrial Sector	1.3	8.6	28.2	39.0	50.4	12.6%
Municipal Sector	2.1	4.5	4.9	9.5	13.8	3.5%
Total Energy Efficiency Saving Target	16.9	50.2	97.2	148.1	210.3	52.7%
Total Energy Saving Target From RE & EE	**41**	**109**	**204**	**315**	**448**	
Year Wise % of Target	10%	27%	51%	79%	112%	



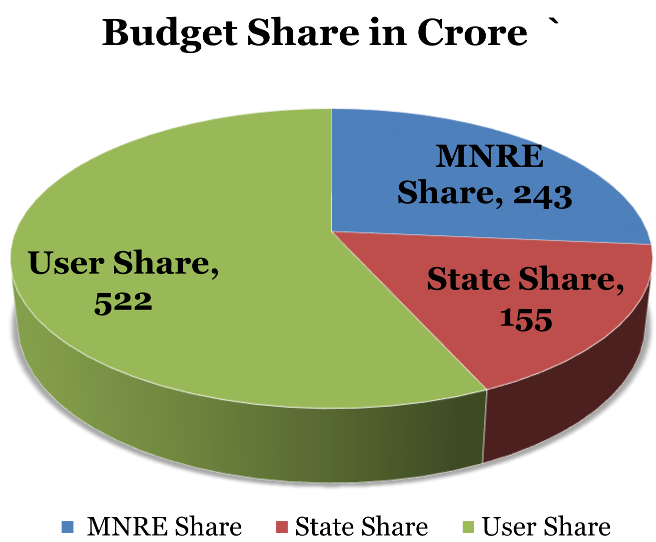
Various options of generating power from renewable energy resources has been assessed and suggested in the Master Plan. The renewable energy options are assessed in solar energy technologies and waste to energy, as biomass potential in Jodhpur district is apparently Zero. Some generic EE measures have been suggested common to all the sectors and some specific to certain sectors depending upon its suitability.

Based on the sector wise proposed project activity to improve the present consumption and projected energy demand scenario of the city, quantum of investment required for various sectors is estimated for Solar City Development Plan over a specified time frame to achieve the mission goals. Gross investment need is approximately ` 920 Crores for the next five years. The costing provided for the projects is a rough cost estimation based on similar kind of projects and interaction with suitable escalation factors in each sector during the implementing period.

The total indicative budget for the development of Jodhpur as a Solar City is estimated to be ` 920 crore, through renewable energy as well as energy efficient system installation, and 13 renewable energy pilot projects, which will be invested over the 5 years of implementation period for solar city development programme.

The budget for implementation of RE strategy and EE strategy is estimated to be Rs. 742 crore and ` 179 crore ` respectively. Estimated budget for the renewable energy pilot projects is around ` 95 Crore. Budget for establishment of the Solar City Cell and awareness and publicity is estimated to be ` 48.30 Lakhs, which could be enhanced depending upon the requirement. While budget for RE strategy will be shared amongst MNRE, state/city and private users, private investors will primarily drive EE activities

S.No.	Budget	Budget in Crore `
1	MNRE Share	243
2	State Share	155
3	User Share	522
4	**Total Budget**	**920**



CHAPTER 1 INTRODUCTION

1.1 About the City

Jodhpur is the second largest city in Rajasthan. It is located on National Highway 65, which is 335 kilometers west from the state capital, Jaipur and 200 kilometers from the city of Ajmer. It is well connected to other main cities of the country through bus, rail and air route. It was formerly the seat of a princely state of the same name, the capital of the kingdom known as Marwar. Jodhpur is a popular tourist destination, featuring many palaces, forts and temples, set in the stark landscape of the Thar Desert. Jodhpur is a city where all major offices of railways, airlines, defence, CPWD, Doordarshan, telecom, etc. are situated.

The city is known as the "Sun City" for the bright, sunny weather it enjoys throughout the year. It is also referred to as the "Blue City" due to the blue-painted houses around the Mehrangarh Fort. Jodhpur lies near the geographic centre of Rajasthan state, which makes it a convenient base for travel in a region much frequented by tourists. Jodhpur was founded in 1459 by Rao Jodha, a Rajput chief of the Rathore clan. Jodha succeeded in conquering the surrounding territory and thus, founded a state which came to be known as Marwar.

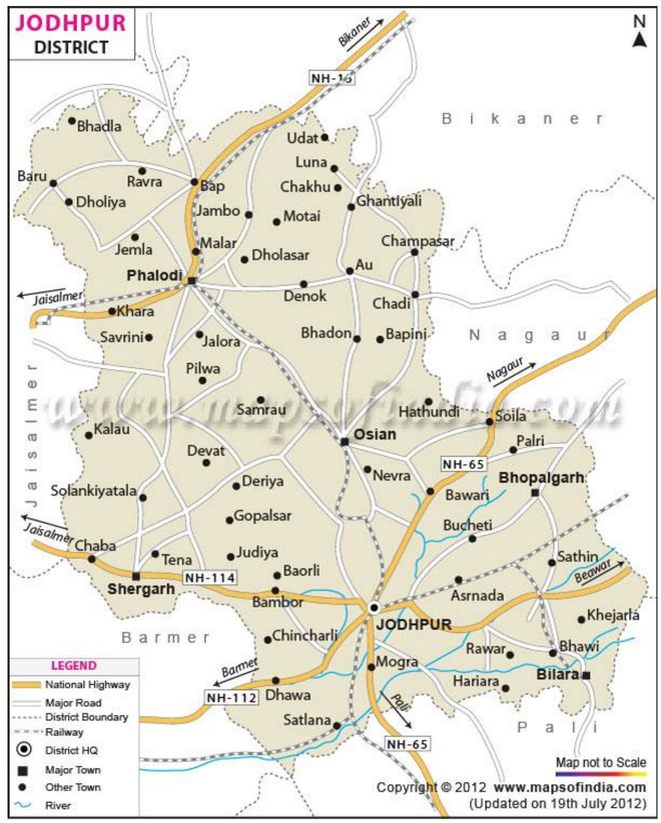


Figure 1: Jodhpur District map

Population

Population of Jodhpur city in 2001 census was 8,60,818 persons, and in 2011 census, the population became 1,033,918 persons , showing a decadal growth rate of 20.11%. Jodhpur's area was 75.05 Square kilometre.

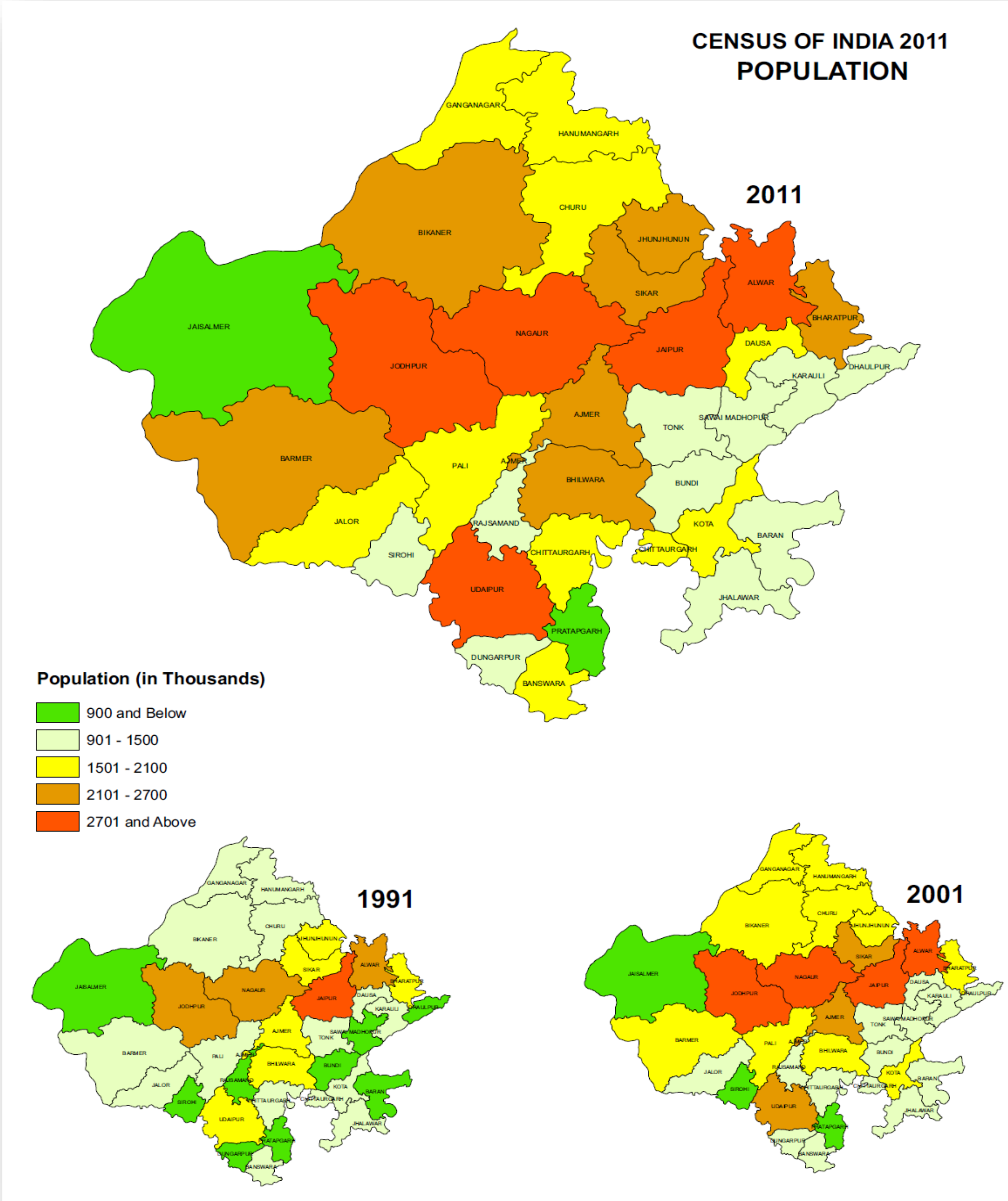


Figure 2: Population Map

1.2 Developing Jodhpur as '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 through 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 Jodhpur Municipal Corporation for preparing a Master Plan for developing Jodhpur as a solar city.

1.2.1. Preparation of Master Plan for 'Jodhpur Solar City'

The solar city master plan preparation process is divided into six steps:

(i) Preparing energy baseline for the year 2011-12

Energy baseline for the city is a detailed documentation of the existing energy demand and supply for the city. Among other things, it consists of sector-wise energy consumption matrix and energy supply mix for the base year. The city is divided into four sectors viz. residential, commercial/ institutional, industrial and municipal sector.

(ii) Demand forecasting for 2018 and 2023

This step involves predicting the energy demand for 5 year and 10 year periods. To estimate the demand and growth in energy used in different sectors has been determined. These growth rates are established based on immediate past trends and future growth plans. 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 2018 (five year) and 2023 (10 year).

(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 through 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 & expected GHG abatements. This includes establishment of solar city cell, capacity building and awareness generation. An indicative financial outlay has been prepared for implementation of the proposed five-year action plan and potential sources of funding from respective sources (both public and private) has been stated.

CHAPTER 2 ENERGY BASELINE SCENARIO OF JODHPUR CITY

The first step in the preparation of the Solar City Master Plan for Jodhpur is the preparation of an energy baseline report for the base year 2012. As elucidated in the MNRE guidelines, energy baseline is a detailed documentation of the existing energy consumption scenario for the Jodhpur city. It consists of sector-wise energy consumption matrix and energy supply-mix for the base year 2012

According to the guidelines, consumption of energy of a city is mainly divided into four sectors, which are residential, commercial and 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 equipments cannot be a part of this sector. 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 Jodhpur and compiled into an energy baseline report.

2.1 Residential Sector – Different type of Energy Consumption

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.

Table 1: Energy/ Fuel Consumption in Residential Sector

Category	Annual Consumption								
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Electricity in MU	196	210	223	236	261	259	291	324	353
LPG in MT	19385	21395	22007	22988	23851	24432	24996	25516	25919
Kerosene in kL	6504	6873	7112	9301	9491	9488	9605	9625	9630

2.2 Commercial and Institutional Sector – 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, hostels, jails, government offices, etc. The major sources of energy uses are electricity and LPG. In addition, a variety of fossil fuels may be used for power back-up, e.g. diesel generators. In some cases, biomass fuels are also used for cooking and water heating." The Jodhpur Discom has classified this under non-domestic usage and mixed load for commercial & institutional sector, as specified in table mentioned below.

Table 2 Energy Consumption in Commercial & Institutional Sector

S.No.	Category	Annual Consumption in Commercial & Institutional Sector								
		2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
1	Electricity In MU	126	134	147	160	182	194	210	233	247
2	LPG in MT	195	236	289	462	808	1014	1431	1456	1498
3	Diesel in kL	2079	2159	2304	2465	2804	2953	3345	3782	4153

2.3 Industrial Sector–Energy Consumption

This includes all types of industries falling within the municipal limits. Besides electricity, other fuels that are used are petroleum products (diesel, natural gas, naptha, furnace oil, etc), coal, biomass, etc.

Type of Industry

1. Guar Gum
2. Textile
3. Handicraft
4. Engineering
5. Steel
6. Agro food
7. Lime (Mining Industry)

Table 3 Energy Consumption in Industrial Sector

S.No.	Category	Annual Energy Consumption in Industrial Sector								
1	**Electricity in MU**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
1.1	**Small Industry**	16	22	29	25	28	33	27	30	31
1.2	**Medium Industry**	46	55	58	61	69	66	69	76	89
1.3	**Large Industry**	128	144	158	173	193	181	193	229	279
	Total Electricity	190	221	240	260	289	279	289	334	399
2	**Petroleum Product**									
2.1	**Furnace Oil in kL**	13956	14336	14856	15142	15736	16125	16524	16939	17362
2.2	**Coal in MT**	2214	2343	2742	2942	3348	3621	3854	4134	4572
2.2	**Diesel in kL**	14538	15021	15953	16354	17856	18542	19854	20942	21457

2.4 Municipal Sector–Energy Consumption

Under the municipal sector, the major energy source comprises of street lights and water supply. Energy consumption data for these two segments is shown in the table below. Energy consumption for the Government buildings and facilities falls under the commercial & institutional sector.

Table 4 : Details of Street Lighting

S.No.	Area	Tube Light 40 Watt	SV 70/150/250 Watt	MH 250 Watt	Decorative 70 Watt
1	Sursagar	10091	7436	5553	1012
2	Jodhpur City	5513	4059	5804	785
3	Sardarpura	6025	5796	4042	139
4	Mixed	-	14365	-	-
5	**Total**	**21629**	**31656**	**15399**	**2216**

Table 5: Annual Consumption of Energy in Municipal Sector

Category	Annual Consumption of Energy (GWh) in Municipal Sector								
Electricity in MU	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Street Lighting	8.9	11.2	9.8	10.1	17.8	40.3	61.5	62.6	69.4
Water Pumping Small*	2.7	0.3	2.3	1.9	1.8	1.8	2	2.7	3.8
Medium*	1.4	1.2	1.4	1.4	1.8	1.8	2.4	1.8	1.9
Large*	24.8	30	26.9	26.4	27.3	27.5	30.3	30.7	31.7
Total	**38**	**43**	**40**	**40**	**49**	**71**	**96**	**98**	**107**

* Small - Up to 25 H.P. capacity Water Pumping Station, Medium from 25 H.P. to 60 H.P. capacity Water Pumping Station Large more than 60 H.P capacity Water Pumping Station

2.5 Total Energy Consumption of Jodhpur City in Energy Base Year 2011-12

Table 6 : Total Energy Consumption of Different Type of Energy sources

Source	Energy Consumption in GWh	% of Energy Consumption
Electricity	1105.3	40.62%
Petrol (transportation)	404.9	14.88%
LPG	398.6	14.65%
Furnace oil	197.6	7.26%
Diesel (Transportation)	272.7	10.02%
Diesel	244.2	8.97%
Kerosene	96.8	3.56%
Coal	1.1	0.4%

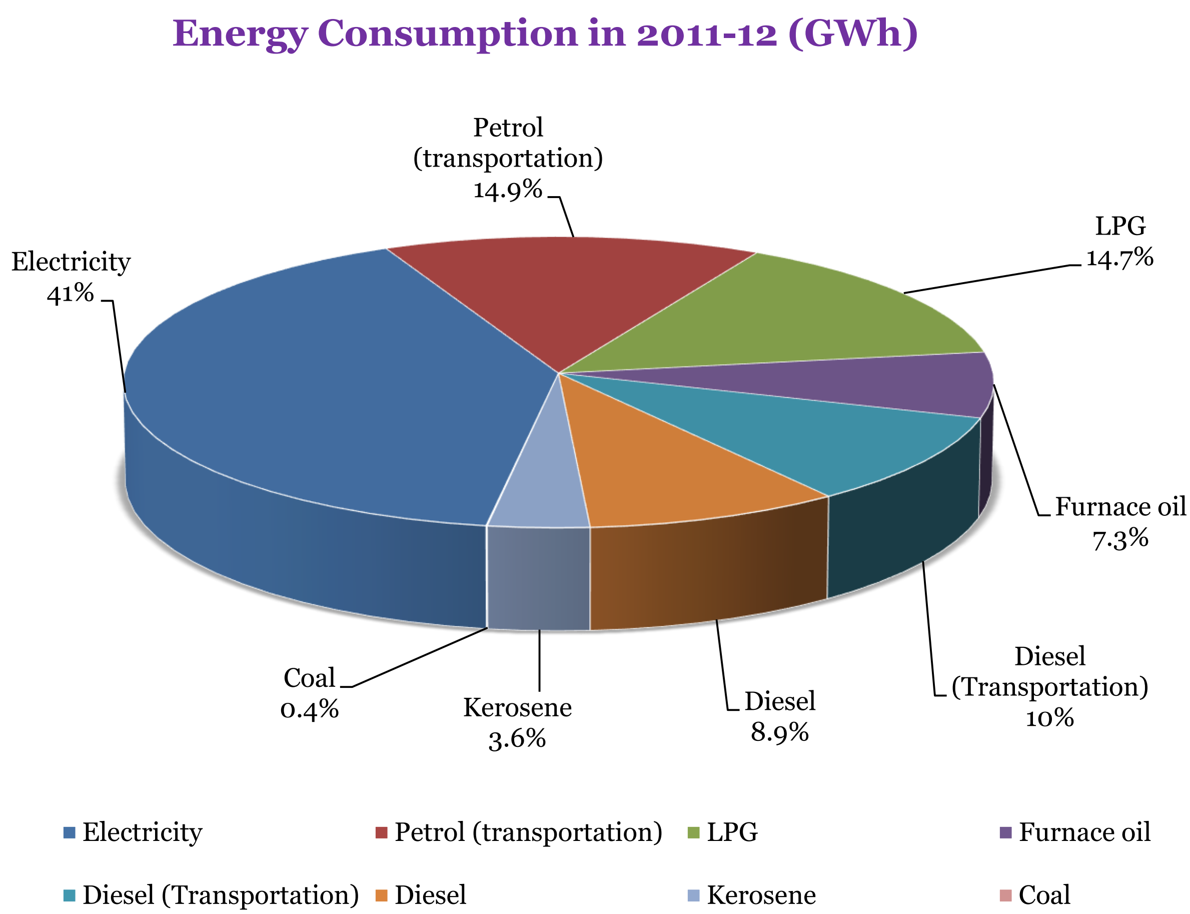


Figure 3 Energy Consumption in Energy Base Year 2011-12

2.6 Green House Gas Emissions of Jodhpur City

2.6.1 Residential Sector – CO_2 Emission through Different Types of Energy Sources

As can be seen from figure 2 electricity has maximum share of GHG emissions in residential sector 71% and kerosne has the least share at 6%.

Table 7: CO_2 Emission from fifferent type of Energy Sources of Residential Sector in Jodhpur city

Category	**Per Year CO_2 Emission in '000 MT**								
CO_2 Emission through	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Electricity	160.7	172.2	182.9	193.5	214.0	212.4	238.6	265.7	289.5
LPG	58.5	64.6	66.5	69.4	72.0	73.8	75.5	77.1	78.3
Kerosene	16.5	17.5	18.1	23.6	24.1	24.1	24.4	24.4	24.5
Total	**235.8**	**254.3**	**267.4**	**286.6**	**310.2**	**310.3**	**338.5**	**367.2**	**392.2**

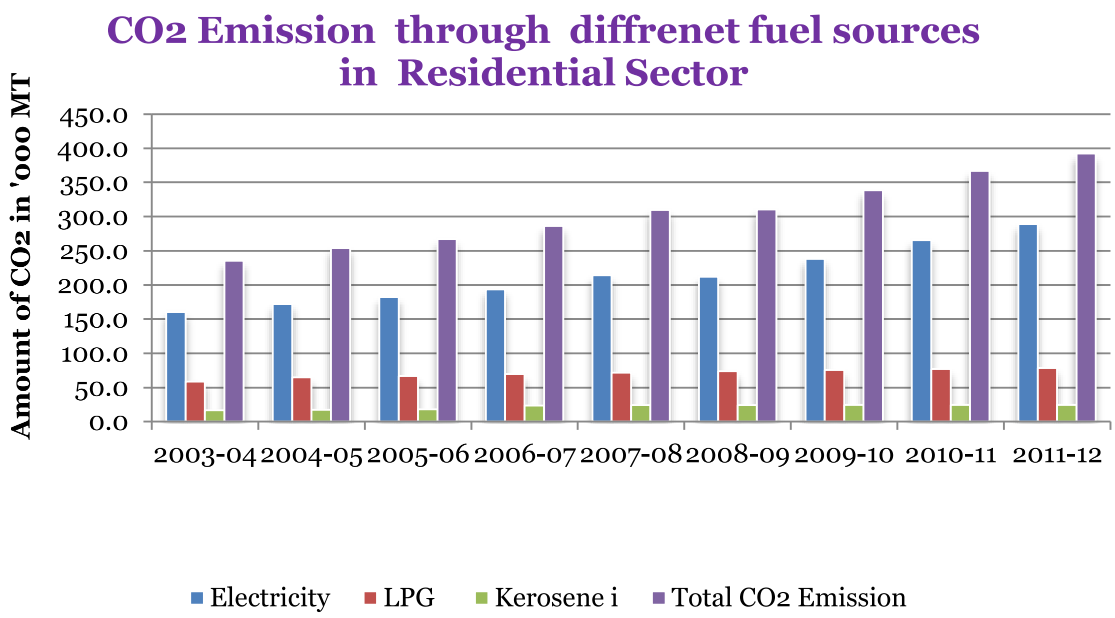


Figure 4: CO_2 Emission through Residential Sector

2.6.2 C & I Sector – CO_2 Emission through Different Types of Energy Sources

As can be seen from figure 3 electricity has maximum share of GHG emissions in C&I sector 93% and diesel has the least share at 5%.

Table 8 : CO_2 Emission from Different type of Energy Sources of C & I Sector

S.No	Category	Per Year CO_2 Emission '000 MT in C & I Sector through different type of fuel								
	CO_2 Emission through	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
1	Electricity	103.3	109.9	120.5	131.2	149.2	159.1	172.2	191.1	202.5
2	LPG	0.6	0.7	0.9	1.4	2.4	3.1	4.3	4.4	4.5
3	Diesel	5.5	5.7	6.1	6.5	7.4	7.8	8.8	10.0	11.0
	Total	109.4	116.3	127.5	139.1	159.1	169.9	185.4	205.4	218.0

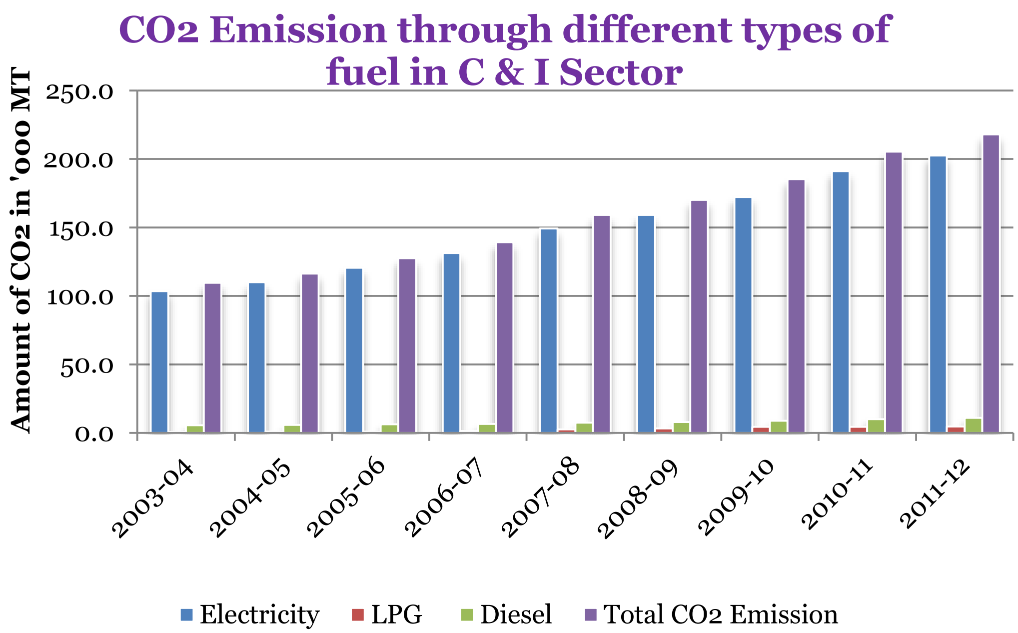


Figure 5: CO_2 emission throgh C & I Sector

2.6.3 Industrial Sector –CO_2 Emission through different types of energy sources

Table 9 : CO_2 Emission through Industrial Sector

Category	Per Year CO_2 Emission in '000 MT								
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Electricity	155.8	181.2	196.8	213.2	237.0	228.8	237.0	273.9	327.2
Petroleum Product									
Furnace Oil	35.2	36.1	37.4	38.2	39.7	40.6	41.6	42.7	43.8
Coal	3.5	3.7	4.4	4.7	5.4	5.8	6.2	6.6	7.3
Diesel	38.4	39.7	42.1	43.2	47.1	49.0	52.4	55.3	56.6
Total CO_2 Emission	**232.9**	**260.8**	**280.7**	**299.2**	**329.1**	**324.2**	**337.2**	**378.5**	**434.9**

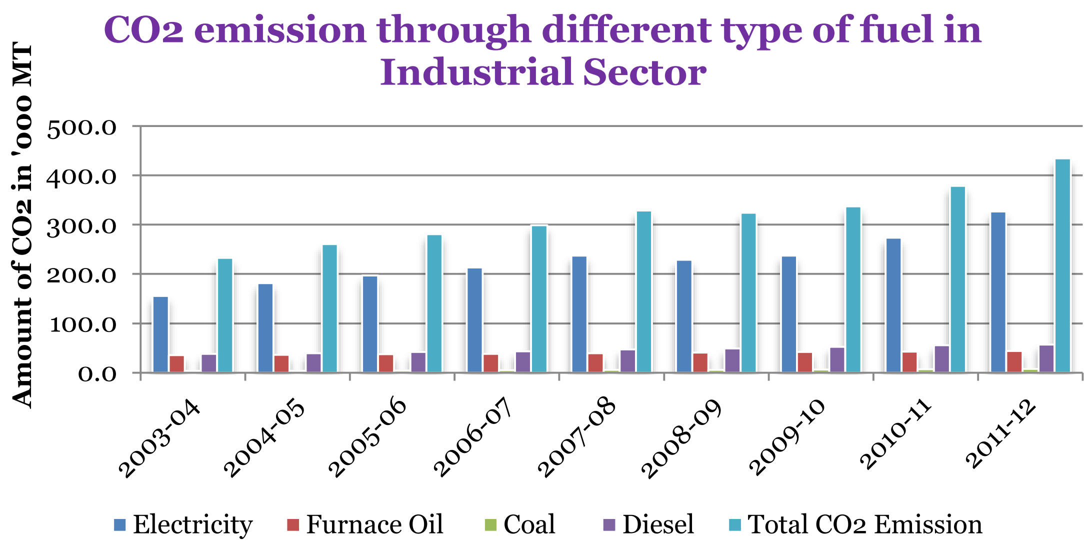


Figure 6: CO_2 emission through Industrial Sector

2.6.4 Municipal Sector –CO_2 Emission through of energy sources

Table 10: Electricity Consumption in Municipal Sector in Jodhpur City

Category	Per Year CO_2 Emission in MT								
CO_2 Emission through	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Electricity	31.2	35.3	32.8	32.8	40.2	58.2	78.7	80.4	87.7

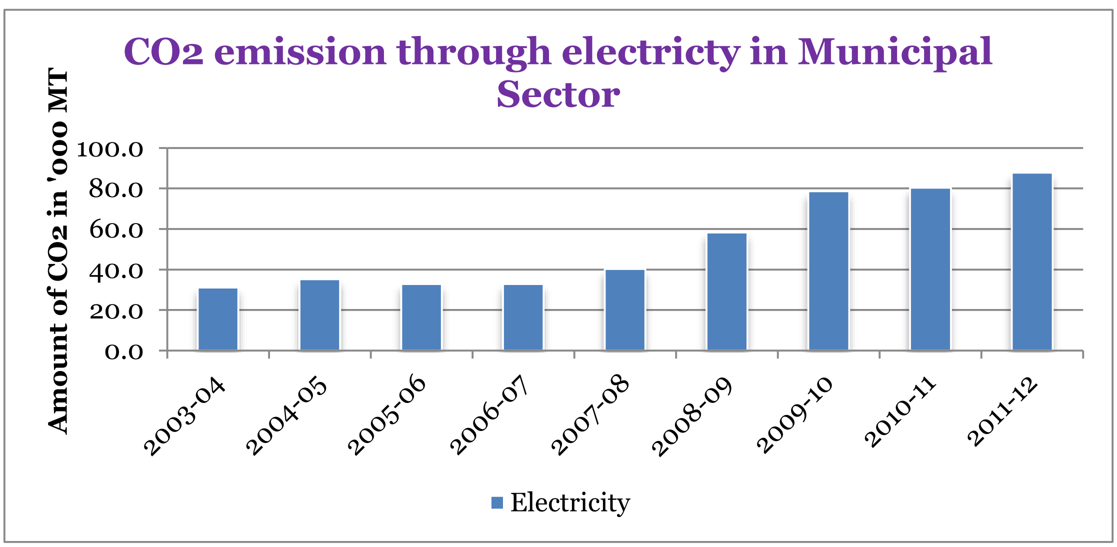


Figure 7: CO_2 emission throuh Municipal Sector

2.6.5 CO_2 Emission from All Sectors

CO_2 emission from all the sectors in energy base year 2011-12 and past year is shown below table

Table 11 : CO2 emission from all sector in Jodhpur sector

Category	CO2 Emission (‘000 MT) through different fuels in All Sector in Jodhpur City								
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Residential	235.8	254.3	267.4	286.6	310.2	310.3	338.5	367.2	392.2
C& I	109.4	116.3	127.5	139.1	159.1	169.9	185.4	205.4	218.0
Industrial	232.9	260.8	280.7	299.2	329.1	324.2	337.2	378.5	434.9
Municipal	31.2	35.3	32.8	32.8	40.2	58.2	78.7	80.4	87.7
Total	**609.2**	**666.6**	**708.4**	**757.7**	**838.6**	**862.6**	**939.8**	**1031.5**	**1132.9**

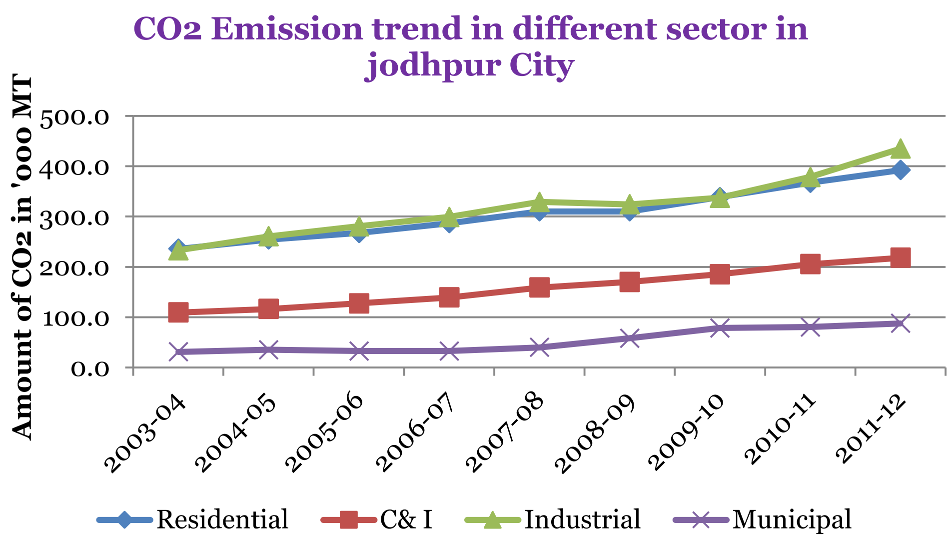


Figure 8 : CO_2 Emission trend in last some years

CHAPTER 3 ENERGY DEMAND FORECASTING

This chapter forecasts the future energy consumption of Jodhpur based on past data, baseline energy consumption and population growth. The figure 6 gives a clear view of the future conventional energy demands in the city, based on which the strategies have been developed and substantiated.

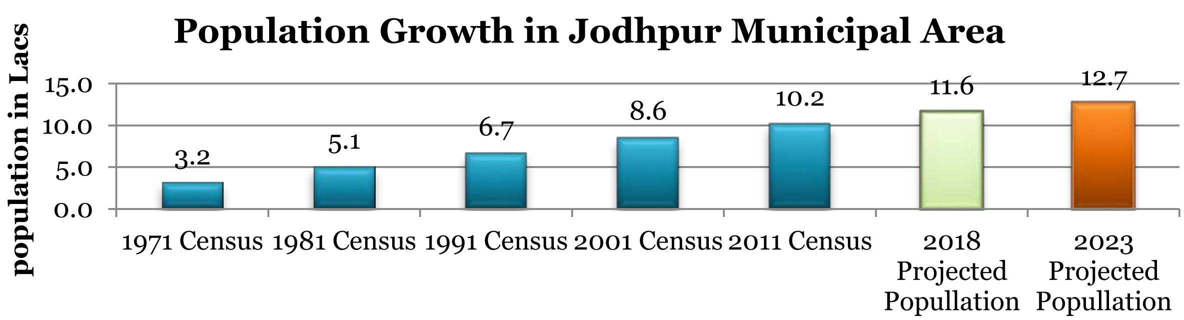


Figure 9: Jodhpur City Population Census Data and Projected Population for 2018 & 2023

Population of Jodhpur city was 10.2 lacs in the energy base line year, which eventually will be 11.6 lacs in 2017-18 and 12.7 lacs in 2022-23 year with the 10 % growth rate.

3.1 Forecasting for the year 2018/2023

The projections for fuel consumption have been done on the basis of past fuel consumption of the city. Table 9 summarizes projections for the year 2018 and 2023.

Table 12: Energy Demand Forecast for different fuels

Year	Energy Demands in GWh	
	2017-18	2022-23
Electricity	1714.4	2305.0
Petrol	477.4	590.0
LPG	587.1	870.2
Furnace oil	227.1	246.6
Diesel (Transportation)	422.3	581.2
Diesel	420.7	533.0
Kerosene	142.3	174.7
Coal	1.8	2.7

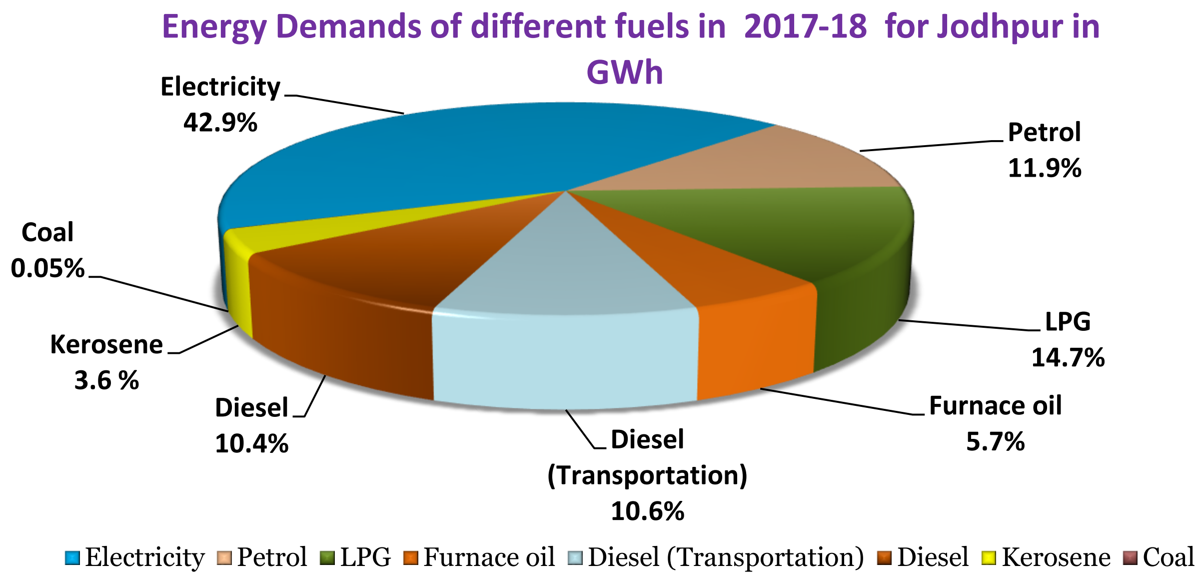


Figure 10: Energy Demand Foreecast percentage

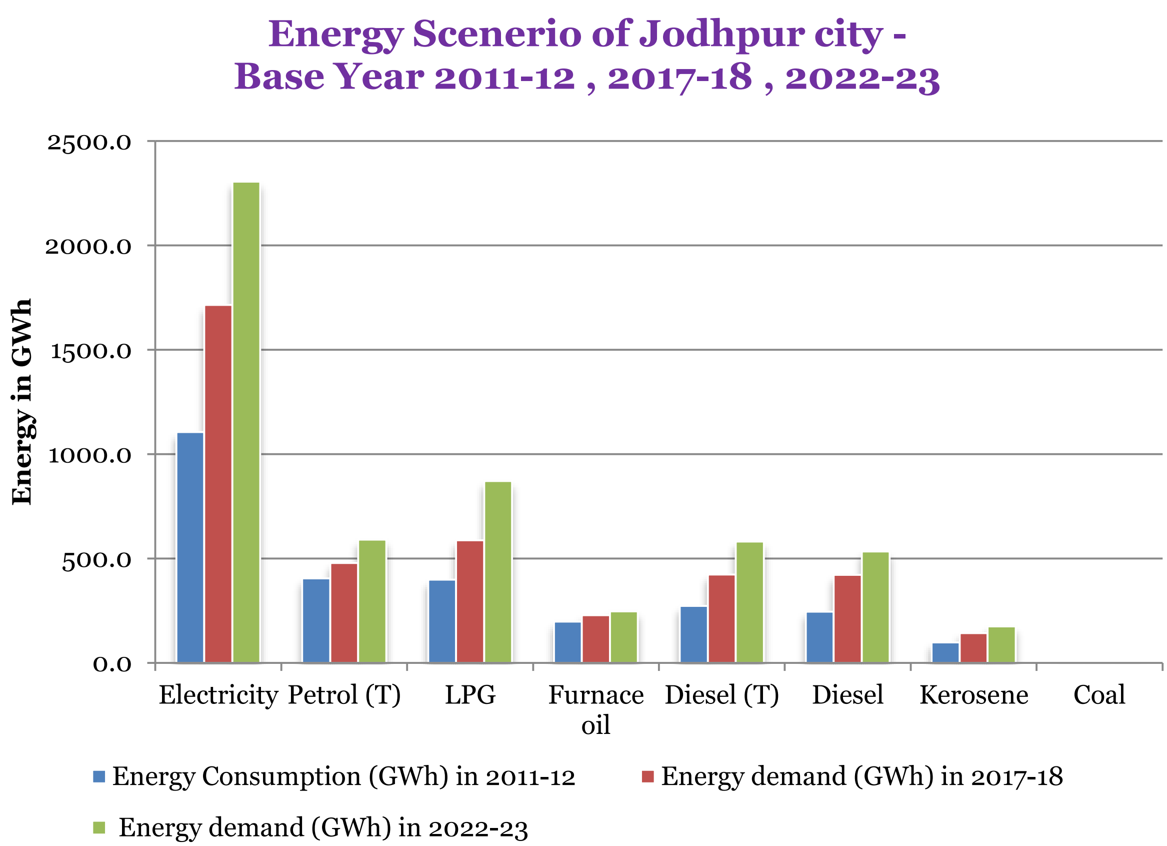


Figure 11: Energy consumption and demand scenerio graph in different years

3.2 Goal for the Year 2017-18

Since the transportation sector is not included in this study, petrol and diesel consumption data is not available separately for different sectors, the energy usage for Petrol and Diesel combined together is considered for defining the energy target. Based on this data, energy demand for the year 2017-18 and 2022-23 are 3995 GWh and 5303 GWh respectively. Targeted reduction in energy consumption (10% of the total based on past data projection) for the year 2017-18 would be 399.5 MU. for the first Five Year Plan.

Table 13: Energy Demand and Energy Demand Reduction Target for Jodhpur city

Energy Statics	2017-18	2022-23
Energy Demand Target in GWh	3995	5303
Target energy demand reduction in GWh @10 % of Total Energy demand	399.5	530.3
Target reduction @10 % of Total Energy demand (GWh) for 2017-18		**399.5 MU**
@ 5 % through Renewable Energy Installation		199.65 MU
@ 5 % through Energy Efficiency Installation		199.65 MU

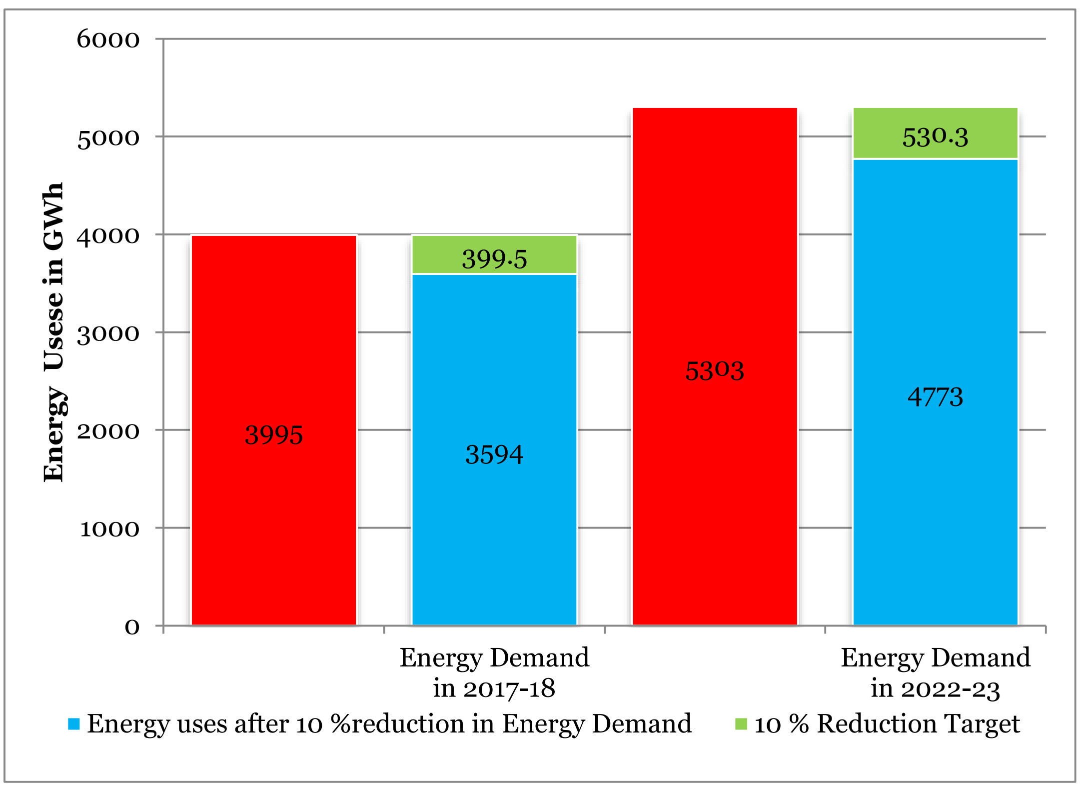


Figure 12: Energy Demand Target and 10 % Energy Reduction Target

CHAPTER 4 RENEWABLE ENERGY RESOURCE ASSESSMENT

The assessment of renewable energy sources has been done to identify its potential for Jodhpur city. Sources, which found to be a renewable energy potential, are solar radiation, wind power availability, biomass resources and energy recovery potential from municipal solid waste and sewage treatment plant.

The strategy has been prepared for each sector, identifying most techno-economically viable renewable energy potentials, to achieve reduction of energy consumption at least 5% from renewable energy on completion of the solar city project in the city.

4.1 Solar Radiation

The city's coordinates ranges from 26^0 11'49'' to 26^0 20'16'' Latitude North and from 72^0 56'42'' to 73^0 05'24'' Longitude East, which receives good amount of solar radiation as the average annual solar radiation is 5.6 kWh/M^2/Day for Jodhpur is presented in the table 12.

Table 14 : Solar Radiation Received at Jodhpur City

Data kWh/m2 /Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NASA Solar Radiance Data	4.4	5.23	6.11	6.74	7.15	6.68	5.74	5.21	5.81	5.5	4.61	4.1	**5.6**
MNRE Solar Radiance data	**4.35**	5.3	6.3	6.98	7.45	6.86	6.02	5.64	6.1	5.64	4.67	4.11	**5.78**

Country - region		India	
Province / State		Rajasthan	
Climate data location	*See map*	Jodhpur	
Latitude	°N	26.3	
Longitude	°E	73.0	**Source**
Elevation	m	224	Ground
Heating design temperature	°C	10.1	Ground
Cooling design temperature	°C	41.3	Ground
Earth temperature amplitude	°C	21.5	NASA

Month	**Air temperature**	**Relative humidity**	**Daily solar radiation - horizontal**	**Atmospheric pressure**	**Wind speed**	**Earth temperature**	**Heating degree-days 18 °C**	**Cooling degree-days 10 °C**
	°C	%	kWh/m²/d	in Hg (0°C)	km/h	°C	°C-d	°C-d
January	17.1	43.6%	4.40	29.0	4.7	17.8	28	220
February	20.4	38.3%	5.23	28.9	5.0	21.5	0	291
March	26.3	31.1%	6.11	28.8	4.7	28.9	0	505
April	31.7	26.3%	6.74	28.7	5.4	34.1	0	651
May	34.7	33.1%	7.15	28.6	8.3	35.3	0	766
June	34.1	47.4%	6.68	28.5	8.3	33.8	0	723
July	31.0	65.3%	5.72	28.5	6.8	31.4	0	651
August	29.6	69.5%	5.21	28.6	6.5	30.1	0	608
September	30.0	57.3%	5.81	28.7	5.4	30.4	0	600
October	28.2	40.1%	5.50	28.8	3.2	29.1	0	564
November	22.9	39.1%	4.61	28.9	2.9	23.9	0	387
December	18.4	42.9%	4.10	29.0	4.7	19.1	0	260
Annual	27.1	44.6%	5.60	28.7	5.5	28.0	28	6,227
Source	Ground	Ground	Ground	NASA	Ground	NASA	Ground	Ground
Measured at				m	10	0		

Figure 13 : Month Wise Details of Solar Radiation and Wind Intensity at Jodhpur City

4.2 Wind Energy

Wind energy has essentially good potential in Rajasthan state. 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 Jodhpur are 3.4-4.0m/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 Jodhpur, but wind power as an alternate has less opportunity in Jodhpur, as Air Force Base and wind installation cannot be installed within the 10 km radius of Air force Station. Detailed Study is required for the assessment of energy generation potential from wind resource.

Wind power generation project of Rajasthan are mentioned below :

Table 15 : Wind Energy power plant in Rajasthan

S. No.	District /Developer	Jaisalmer	Jodhpur	Sikar	Barmer	Chittorgarh	Total Capacity Commissioned
1	RREC	37.2	2.1			2.25	41.55
2	RSMML	19.8					19.8
3	Suzlon	1087.45	285.3		9.6		1382.35
4	Enercon	683.97	98.4	12			794.37
5	NEPC					0.675	0.675
6	RRB Energy	29.4					29.4
7	Veer	59.5					59.5
8	Regen					137.9	137.9
9	Inox	264					264
	Total	**2181.32**	**385.8**	**12**	**9.6**	**140.825**	**2729.545**

(Capacity of Power Plant inb MW)

4.3 Biomass Resource Potential

According to RRCEL report on " BIOMASS FUEL ASSESSMENT REPORT" biomass of different district of Rajasthan , average biomass generation of Jodhpur has 1195261 MT(2008-09) where as average consumption of generated biomass is 723965 MT. urplus available biomass for Jodhpur district is 471296 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 the Jodhpur city.

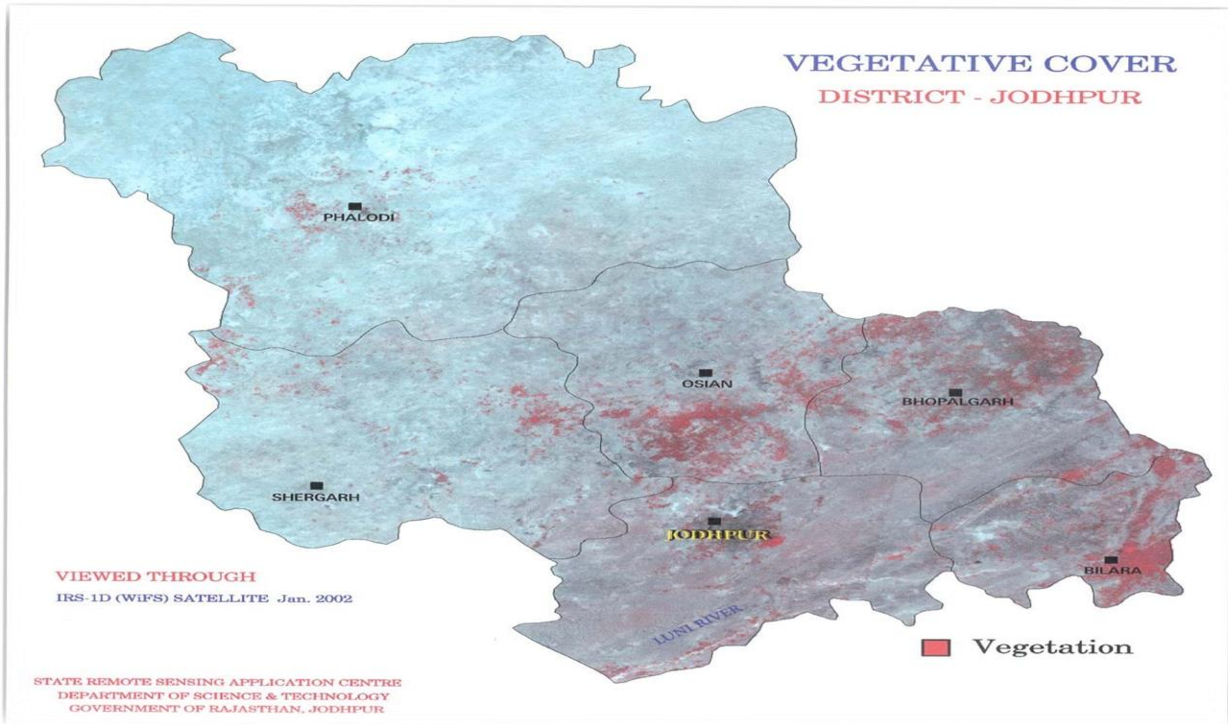


Figure 14 : Biomass Potential Graph of Jodhpur District

4.4 Waste Generation

Waste generation data for Jodhpur Municipal Corporation area for the last 5 years is presented in the table given below.

Table 16 : Municipal Solid Waste Generation Data

Year	Solid Waste Generation in MT
2007-2008	311
2008-2009	322
2009-2010	338
2010-2011	345
2011-2012	351

4.4.1 Waste to Energy Potential in Jodhpur

Studies are conducted by the Central Pollution Control Board, CPCB, Central Zonal Office, Bhopal on "*Status of Municipal Solid Waste Management in the Jodhpur City*". According to the report, 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. Earlier in the year 2008, M/s Kanak Resource Management, Jodhpur was given a tender for the door-to-door collection, but the group worked only for one year and discontinued due to some financial crisis. Street sweeping is thus the only method of primary collection of waste.

There has been a significant increase in the generation of municipal solid waste in Jodhpur over the last few years. The daily estimated generation of municipal solid waste in the city is about 325 to 375 MT/day, which is collected through street sweepings and from communal waste storage sites. The quantity of waste generally collected and transported to the waste processing site is only about 200 MT/Day, which is about 57% of the waste generated in the city. Remaining solid waste not being transported is the main concern of all the visible solid waste pollution in the city.

Municipal solid waste comprises of predominantly household or domestic waste in addition commercial wastes, which are in either solid or semisolid form.

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 17: Jodhpur Municipal Solid Waste Characterization

Waste Composition	Percentage Waste	Quantity
Biodegradable	44.6%	156.1
Recyclable	20.9%	73.15
Non biodegradable (Inert)	34.5%	120.75
Total Waste	100%	350
Per capita waste (Kg/capita/day)	332.3 gms/day/person	

Assessment of Energy Recovery Potential

A rough assessment of the potential of recovery of energy from MSW through different treatment methods can be made from knowledge of its calorific value and organic fraction as shown in Table 14. Since relevant details 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 18 : Waste to Energy Power Generation Potential through MSW in Jodhpur City

Particulars	Value

Total waste quantity :	200 tonnes
Net Calorific Value :	NCV k-cal/kg.
Energy recovery potential (kWh)	NCV x 200 x 1000/860 = 1.16 x NCV x 200
Power Generation Potential (kW)	1.16 x NCV x 200/ 24 = 0.048 x NCV x 200
Conversion Efficiency	40 %
Net Power Generation Potential (kW)	0.012 x NCV x 200
If NCV	700 kcal/kg., then
Net power generation potential (kW)	8.4 x 200= 1680 (kW) or 1.68 MW
Power Generation Annually	13.14 MU
GHG Emission Reduction Equivalent CO_2 MT / Year	21840 MT

4.4.2 Waste to Energy Potential through Thermo-Chemical Conversion

In thermo-chemical conversion, all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output. Total electrical energy generation potential is estimated to be 0.73MWe and savings per year with 70% PLF is estimated as 4.46 MU.

4.4.3 Liquid Waste to Energy Potential from Sewage Treatment Plant (STP)

Liquid Waste from Sewage Treatment Plant

Sewage generation of the city is 250 MLD per day, out of which Jodhpur Nagar Nigam is treating 80 MLD Sewage through its two treatment plants of 50 and 30 MLD capacity, respectively in Jhalawar and Nadri. The third plant, 50 MLD capacity sewage treatment plant is under construction. The total current capacity is 80 MLD, which will become 130 MLD per day once the third Sewerage treatment plant is functional.

Table 19 : Liquid Waste Generation data of Jodhpur City

STP	Capacity in MLD
SPT – I	50
STP – II	30
STP- III	50 (Under Process)
Total	**130**

Water Demand for Distribution Zones

There are 65 wards in the city. Ward wise population projections have been made and the water demand is worked out using 265 lpd for urban population and 110 lpd for supply through public stand posts for the years 2011 and 2034. Consideration has been given to non-domestic consumption type locations such as hotels, cinema halls, and bulk supplies. The losses incurred by water treatment plants, transmission, and distribution systems are added to attain gross demand at the source level. For each water distribution zone, the fraction of ward contributing to that zone is assessed based on zonal boundary and ward boundary. Water demands for each zone have been calculated depending upon the population of all fractional wards coming under a particular zone. The zonal demands are reduced by 2% and 3% to account for the transmission and treatment of losses respectively in a uniform manner.

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. Jodhpur has sewage treatment plants through which approximately 200 MLD of wastewater is being treated every day. Energy consumption in these sewage treatment plants is about 16MU per year (2007-08). The produce of waste water treatment can be used as a raw material for anaerobic distention and subsequent power generation. A very preliminary assessment shows that there is a potential of generating 3.14MW power, which could deliver 19.25MU of electrical energy per year with 70% PLF. A detailed study has to be made for Jodhpur to generate power from STPs.

Table 20 : Energy Generation Potential from 50 MLD Sewage Treatment plant

Sewage Treatment Plant 1		
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 CO_2 per year	68322	MT

Table 21 : Energy Generation Potential from 50 MLD Sewage Treatment plant

Sewage Treatment Plant 2		
Particulars	**Value**	**Unit**
Plant Capacity	50	MLD
Biogas yield	8000	m3
Electricity (kWh) potential	48000	kW
Capacity of the plant	2000	kW
Conversion Efficiency	33%	%

Total Electricity Generated Per Year	5.8	MU
Plant Load Factor	70%	%
Net electrical energy savings potential	4	MU
Emission reduction CO2 per year	68322	MT

Table 22 : Energy Generation Potential from 30 MLD Sewage Treatment plant

Sewage Treatment Plant 3		
Particulars	**Value**	**Units**
Plant Capacity	30	MLD
Biogas yield	4800	m3
Electricity (kWh) potential	28800	kW
Capacity of the plant	1200	kW
Conversion Efficiency	33%	%
Total Electricity Generated Per Year	3.5	MU
Plant Load Factor	70%	%
Net electrical energy savings potential	2.5	MU
Emission reduction CO2 per year	40993	MT

CHAPTER 5 RENEWABLE ENERGY STRATEGIES FOR JODHPUR

Renewable energy strategies are adopted to help in building a more sustainable community by investing in long-term strategies to conserve energy and increase energy from renewable resources. The city can help in encouraging the tourism and "green industry" job growth, preventing the rising cost of energy and help in protecting our nation from dependence on foreign oil. There are three components to the strategy- city operations, city codes and policies, and community involvement.

- **City Operations:** In this segment, the goal is to reduce the city's carbon footprint by 10 percent in 2017-18, and electricity use by 5 percent per unit by 2017-18 through energy efficiency.
- **City Codes, Regulations and Policies:** The aim is to adopt an energy code, that is 5 percent more efficient than the current code by 2011, 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 by 2012.

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 fun, but also a leader in caring for the environment. Also, investing in renewable energy and energy conservation in Jodhpur will help in diversifying the economy and creating opportunities for on-the-job training for skilled labor, and graduates of Jodhpur University

Investing in renewable energy and energy conservation will also protect the city from escalating electricity costs. Jodhpur, 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 makes jodhpur 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.

Renewable energy resource assessments and strategies are prepared for different types of renewable energy technologies in all sectors.

Sector Wise Strategies

This step involves carrying out techno-economic feasibility of different renewable energy options for each sector and making a priority list of renewable energy options.

Solar Energy

Solar energy can be used as solar thermal and solar photovoltaic, which are of two types:

Solar Thermal Systems

Solar thermal energy (STE) is an innovative technology for harnessing solar energy for thermal energy (heat). Solar thermal collectors are classified as low, medium, or high-temperature collectors. Low-temperature collectors are flat plates, generally used to heat swimming pools. Medium-temperature collectors are also flat plates but are used for heating water or air for residential and commercial use. High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for electric power production. STE is different from and much more efficient than photovoltaic. A list of different types of STE systems is listed below:

1. Solar water heating systems
2. Solar cookers (Box and dish type)
3. Solar steam generating systems
4. Solar drying/air heating systems
5. Solar refrigeration and air conditioning plants
6. Solar concentrators for process heat applications

Solar Photovoltaic Systems

Solar photovoltaic systems use solar panels to convert sunlight into electricity. A system is made up of one or more Photovoltaic (PV) panels, power converter, a racking that holds the solar panels and electric interconnections. A list of different types of solar photovoltaic systems is listed below:

1. Solar lanterns
2. Solar home lighting systems
3. Solar inverters
4. Street light solar control systems
5. Solar hoardings
6. Solar street light/garden lights
7. Solar traffic lights

8. Solar blinkers
9. Solar Road studs
10. Solar power packs
11. Building integrated photovoltaic
12. SPV power plants for decentralization applications
13. Roof top plants for replacing DG gensets

5.1 Renewable Energy Strategies for Residential Sector

Residential sector is the major energy consumer of the total energy consumption of the city. This sector consumes 32.3 % of electricity and 30.4 % of energy consumption of the total energy consumption of the city. The current population of the city is 10,34,524 with the current number of household residents 2,92,591 and the projected population for 2018 is 11,62,185. Current energy demand of electricity in residential sector is 352.3 MU per year in 2011-12, which will be 489.1 MU in 2017-18. Energy demand and green house gases emission (GHHs) can be reduced through different types of renewable energy techniques in residential sector. Following technologies are suggested, which are technologically proven and approved by the Ministry of New and Renewable Energy.

- Installation of Solar Lantern
- Installation of Solar Home lighting System
- Installation of Solar Water Heater Systems
- Installation of Solar Inverter
- Installation of Solar PV for Home Inverter
- Installation of Solar Cooker
- Installation of ROOF top Solar PV for replace home D.G. sets for power backup

5.1.1 Installation of Solar Water Heating System

Solar energy has a great potential to heat up the water. There is plentiful radiation is available throughout India to use solar energy to heat the water. Solar water heater is widely promote by ministry of new and renewable energy all over the India and make it a 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 600 units of electricity units yearly. Many states including Delhi, Haryana etc have taken initiatives and made use of solar water heating systems in residential sector.

In the sample survey, survey team found that residents of Jodhpur city use electricity for water heating. As Jodhpur is located in desert climatic zone, it requires water heating only for three four months in winters (from November to February). As the city developed under the solar city master plan, hence solar water heating systems should mandatory in residential sectors. It has been notice from energy use pattern in residential sector of Jodhpur city that the water heating application consumes approximately 10% of the total energy, which works out to be in 2011-12.

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 water heating in the city is through the electricity. Therefore, it is assumed that solar water heating technology will be adopted by residents in 2017 and 2018 (5 % as medium term targets) 10 % of in 2022, 2023 (20% as long-term targets).

Table 23: Techno-Economical Analysis of Solar Water Heater (100 LPD)

Particulars	Value	Units
Number of Houses in Jodhpur City in Residential Sector	292591	Nos.
Target to Replace SWH with Geyser	38994	Nos.
Cost of installation of SWH	18000	Lacs
State Share @ 20 %	3600	Lacs
MNRE Subsidy @ 30 %	3509	Lacs
Energy saving by replacing SWH with Geyser	29	MU
Cost of electricity savings	1170	Lacs
Payback period	3	years
GHG Emission reduction per year	23981	MT

5.1.2 Installation of Solar Lantern

Solar lantern can be using the substitute of kerosene lamp through which combustion GHG gases produce. Kerosene is source for lighting is poor family or BPL family. Through Solar lantern energy consumption can be reduce and reduce the direct emission of green house gases from burning of kerosene. Solar lantern is a portable device for lighting. It is available with a 10 W SPV (solar photovoltaic) module, 7W CFL, maintenance-free lead acid solar cooker solar lantern battery, and electronics. The lantern can provide light for a minimum of three hours daily and covers a range of 360°. Solar

Lanterns that follow MNRE specifications cost Rs 2500–3000. 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 has the average capacity of providing three to hours of continuous light from a single charge per day, and can work as source of light for poor families without electricity. Kerosene is the main source of burning light in poor families or BPL family. 30 % of population use kerosene lanterns during load shedding to illuminate their houses. Average consumption of kerosene per household is 30 litres per year. Assuming that each household uses 3-4 lanterns, consumption of one lantern will be about 9 litres per year. Targeting 5 % of population to replace at least one kerosene lantern with solar lantern who uses 487 Kilo litres of kerosene for lighting and cooking which emits 400 metric ton of GHG per year.

Table 24: Techno-Economical Analysis of Solar Lantern

Particulars	Value	Units
Number of Houses in Jodhpur City in Residential Sector	292591	Nos.
Target to install SL in Jodhpur city	16247	Nos.
Cost of installation of SHL	325	Lacs
MNRE Subsidy @ 30 %	97	Lacs
Kerosene saving by installing SHL	487	kL
Cost of kerosene savings	156	Lacs
Payback period	2.1	years
GHG Emission reduction per year	399	MT

5.1.3 Installation of Solar Home Light Systems

Solar home lighting systems are ideal sources for providing indoor illumination in remote areas and un-electrified villages. The Solar home lighting system essentially consists of the Solar module, suitable module mounting structure, battery, battery box, charge-controller, luminaries, inter-connecting cables and switches etc.A Solar Home System is a fixed indoor lighting system and consists of solar PV module, battery and balance of systems. Capacity of such system could be of 18Wp, 37Wp and 74Wp for different configuration. The luminaries used in the above systems comprise compact fluorescent lamp (CFL) of 7 W / 9 W / 11 W capacity respectively. The fan is of DC type with less than 20 W rating. One Battery of 12 V, 40 / 75 Ah capacity is also provided with SPV modules of 37Wp / 74Wp as required. The system will work for about 4 hours daily, if charged regularly. The Solar Home Lighting systems have been proposed to replace kerosene lamps used by28% population in Jodhpur Municipality area during load shedding hours. A 74Wp Solar Home System can replace 3-4 kerosene lamps with 4-5 hours backup hence replacing entire need of kerosene, which is estimated at an average of 30 litres per year per household. Assuming 10% replacement in the planned 5 years period an estimated amount of 1.94 million litres of kerosene could be saved reducing 1599 tonnes of GHG emission from the city.

Table 25 : Techno -Economical Analysis of Solar Home light

Particulars	Value	Units
Number of Houses in Jodhpur City in Residential Sector	292591	Nos.
Target to install SHL in Jodhpur city	32495	Nos.
Cost of installation of SHL	3249	Lacs
MNRE Subsidy @ 30 %	975	Lacs
Kerosene saving by installing SHL	1949.7	kL
Cost of kerosene savings	623.9	Lacs
Payback period	5.2	years
GHG Emission reduction per year	1.6	MT

5.1.4 Installation of 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 available, and have an advantage of being able to work in diffused light, but it is not so frequently used as it is very expensive. The vast majority of the solar cookers presently used are relatively cheap because they do not use fuel and cost nothing to operate; solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important

Solar cooker and dish type solar cooker can be promoted in the 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. On the other hand, dish type solar cooker can be used for indoor cooking. The stagnation temperature at the bottom of the cooking pot could be over 300^{o}C depending upon the weather conditions. Continuous use of a box type solar cooker may save 3-4 LPG cylinders per year. The use of solar cooker to its full capacity may result in savings up to 10 LPG cylinders per year at small establishments.

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 is available)

Scope

- Individuals, mid day meal schools, tribal areas, Aganwadis, Army Border Posts, etc. may use for saving LPG.

Cost & Fuel savings

- A dish solar cooker of smaller size can cook food for about 10-12 people and may cost around Rs. 6,000. It may be able to save around 8-10 LPG cylinders in a year on full use.
- Cookers may cost Rs. 30,000 appx. cooks food for about 40 people. It should be able to save around 30 LPG cylinder in a year on full use

- An indoor cooking system may use dish of 7 to 16 sq. m. area and could cook food for 50 to 100 people depending on size. It may cost Rs. 75,000 to 1.6 lakh depending on size and may be able to save 30 to 65 of LPG cylinders in a year.

Table 26 : Techno-Economical Analysis of Solar Cooker

:

Particulars	Value	Units
Number of Houses in Jodhpur City in Residential Sector	292591	Nos.
Total number of Potential house in for Solar cooker Jodhpur city	113732	Nos.
Target to install Solar cooker	11373	Nos.
Cost of installation of Solar Cooker	682.4	Lacs
State Subsidy	136.5	Lacs
MNRE Subsidy	238.8	Lacs
LPG saving by replacing Solar Cooker with LPG Lamp	5.7	kL
Cost of LPG savings	1.6	Lacs
GHG Reduction Per year	17	MT

5.1.3 Installation of Solar Inverters

Use of solar panels to charge home inverter system seems to be lucrative option during load shedding hours. The power supply situation in Jodhpur is very poor. About 5-6 hours load shedding occurs per day in most of the places. About 48% of residential consumers use inverters during load shedding hours. Assuming that 10% of HH who are already using inverters will adopt the 250 Wp solar PV systems to charge their inverter battery, an aggregate of 2.62MWp solar PV systems could be installed in the residential buildings, which will generate 3.92 MU green energy per year and reduce the load demand and emission by 3178 tonnes per year. The potential of energy savings, green house gas emission reduction and budgetary financial implication is indicated in the table below.

Table 27: Techno-Economical Analysis of Solar Inverter

Particulars	Value	Units
Number of Houses in Jodhpur City in Residential Sector	292591	Nos.
Total number of Solar panel needed	52804	Nos.
Indicative cost of installation	5808	Lacs
State Subsidy	1162	Lacs
MNRE Subsidy	3485	Lacs
Energy saving by Installing Solar PV	48	MU
Amount of electricity savings per year	2407.9	Lacs
Payback period	2.41	years

GHG Emission reduction per year	39511	MT

5.1.4 Installation of Roof Top Solar Power Plant for replacement of Diesel Generator sets

Due to poor power supply situation, about 20% of resident of Jodhpur city uses typically 5-10 kW diesel generator sets during the load shedding hours. Solar PV power packs can be used to replace those polluting generator sets with high operating cost. A 1000 Wp solar PV power pack has been considered for an average household in Jodhpur. For 5-year framework, 10 % households have been taken into consideration for replacement of DG /kerosene sets with solar PV systems with a target to save 10428 kilo Liters of diesel per year to reduce GHG in the tune of 26071 tons per year.

Table 28 : Installation of Roof top Solar PV in Residential Sector

Particulars	Value	Units
Number of Houses in Jodhpur City in Residential Sector	292591	Nos.
Target to Install Solar Power Plant	35744	Nos.
Diesel Generator Generally used	2- 5 kW	kW
Diesel Consumption per year	104373	kL
Indicative cost of installation SPP	32170	Lacs
State Subsidy	6434	Lacs
MNRE Subsidy	9651	Lacs
Payback period	4.93	years
GHG Emission reduction per year	53491	MT

5.1.5 Renewable Energy Systems for Residential Apartments

Jodhpur has more than 30 residential apartment societies in the city with average 50 number of apartments in each complex. Solar water heaters and solar PV power plants are considered to be most viable renewable energy devices for the existing as well as new residential complexes.

Summary of Energy Savings through Renewable Energy Installation in Residential Sector

Table 29 : Year Wise Energy Saving Target through RE System for Residential Sector

Particulars	Energy savings in MU				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
SL	0.6	1.5	2.7	4.2	5.9
SHL	2.4	6.1	11.0	17.1	24.4
SWH	2.9	7.3	13.2	20.5	29.2
Solar Cooker	0.9	2.3	4.2	6.5	9.3

Solar Inverter	4.8	12.0	21.7	33.7	48.2
Solar Power Plant	6.5	16.3	29.4	45.7	65.2
Total Energy savings	**18.2**	**45.5**	**82.0**	**127.5**	**182.2**

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

Table 30 : RE System Installation & Budget for Residential Sector

Budget Estimation for Residential Sector						
System	**Total Installation**	**Per Item Cost `**	**Total Cost (Lacs`)**	**State Share @ 20 % in Lacs**	**MNRE Share @ 30 % in Lacs**	**User share @ 50 %in Lacs**
SL	16247	2000	325	65	97	227 @ 70%
SHL	32495	10000	3249	650	975	1625
SWH (100 LPD)	64990	18000	11698	2340	3509	5849
Solar Cooker	11373	6000	682	136	205	341
Solar Inverter	52804	22000	11617	2323	3485	5808
Solar Power Plant	7799	90000	7019	1404	2106	3509

(Budget in `)

Summary of Year Wise Budget Sharing for Renewable Energy System Installation

Table 31 : Year Wise Investment for RE System installation for Residential Sector

Type of System	Total Installation	Item Cost in `	Year wise Investment in Lacs `				
			1st Year	2nd Yeart	3rd Year	4th Year	5th Year
SL	16247	2000	32	49	65	81	97
SHL	32495	10000	975	487	650	812	975
SWH (100 LPD)	64990	12600	819	1228	1638	2047	2457
Solar Cooker	11373	3900	44	67	89	111	133
Solar Inverter	52804	15400	813	1220	1626	2033	2440
SPP	7799	119000	928	1392	1856	2320	2784

5.2 Renewable Energy strategies for Commercial & Institutional Sector

The commercial and institutional sector is also a large energy-consuming sector in Jodhpur. The sector consumes about 22% 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 has been found that not much attention has been paid towards the energy efficiency in this sector. There exist a significant potential to improve 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 Jodhpur is moiré than 600 which was 496 in 2001. List of various building in Commercial and Institutional Sector below

Table 32 : Commercial Building details in Jodhpur City

Commercial and Institutional Building details			
Hotel /Lodge / restaurant	168	Schools	273
Cinema	8	Hospitals	19
Marriage Garden	130	Health Centers	29
Water park	2	Mobile Dispensaries	8
Bank	46	Medical College	1
Private Hospital	57	Aanganwadi	516
Park	8	Gardens:	88
Temple	21	Swimming pools	10
Govt School	8	Community halls	10
Central govt. College	4	Library	2
State govt Building	9	Reading Rooms	38
RSEB	19	Fire Stations	12
BSNL	10	FCI	1
JVVNL	38	Fruit Mandi	247
Police Department	4	Krishi Upaj Mandi	217

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

- Installation of Solar Water Heater
- Installation of Solar Inverters
- Installation of Solar Community Cooker
- Installation of Roof top Solar PV for replace home D.G. sets for power backup

5.2.1 Installation of Solar Water Heater

Jodhpur is the most famous tourist destination of India. There are very few cities in the world that can match the history and heritage of Jodhpur. Thousands of domestic and foreign tourists visit Jodhpur every day. The city has five star, three star category hotels and many budget hotels , hospitals , hostels and other commercial accommodations facilities. Three case studies are made to assess renewable energy and energy conservation measures in each of these categories. 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 through air-heating

Table 33 : Techno-Economical Analysis of Solar water heater 500 LPD

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of SWH 500 LPD needed in Jodhpur city	1053	Nos.
Cost of installation of SWH	895.1	Lacs
State Subsidy	179.0	Lacs
MNRE Subsidy	268.5	Lacs
Energy saving by replacing SWH with Geyser	7.1	MU
Cost of electricity savings	35.5	Lacs
Payback period	1.26	years
GHG Emission reduction per year	5828.4	MT

5.2.2 Installation of Solar water heater 1000 LPD

Table 34 : Techno-Economical Analysis of Solar water heater 1000 LPD installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of SWH 500 LPD needed in Jodhpur city	150	Nos.
Cost of installation of SWH	255.0	Lacs
State Subsidy	51.0	Lacs
MNRE Subsidy	76.5	Lacs
Energy saving by replacing SWH with Geyser	1.8	MU
Cost of electricity savings	9.1	Lacs
Payback period	1.40	years
GHG Emission reduction per year	1494	MT

5.2.3 Installation of Solar water heater 3000 LPD

Table 35 : Techno-Economical Analysis of SWH 3000 LPD installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of SWH 500 LPD needed in Jodhpur city	250	Nos.
Cost of installation of SWH	840.0	Lacs
State Subsidy	240.0	Lacs
MNRE Subsidy	360.0	Lacs

Energy saving by replacing SWH with Geyser	8.1	MU
Cost of electricity savings	32.4	Lacs
Payback period	6.91	Years

5.2.4 Installation of 5000 LPD Solar water heater

Table 36 : Techno-Economical Analysis of 5000 LPD SWH installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of SWH 5000 lpd needed	203	Nos.
Cost of installation of SWH	852.6	Lacs
State Subsidy	170.5	Lacs
MNRE Subsidy	365.4	Lacs
Energy saving by replacing SWH with Gyser	1.4	MU
Cost of electricity savings	219.2	Lacs
Payback period	8.64	years
GHG Emission reduction per year	4494.4	MT

5.2.5 Installation of Solar Inverter

The commercial inverter system could be charged with solar panels for uninterrupted power supply. About 85 % of commercial & institutional consumers use inverters during power failure. It is assumed that MNRE will provide 30% subsidy for these system. The potential of energy savings, green house gas emission reduction and budgetary financial implication is indicated in the table below.

Table 37 : Techno-Economical Analysis of Solar inverters installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of Solar Inverters installation	4009	Nos.
Indicative cost of installation	881.9	Lacs
State Subsidy	176.4	Lacs
MNRE Subsidy	264.6	Lacs
Energy saving by Installing Solar PV	3.7	MU
Amount of electricity savings per year	182.8	Lacs
Payback period	4.82	years
GHG Emission reduction per year	2997.8	MT

5.2.6 Installation of 1 kW Solar Power Plant

Table 38 Techno-Economical Analysis of 1 kW Solar Power Plant Installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Target to install of 1 KW Solar power Plant	5011	Nos.

Indicative cost of installation	4509.7	Lacs
State Subsidy	901.9	Lacs
MNRE Subsidy	1352.9	Lacs
Payback period	6.00	years
GHG Emission reduction per year	6163.2	MT

5.2.7 Installation of 3 kW Solar Power Plant

Table 39 : Techno-Economical Analysis of 3kW Solar Power Plant installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of Inverters	1403	Nos.
Indicative cost of installation	3788	Lacs
State Subsidy	758	Lacs
MNRE Subsidy	1136	Lacs
Payback period	4.9	years
GHG Emission reduction per year	6299	MT

5.2.8 Installation of 5 kW Solar Power Plant

Table 40 : Techno-Economical Analysis of 5 kW Solar Power Plant installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Target to install of 1 KW Solar power Plant	1203	Nos.
Indicative cost of installation	5412	Lacs
State Subsidy	1082	Lacs
MNRE Subsidy	1623	Lacs
Payback period	4.9	years
GHG Emission reduction per year	8998	MT

5.2.9 Installation of 48 Watt Solar Street Light

Table 41: Techno-Economical Analysis of 48 W SSL installation in C& I Sector

Particulars	Value	Units
Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of 60 watt Solar street light install	2000	Nos.
Cost of installation of 60 watt LED Light	320.0	Lacs
MNRE Subsidy	96.0	Lacs
Energy saving through 48 watt SSL	1	MU
Cost of electricity savings	52	Lacs
Payback period	5.53	years
GHG Emission reduction per year	856.0	M. T.

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

Table 42 : Year Wise Energy Saving Target through RE System for Commercial & Institutional

RE System Installation for C& I Sector	Energy savings in MU				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
SWH 5000 LPD	0.5	1.4	2.6	4.1	5.7
SWH 3000 LPD	0.4	1.0	1.8	2.8	4.1
SWH 1000 LPD	0.2	0.5	0.8	1.3	1.8
SWH 500 LPD	0.7	1.8	3.2	5.0	7.1
Community Solar Cooker	0.4	1.0	1.8	2.8	4.0
Solar Inverter	0.4	0.9	1.6	2.6	3.7
SPP 5 KW	1.1	2.7	4.9	7.7	11.0
SPP 3 KW	0.8	1.9	3.5	5.4	7.7
SPP 1 kW	0.8	1.9	3.4	5.3	7.5
Solar Street Light 48 W LED	0.1	0.3	0.5	0.7	1.0
Total	**5.3**	**13.3**	**24.1**	**37.6**	**53.6**

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

Table 43: RE System Installation & Budget for Commercial & Institutional Sector

Renewable Energy System Installation for Jodhpur City					
System	Total Installation	Item Cost `	Budget in Lac `		
			MNRE Subsidy	State Subsidy	User Share
SWH (500 LPD)	1053	85000	269	179	448
SWH (1000 LPD)	150	170000	77	51	128
SWH (3000 LPD)	250	480000	360	240	600
SWH (5000 LPD)	203	600000	365	244	609
Solar Community Cooker	496	45000	67	45	156
Solar Inverter	4009	22000	265	176	441
Solar Power Plant 1kW	5011	90000	1353	902	2255
Solar Power Plant 3 kW	1403	270000	1136	758	1894
Solar Power Plant 5 kW	1203	450000	1623	1082	2706
Solar Street Light 48 W LED	2000	16000	96	64	160

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

Table 44: Year Wise Investment for RE System installation for Commercial & Institutional Sector

Type of System	Total Number	Item cost `	Budget in Lac `				
			1st Year	2nd Year	3rd Year	4th Year	5th Year
Solar Water Heater (500 LPD)	1053	85000	90	134	179	224	269

Solar Water Heater (1000 LPD)	150	170000	26	38	51	64	77
Solar Water Heater (3000 LPD)	250	480000	120	180	240	300	360
Solar Water Heater (5000 LPD)	203	600000	122	183	244	305	365
Solar Community Cooker	496	45000	22	33	45	56	67
Solar Inverter	4009	22000	88	132	176	220	265
Solar Power Plant 1kW	5011	90000	451	676	902	1127	1353
Solar Power Plant 3 kW	1403	270000	379	568	758	947	1136
Solar Power Plant 5 kW	1203	450000	541	812	1082	1353	1623
Solar Street Light 48 W LED	2000	16000	32	48	64	80	96

5.3 Renewable Energy Strategies for Industrial Sector

Jodhpur industrial sector is a large energy-consuming sector. In Jodhpur, there are more than 4500 different types of industries registered in District industry center (Zila Udhayog Kendra .Jodhpur) .Five main industrial clusters, namely textile, handicraft, Guar Gum, stainless steel utensils and stone processing. Details of these clusters are as follows:

Table 45 : Types of Industrial Units in Jodhpur

S.No.	Name of Cluster	No. of Units
1	Textile	150
2	Handicraft	1000
3	Guar Gum	60
4	Stainless Steel Patta Patti / Utensils	150
5	Stone Processing	116

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

- Installation of Solar Water Heater
- Installation of Solar Light
- Installation of Solar Cooker
- Installation of RoofTop Solar PV for replace home D.G. sets for power backup
- Installation of Solar Dryers

5.3.1 Installation of 1 kW Roof Top Solar Power Plant

Table 46 : Techno-Economical Analysis of 1 kW SPP installation in Industrial Sector

Particulars	Value	Units
Total Industry in Jodhpur	4597	Nos.
Target to install of 1 KW Solar power Plant	919	Nos.
Indicative cost of installation	827.5	Lacs
State Subsidy	165.5	Lacs
MNRE Subsidy	248.2	Lacs
Electricity Saving per year	1.7	MU
Payback period	9.86	years

GHG Emission reduction per year	1375.9	MT

5.3.2 Installation of 3 kW Roof Top Solar Power Plant

Table 47 : Techno-Economical Analysis of 3 kW SPP installation in Industrial Sector

Particulars	Value	Units
Total Industry in Jodhpur	4597	Nos.
Target to install of 3 KW Solar power plant	460	Nos.
Indicative cost of installation	1241	Lacs
State Subsidy	248	Lacs
MNRE Subsidy	372	Lacs
Electricity generation per Year	2.5	MU
Payback period	4.9	years
GHG Emission reduction per year	2064	MT

5.3.3 Installation of 5 kW Roof Top Solar Power Plant

Table 48 : Techno-Economical Analysis of 5 kW SPP Installation in Industrial Sector

Particulars	Value	Units
Total Industry in Jodhpur	4597	Nos.
Target to install of 5KW Solar power plant	690	Nos.
Indicative cost of installation	3103	Lacs
State Subsidy	621	Lacs
MNRE Subsidy	931	Lacs
Electricity Saving Per Year	6.3	MU
Payback period	4.9	years
GHG Emission reduction per year	5160	MT

5.3.4 Installation of 60 watt Solar Light

Table 49 : Techno-Economical Analysis of 60 watt SSL Installation in Industrial Sector

Particulars	Value	Units
Number of Industry in Jodhpur	4597	Nos.
Target to install 60 watt led Solar street light	7355	Nos.
Cost of installation of 60 watt LED Light	1471	Lacs
MNRE Subsidy	441	Lacs
Energy saving through 60 watt LED Solar Street light	5.3	MU
Cost of electricity savings	266	Lacs
Payback period	6.92	years
GHG Emission reduction per year	4358.8	MT

5.3.5 Installation of 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 through 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 50 : 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 (@ ` 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

5.3.6 Installation of Solar water heater 1000 LPD capacity

Table 51 : Techno-Economical Analysis of 1000 LPD SWH Installation in Industrial Sector

Particulars	Value	Units
Number of Industry in Jodhpur City	4597	Nos.
Target to install of 1000 LPD SWH	92	Nos.

Cost of installation of SWH	109.4	Lacs
State Subsidy	32.8	Lacs
MNRE Subsidy	21.9	Lacs
Energy saving through 1000 LPD SWH	1.1	MU
Cost of electricity savings	4.5	Lacs
Payback period	2.45	years
GHG Emission reduction per year	916.0	MT

5.3.7 Installation of Solar water heater 3000 LPD Capacity

Table 52 : Techno-Economical Analysis of 3000 LPD SWH installation in Industrial Sector

Particulars	Value	Units
Number of Industry in Jodhpur	4597	Nos.
Target to Install 3000 LPD SWH in Jodhpur	157	Nos.
Cost of installation of SWH	753.6	Lacs
State Subsidy	150.7	Lacs
MNRE Subsidy	226.1	Lacs
Energy saving through 3000 LPD SWH	6	MU
Cost of electricity savings	218.7	Lacs
Payback period	2.63	years
GHG Emission reduction per year	4483.4	MT

5.3.8 Installation of Solar water heater 5000 LPD Capacity

Table 53 : Techno-Economical Analysis of 5000 LPD SWH installation in Industrial Sector

Particulars	Value	Units
Number of Industry in Jodhpur City	4597	Nos.
Target to Install 5000 LPD SWH in Jodhpur	145	Nos.
Cost of installation of SWH	900.0	Lacs
State Subsidy	180.0	Lacs
MNRE Subsidy	270.0	Lacs
Energy saving through5000 LPD SWH	9	MU
Cost of electricity savings	36.5	Lacs
Payback period	5.93	years
GHG Emission reduction per year	7472.3	MT

Other Solar Installation in Industrial Sector

Installation of 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

Types

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 through a fine mesh to trap any dust, dirt or foreign particles entering the drying process. This air then passes through 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 through 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 through suitable media.

Installation of Solar Furnace

A solar furnace is a structure that uses concentrated solar power to produce high temperatures, usually for industry. Parabolic mirrors or heliostats concentrates light (Insulation) on a focal point. The temperature at the focal point may reach 3,500 °C (6,330 °F), and this heat can be used to generate electricity, melt steel, and make hydrogen fuel.

Summary of Energy Savings through Renewable Energy Installation in Industrial Sector

Table 54 : Energy Saving target through RE system installation in Industrial sector

RE System	Energy Savings in MU				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
SWH 5000 LPD	0.9	2.2	4.1	6.5	9.2
SWH 3000 LPD	0.6	1.4	2.7	4.2	6.0
SWH 1000 LPD	0.1	0.3	0.5	0.8	1.1
Solar Power Plant 5	0.6	1.6	2.8	4.4	6.3
Solar Power Plant 3	0.3	0.6	1.1	1.8	2.5
Solar Power Plant 1	0.2	0.4	0.8	1.2	1.7
Solar Inverter	0.5	1.3	2.4	3.7	5.3

60 watt SSL	3.1	7.9	14.4	22.6	32.0
Total	**858**	**1288**	**1749**	**2178**	**2327**

Summary of Budget through Renewable Energy Installation in Industrial Sector

Table 55 : RE System Installation & Budget For Industrial Sector

Renewable Energy System Installation for Jodhpur					
System	**Total Installation**	**Per Item Cost `**	**MNRE Subsidy (Lacs `)**	**State Subsidy (Lacs `)**	**Public Share (Lacs `)**
SWH (1000 LPD)	92	170000	47	31	78
SWH (3000 LPD)	157	480000	226	151	377
SWH (5000 LPD)	145	600000	261	174	435
Solar Inverter	731	22000	48	32	80
Solar Power Plant 1kW	919	90000	248	165	414
Solar Power Plant 3 kW	460	270000	372	248	621
Solar Power Plant 5 kW	690	450000	931	621	1551
SSL 60W LED	7355	16000	353	235	588

Table 56 : Year Wise Investment for RE System installation for Industrial Sector

Budget Estimate in Lacs `					
Particulars	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**
SWH 5000 LPD	63	95	139	170	189
SWH 3000 LPD	50	76	111	136	151
SWH 1000 LPD	16	23	31	39	47
5 kW Solar Power Plant	310	465	621	776	931
3 kW Solar Power Plant	124	186	248	310	372
1 kW Solar Power Plant	62	93	124	155	186
Solar Inverter	16	24	32	40	48
48 watt Led	40	60	80	100	120
Total	**682**	**1022**	**1386**	**1727**	**2045**

5.4 Renewable Energy strategies for Municipal Sector

The municipal sector of the city consumes 10 % of total electrical energy in the city. The primary consumption in this sector is through 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 through 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 Jodhpur city
- Renewable Energy Strategies for Parks under Jodhpur Municipal Corporation

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

The Jodhpur Municipal Corporation has about nearly 66000 outdoor lights with different wattage, which has been fixed for illumination streets, wards, monuments, etc. The objective is to introduce one solar PV outdoor light in every three conventional lights so that minimum illumination level is maintained during power outage. The table below indicate targets, investment and energy savings potential.

Table 57 : No of Street Light Installed in Jodhpur city

Item	Per unit Load in watt	Total Light
Tube Light	40	21629
SV 70/150/250 Watt	150	22756
MH Light	250	15399
Decorative Light	70	2216

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 throughout 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
- No wiring
- 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

5.4.1 Installation of Solar Street Light 112 Watt LED

Table 58 : Techno-Economical Analysis 112 watt SSL installation in Municipal Sector

250 Watt Metal halide MH replace with 112 watt SSL in Jodhpur		
Particulars	**Value**	**Units**
Total number of Metal halide MH Light in Jodhpur city	15399	Nos.
Total number of 112 watt LED Light	4620	Nos.
Cost of installation of 112 watt LED Light	1340	Lacs
State Subsidy	268	Lacs
MNRE Subsidy	388.1	Lacs
Energy saving by replacing Incandescent Light Bulb Solar Street Light 112 watt LED Light	4	MU
Cost of electricity savings	148	Lacs
Payback period	5.31	years
GHG Emission reduction per year	3041.9	MT

5.4.2 Installation of Solar Street Light 60 Watt LED

Table 59 : Techno-Economical Analysis 60 Watt SSL installation in Municipal Sector

150 Watt Sodium vapor HVPS replace with 60 watt SSLin Jodhpur		
Particulars	**Value**	**Units**
Total number of Sodium vapor HVPS Light in Jodhpur city	22756	Nos.
Total number of 60 watt SSL	6827	Nos.
Cost of installation of 60 watt LED Light	1365	Lacs
MNRE Subsidy	409	Lacs
Energy saving by replacing Incandescent Light Bulb with 60watt SSL	4.9	MU
Cost of electricity savings	197	Lacs
Payback period	5.53	years
GHG Emission reduction per year	4045.7	MT

5.4.3 Installation of Decorative Solar Street Light 28 watt LED

Table 60 : Economical Analysis 28 watt SSL installation in Municipal Sector

Particulars	Value	Units
Number of Tube Light in Jodhpur City in Municipal Sector	2216	Nos.
Total number of 28 watt SSL instalation	1108	Nos.
Cost of installation of Solar Street Light 28 watt LED Light	110	Lacs
MNRE Subsidy	33	Lacs
Energy saving by replacing 40 watt T12 Tube Light with 28 watt SSL	0.31	MU
Cost of electricity savings	12.5	Lacs
Payback period	6.32	years
GHG Emission reduction per year	255.4	MT

5.4.4 Installation of Solar Street Light 18 watt LED

Table 61 : Techno Economical Analysis 18 watt SSL installation in Municipal Sector

Particulars	Value	Units
Number of Tube Light in Jodhpur City in Municipal Sector	21629	Nos.
Total number of 40 watt Tube lights in Jodhpur city	10814	Nos.
Cost of installation of Solar Street Light 18 watt Light	865.1	Lacs
MNRE Subsidy	259.5	Lacs
Energy saving by replacing 40 watt T12 Tube Light with 18 watt Solar Street Light	2.34	MU
Cost of electricity savings	117.2	Lacs
Payback period	7.38	Years
GHG Emission reduction per year	1922.6	MT

5.4.5 Installation of 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.

Table 62 : Economical Analysis Solar Traffic Light installation in Municipal Sector

Particulars	Value	Units
Target to Replace Traffic Light Signal with Solar Traffic Light Signal	50	Nos.
Cost of installation of Solar Street Light 18 watt LED Light	7.0	Lacs
MNRE Subsidy	6.0	Lacs
Energy saving by replacing Traffic Light Signal with Solar Traffic Light Signal	0.040	MU
Cost of electricity savings	1.8	Lacs
Payback period	4.00	Years
GHG Emission reduction per year	35.9	MT

Installation of 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.

Renewable Energy System for Advertisement hoardings

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. Financial implication and energy savings potential is indicated for replacement of 220 hoardings during 5 years of solar city implementation period.

Renewable Energy Systems for Parks

Jodhpur City has responsibility of lighting of 'Municipal Corporation Parks', where electrical energy is consumed for outdoor lighting and water pumping for sprinkling and irrigation. Solar PV outdoor lights and solar pumps are recommended for these parks.

Renewable Energy Systems for Parks

Category	No. of units	Unit load (W)	Total Load (kW)	Hours of operation	Energy Demand per day (kWh)
Water Pump	1	1000	1.00	10	10
Providing	1	1	kWp	1.75	

Summary of Energy Savings through Renewable Energy Installation in Municipal Sector

Table 63 : Year Wise Energy Saving Target through RE System for Municipal Sector

Particulars	Energy savings in MU				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
18 watt SSL	0.2	0.6	1.1	1.6	2.3
28 watt SSL	0.0	0.1	0.2	0.2	0.4
60 watt SSL	0.5	1.2	2.2	3.5	4.9
112 watt SSL	0.6	1.4	2.5	3.9	5.6
Traffic Light	0.1	0.2	0.4	0.6	0.9
Waste To Energy	10.5	10.5	10.5	10.5	10.5
Total Energy savings	1.4	3.5	6.4	9.9	14.1

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

Table 64 : RE System Installation & Budget for Municipal Sector

System	Total Installation	Per Item Cost `	Total Cost (Lacs `)	MNRE Share (Lacs`)	User share (Lacs `)
SSL 18 watt LED	10814	8000	865	260	606
SSL 28 watt LED	1108	10000	111	33	78
SSL 60 watt LED	6827	20000	1365	410	956
SSL 112 watt LED	4620	32000	1478	443	1035
Solar traffic light	50	14000	7	2	5
Solar hoardings	220	6000	13	4	9
Solar road studs	10000	250	25	8	18

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

Table 65 : Year Wise Investment for RE System Installation for Municipal Sector

Type of System	Total Number	Per item cost `	Investment in Lacs `				
			1st Year	2nd Year	3rd Year	4th Year	5th Year
18 watt SSL	10814	8000	87	130	173	216	260
28 watt SSL	1108	10000	11	17	22	28	33
60 watt SSL	6827	20000	137	205	273	341	410

112 watt SSL	4620	32000	148	222	296	370	443
Solar traffic light	50	14000	0.7	1.1	1.4	1.8	2.1
Solar Hoardings	220	10000	2.2	3.3	4.4	5.5	6.6
Solar Road Studs	10000	250	2.5	3.8	5.0	6.3	7.5

CHAPTER 6 RENEWABLE ENERGY PILOT PROJECTS

Some pilot projects will be installed to promote and create awareness of renewable energy use. MNRE sanctioned some pilot projects for each solar city based on the need and feasibility of RE and EE in the city. Following pilot project notes have been prepared. These shall be implemented on a pilot basis and shall find replication throughout the city in future.

6.1 Special Area Demonstration Project Programme

The Special Area Demonstration Project Scheme of the Ministry of New and Renewable Energy has been introduced with an objective of demonstrating application of various renewable energy systems in a project mode at places of national and international importance, including world heritage sites, heritage monuments, religious locations and places of public interest, to create greater awareness of renewable and to supplement the energy requirement at such locations.

6.2 Pilot Projects Details for Renewable Energy Installation for Jodhpur city

- Jodhpur Municipal Corporation Building Solar Power Pack 100 kW capacity
- New High Court Building Solar Power Pack 35 kW capacity
- Collectorate Office Solar Power Pack 25 kW capacity
- Umaid Hospital Solar Power Pack 30 kW capacity
- MDM Hospital Solar Power Pack 30 kW capacity
- MGH Hospital Solar Power Pack 30 kW capacity
- Circuit House Solar Power Pack 20 kW capacity
- Treasury & Tax Building Solar Power Pack 20 kW capacity
- Solar Street Light Pack Circuit to Airport 3 K.M. Distance
- Ashok Udhayan Solar Energy Park
- Waste to Energy Electricity Generation
- Sewage Treatment Plant 30 MLD (Biogas to Electricity)
- Sewage Treatment Plant 50 MLD (Biogas to Electricity)

Pilot Project Concept Note -1

Jodhpur Municipal Corporation Building Solar Power Pack -100 kW

Table 66 : 100 kW Grid Connected Solar Power Plant

100 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 100 kW Solar Power Project at Jodhpur Municipal Corporation Building
Project Description	100 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.18 MU
Capital Cost :	90 Lacs
Roof Top Requirement	1000 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 90 %	81 Lacs
State Share @10 %	9 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note -2

New High Court Building, Jodhpur Solar Power Pack- 35 kW

Table 67 : New High Court Building, Jodhpur Solar Power Pack- 35 kW

35 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 35 kW Solar Power Project at New High Court Building, Jodhpur
Project Description	35 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.06 MU
Capital Cost :	31.5 Lacs
Roof Top Requirement	350 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 90 %	28.4 Lacs
State Share @10 %	3.15 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note 3

Umaid Hospital Building , Jodhpur Solar Power Pack- 30 kW

Table 68 : Umaid Hospital Building , Jodhpur Solar Power Pack- 30 kW

30 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 30 kW Solar Power Project at MDM Hospital Building
Project Description	30 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.054 MU
Capital Cost :	27 Lacs
Roof Top Requirement	300 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 90 %	24.3 Lacs
State Share @10 %	2.7 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note 4

Collect rate Office Building, Jodhpur Solar Power Pack- 25 kW

Table 69 : Collect rate Office Building, Jodhpur Solar Power Pack- 25 kW

25 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 25 kW Solar Power Project at Collectorate Office Building, Jodhpur
Project Description	25 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.04 MU
Capital Cost :	22.5 Lacs
Roof Top Requirement	250 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 90 %	20.25 Lacs
State Share @10 %	2.25 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note 5

Circuit House Building Solar Power Pack – 20 kW

Table 70 : Circuit House Building Solar Power Pack – 20 kW

20 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 20 kW Solar Power Project at Circuit House Building, Jodhpur
Project Description	20 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.036MU
Capital Cost :	18 Lacs
Roof Top Requirement	200 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 90 %	16.2 Lacs
State Share @10 %	1.8 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note 6

Treasury & Tax Building Solar Power Pack – 20 kW

Table 71 : Treasury & Tax Building Solar Power Pack – 20 kW

10 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 10 kW Solar Power Project at Treasury & Tax Building, Jodhpur
Project Description	10 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.06 MU
Capital Cost :	9 Lacs
Roof Top Requirement	100 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 90 %	8.1 Lacs
State Share @10 %	0.9 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note- 7

Solar Street Light 60 Watt LED Pack Circuit to Airport 3 K.M. Distance

Table 72 : Solar Street Light 60 Watt LED Pack Circuit to Airport 3 K.M. Distance

Solar Street Light 60 Watt LED Pack Circuit to Airport 3 K.M. Distance		Units
Total number of Solar street light 60 watt	300	Nos.
Cost of installation of 60 watt LED Light	60.0	Lacs
MNRE Contribution@ 90 %	54.0	Lacs
State Contribution @ 10 %	6.0	Lacs
Energy saving by replacing Sodium Vapour High Mask 150 Watt with Solar Street Light 60 watt LED Light	0.22	MU
Cost of electricity savings	11	Lacs
Payback period	3.46	Years
GHG Emission reduction per year	177.8	M. T.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project	
Time Frame	2013 to 2015	

Pilot Project Concept Note-8

MDM Hospital Building, Jodhpur Solar Power Pack- 30 kW

Table 73 : MDM Hospital Building, Jodhpur Solar Power Pack- 30 kW

30 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 30 kW Solar Power Project at MDM Hospital Building, Jodhpur
Project Description	30 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.054 MU
Capital Cost :	27 Lacs
Roof Top Requirement	300 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 50 %	13.5 Lacs
State Share@ 20 %	5.4 Lacs
State Share@ 30 %	8.1 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note-9

MGH Hospital Building , Jodhpur Solar Power Pack- 30 kW

Table 74 : MGH Hospital Building , Jodhpur Solar Power Pack- 30 kW

30 kW Grid Connected Solar Power Plant	
Project Title:	Installation of 30 kW Solar Power Project at MGH Hospital Building, Jodhpur
Project Description	30 kW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 0.054 MU
Capital Cost :	27 Lacs
Roof Top Requirement	300 Square Meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 50 %	13.5 Lacs
State Share@ 20 %	5.4 Lacs
State Share@ 30 %	8.1 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note-10

Ashok Udhayan State Level Solar Energy park

Table 75 : Ashok Udhayan State Level Solar Energy Park

State Level Energy Park Ashok Udhayan	
Project Title:	Ashok Udhayan State Level Solar Energy park, Jodhpur
Project Objective	To create awareness and give publicity among the students, teachers, rural and urban masses to the extent possible about the use and benefits of renewable energy systems and devices.
Capital Cost :	100 Lacs
Roof Top Requirement	8000 to 12000 square meter
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under Demonstration Project
MNRE Share @ 100 %	100 Lacs
Time Frame:	2013 to 2015

Pilot Project Concept Note-11

Waste To Energy Generation 3 MW Power Generation Plant at Keru Dumping Site	
Project Title:	**3 MW Power Generation Plant Project** at Keru Dumping Site, Jodhpur
Project Description	3 MW Grid Connected to HT distribution network (11 KVA)
Project Benefits:	Estimated Annual Electricity Generation 30.27 MU
Capital Cost :	
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 Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under CFA Scheme Project
MNRE Share @ 50 %	13.5 Lacs
State Share@ 50 %	8.1 Lacs
Time Frame:	2013 to 2015

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

Total waste quantity :	200 tonnes
Net power generation potential (kW)	7.5 x 200= 1500 (kW) or 1.5
Power Generation Annually	13.14 MU
GHG Emission Reduction Equivalent CO2 MT / Year	21840 MT

Pilot Project Concept Note-12

Generation of Electricity from Sewage treatment plant 50 MLD at Salawas , Jodhpur

Table 76 : Generation of Electricity from STP 50 MLD at Salawas, Jodhpur

Sewage Treatment Plant		
Particulars	**Value**	**Unit**
Plant Capacity	50	MLD
Biogas yield	8000	m3
Electricity (kWh) potential	48	MW
Capacity of the plant	2	MW
Conversion Efficiency	33%	%
Total Electricity Generated Per Year	5.7816	MU
Plant Load Factor	70%	%
Net electrical energy savings potential	4.04712	MU
Emission reduction CO2 per year	68322.53	MT

Table 77 : Generation of Electricity from STP 50 MLD at Salawas, Jodhpur

Waste To Energy Generation 2 MW Power Generation Plant at Salawasa ,STP Jodhpur	
Project Title	2 MW Power Generation Plant Project at Salawasa ,STP Jodhpur
Project Description	2 MW Grid Connected to HT distribution network (11 KV)
Project Benefits	Estimated Annual Electricity Generation 4.04 MU
Capital Cost	420 Lacs
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism	Program to be supported by MNRE under CFA Scheme Project
MNRE Share @ 50 %	210 Lacs
State Share@ 50 %	210 Lacs
Time Frame	2013 to 2015

Pilot Project Concept Note-13

Table 78 : 1.2 MW Capacity Electricity generation STP

1.2 MW Capacity Electricity generation Sewage Treatment Plant		
Particulars	Value	Unit
Plant Capacity	30	MLD
Biogas yield	4800	cubic m3
Electricity (kWh) potential	28800	kW
Capacity of the plant	1200	kW
Conversion Efficiency	33%	%
Total Electricity Generated Per Year	3.46896	MU
Plant Load Factor	70%	%
Net electrical energy savings potential	2.428272	MU
Emission reduction CO2 per year	40993.52	MT

Waste To Energy Generation 1. 2 MW Power Generation Plant at Salawasa, STP Jodhpur	
Project Title:	1.2 MW Power Generation Plant Project at Nadri, STP Jodhpur
Project Description	1.2 MW Grid Connected to HT distribution network (11 KV)
Project Benefits:	Estimated Annual Electricity Generation 2.4 MU
Capital Cost :	250 Lacs
Implementation Structure:	Project Proponent shall enter into MOU with concerned Jodhpur DISCOM for sale/purchase of power.
Financing Mechanism :	Program to be supported by MNRE under CFA Scheme Project
MNRE Share @ 50 %	125 Lacs
State Share@ 50 %	125 Lacs
Time Frame:	2013 to 2015

Electricty generation per year through Pilot Projects

Table 79 : Electricty generation per year through Pilot Projects

Building	Capacity in kW	Electricity generation per year in MU
Jodhpur Municipal Building Solar power pack 100 kW	100	0.18
New High Court Building Solar power pack	35	0.06
Collectrate Office Solar power pack	25	0.05
Umaid Hospital Solar power pack	30	0.05
MDM Hospital Solar power pack	30	0.05
MGH Hospital Solar power pack	30	0.05
Circuit House Solar power pack	20	0.04
Treasury & Tax Building Solar power pack	10	0.02
Ashok Udhayan Solar Energy Park		
Solar Street Light Pack Circuit to Airport 3 K.M. Distance		

Summary Special Area Demonstration Program - Project Estimate Budget

Table 80 : Pilot Project Solar Power Pack Budget Estimation for Jodhpur city

Building	Total Budget in Lacs`	MNRe Sharein Lacs`	State Share in Lacs`
Jodhpur Municipal Building Solar power pack 100 kW	90	81	8.1
New High Court Building Solar power pack	31.5	28.35	2.835
Collectorate Office Solar power pack	22.5	20.25	2.025
Umaid Hospital Solar power pack	27	24.3	2.43
Circuit House Solar power pack	18	16.2	1.62
Treasury & Tax Building Solar power pack	9	8.1	0.81
Solar Street Light Pack Circuit to Airport 3 K.M. Distance	60	54	6
Ashok Udhayan State Level Solar Energy park, Jodhpur	100	-	-
Total Estimated Budget (Lacs)	**358**	**232.2**	**23.82**

Summary Pilot Project Estimate Budget

Building	Total Investment in Lacs	MNRE Share @ 50 %	State Share @ 20 %	User Share @ 30 %
MDM Hospital Solar Power Pack 30 kW capacity	27	13.5	5.4	8.1
MGH Hospital Solar power pack Pack 30 kW capacity	27	13.5	5.4	8.1

Summary Pilot Project Waste to Energy - Estimate Budget

Table 81 : Pilot Project Waste To Energy Budget for Jodhpur city

Proposed Power Plant	Total Investment in Lacs `	MNRe Share @ 50 % Lacs `	State Share @ 50 % Lacs `
Waste to Energy Electricity Generation from MSW	2400	1200	1200
Sewage Treatment Plant(Electricity Generation from Biogas)	4200	2100	2100
Sewage Treatment Plant(Electricity Generation from Biogas)	2500	1250	1250

Pilot Projects Estimate Budget

Total budget for proposed pilot projects for jodhpur city is 95 crore ` for jodhpur city.

Table 82 : Pilot Project Estimated Budget for Jodhpur City

	Total Budget	MNRE Share	State Share
In Lacs `	9512	4909	4601
In Crore `	95	49	46

Chapter 7 Energy Efficiency Strategies for Jodhpur

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

- Replace incandescent bulb with fluorescent tube
- T5 tube light + electronic ballast to replace T12 tube light+ magnetic ballast
- Replacement of 150 watt HPSV with LEDs
- 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

7.1 Energy Efficiency in Residential Sector

Residential sector shares large amount of energy consumption in Jodhpur city. There are various suggestions to reduce energy demand through energy efficiency that are described below. According to the survey, it is observe 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:

7.1.1 Replacement of 60 watt Incandescent Bulb with Light 18 watt EE CFL

Conventional incandescent bulbs consume large electricity in the residential sector due to its low initial cost. During the sample survey, it was found that incandescent bulbs are being used by all households in residential sector. Replacement of incandescent lamps with energy efficient CFL is a feasible option to reduce energy demand in residential sector. The techno feasible calculations for replacement of incandescent bulbs with CFL are given below.

Table 83 : Techno-Economical Analysis 18 watt EE CFL

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Total number of CFL needed	64990	Nos.
Cost of installation of Compact Fluorescent Light	78.0	Lacs
Energy saving by replacing Incandescent Light Bulb with CFL	5.4	MU
Cost of electricity savings	270.2	Lacs
Payback period	0.36	years
GHG Emission reduction per year	4431.7	MT

7.1.2 Replacement of 100 watt Incandescent Bulb with 28 watt EE CFL

Table 84 : Techno-Economical Analysis of 28 EE CFL

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Total number of CFL needed	97484	Nos.
Cost of installation of 28 watt Compact Fluorescent Light	146.2	Lacs
Energy saving by replacing Incandescent Light Bulb with CFL	13.90	MU
Amount of electricity savings per year	14	Lacs
Payback period	0.21	Years
GHG Emission reduction per year	11397	MT

7.1.3 Replacement of 40-watt T 12 tube lights from 28 watt EE T5 Tube 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.

Assumptions of Energy Efficiency:

- T12 = old and inefficient
- T8 = higher efficiency
- T5 = highest efficiency

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-residential environment, so that there can be fluctuations.

CRI levels:	LPW levels:	CU (Generally):
T12 = 62CRI	T12 = 78LPW	T12 = .46CU
T8 = 85CRI	T8 = 92LPW	T8 = .76CU
T5 = 85CRI	T5 = 105LPW	T5 = .90CU

Considering these general factors, it is obvious that T5 is the best.

- T5 is 51% more efficient than T12.

Magnetic ballasts are made of wire coiled to create a magnetic field. Electronic ballasts use electronic components. Magnetic ballasts are not energy efficient. They generate flicker, noticeable in the fluorescent lamp. When the power switch is turned on, the fluorescent lamp will flicker for a few times before it can give a steady light. Electronic ballasts are energy efficient. Electronic ballasts do not generate flicker. They provide a rapid start for the fluorescent lamp. When the power switch is turned on, the fluorescent lamp lights up instantly.

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 all the households of residential sector. Replacement of T12 40 watt tube light with energy efficient T5 32 Watt is feasible option to reduce energy demand in residential sector. T5 32 Watt illuminates nearly same lumens to T12 40 watt tube light. T5 32 Watt tube lights have much longer life as compared to T12 40 watt tube light. The techno feasible calculations for replacement of T12 40 watt tube light with T5 32 watt are given below in Table 84.

Table 85 : Techno-Economical Analysis EE T 5 Tube Light

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Total number of T5 Tube Light needed	64990	Nos.
Cost of installation of T5 Tube Light	194.9	Lacs
Energy saving by replacing 40 watt T12 Tube Light with T5 Tube Light	2.8	MU

Cost of electricity savings	141.5	Lacs
Payback period	0.00	Years
GHG Emission reduction per year	2321.4	M. T.

7.1.4 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 86 : Techno-Economical Analysis EE star rated Ceiling Fan

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Total number of Ceiling fans needed	64990	Nos.
Indicative cost of installation	1169.8	Lacs
Energy saving by replacing conventional C.F. to star rated EE C.F. per Year	9.8	MU
Amount of electricity savings per year	314.5	Lacs
Payback period	2.38	Years
GHG Emission reduction per year	8057.7	MT

7.1.5 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.

Table 87 : Techno-Economical Analysis of EE Star rated A.C.

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Target to Replace conventional A.C. to star EE A.C.	23396	Nos.
Indicative cost of installation	6317.0	Lacs
Energy saving by replacing conventional A.C. to star EE A.C.per Year	14.0	MU
Amount of electricity savings per year	70.0	Lacs
Payback period	7.35	Years
GHG Emission reduction per year	11487.9	MT

7.1.6 Replacement of Conventional Refrigerator with EE Star rating Refrigerator

Energy Efficient 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'.

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	Pay Back Period
	Units (kWh)	`	`	`	`	`	Years
No Star	1100	5	5500	0	14000	0	0
1	977	5	4885	615	15000	1000	1.6
2	782	5	3910	975	15500	1500	1.5
3	626	5	3130	780	16500	2500	3.2
4	501	5	2505	625	17500	3500	5.6
5	400	5	2000	505	18500	4500	8.9

Source: Bureau of Energy Efficiency

Table 88 : Techno-Economical Analysis EE 5 Star rated Refrigerator

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Total number of refrigerator needed	36557	Nos.
Indicative cost of installation	6580.2	Lacs
Energy saving by replacing conventional Refrigerator to star rated EE Refrigerator per Year	26	MU
Amount of electricity savings per year	1279.5	Lacs
Payback period	5.14	Years
GHG Emission reduction per year	20983.5	MT

7.1.7 Replacement of Conventional Water Pump with EE Star rating Water Pump

Table 89 : Techno-Economical Analysis of EE Star rated Water Pump

Particulars	Value	Units
Total Number of users of Residential Sector in Jodhpur City	292591	Nos.
Total number of water pump needed	59141	Nos.
Indicative cost of installation	1182.8	Lacs
Energy saving by replacing conventional water pump to star EE water pump per Year	7	MU
Amount of electricity savings per year	314.5	Lacs
Payback period	2.54	Years
GHG Emission reduction per year	5761.2	MT

7.1.8 Summary of Saving target through EE Installation in Residential Sector

Table 90 : Summary of Energy Saving Target through Replacement of Conventional System with EE System in Residential Sector

Type of Installation	Energy savings in MU				
	1st Year	2nd Year Cumulative	3rd Year Cumulative	4th Year Cumulative	5th Year Cumulative
Replacement of 60 Watt Bulb with 18 watt CFL	0.1	1.2	1.5	3.3	5.5
Replacement of 100 Watt Bulb with 28 watt CFL	0.4	3.2	3.9	8.5	14.1
Replacement of T12 with EE T5 Tube Light	0.2	0.8	1.1	2.1	3.2
Replacement of conventional Ceiling Fan with EE ceiling Fan	0.8	1.9	3.4	5.3	7.6
Replacement of conventional A.C. with 5 Star EE A.C.	2.1	5.4	9.7	15.0	21.5
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	2.1	5.3	9.5	14.8	21.2

Replacement of conventional Water Pump with 5 Star EE Water Pump	1.2	2.9	5.2	8.2	11.7
Total Energy savings	**6.9**	**20.6**	**34.4**	**57.3**	**84.7**

7.1.9 Summary of Energy Efficient Installation Budget for Residential Sector

Table 91: Summary of Energy Efficient System Installation in Residential Sector

Type of Installation	Total Installation	Per item cost in `	Public share (in Lacs `)
Replacement of 60 Watt Bulb with 18 watt CFL	64990	120	78.0
Replacement of 100 Watt Bulb with 28 watt CFL	97490	150	146.2
Replacement of T12 with EE T5 Tube Light	64990	300	195.0
Replacement of conventional Ceiling Fan with EE Star rated ceiling Fan	64990	1500	1169.8
Replacement of conventional A.C. with Star rated EE A.C.	23396	27000	6317.0
Replacement of conventional Refrigerator with Star rated EE Refrigerator	30220	18000	5439.6
Replacement of conventional Water Pump with Star rated EE Water Pump	59141	2000	1182.8

Year wise summary of Investment for Energy Efficient Installation in Residential Sector

Table 92 : Summary of Year Wise Investment of EE System in Residential System

Type of System	Total Number	Investment in Lacs `					
		Item Cost in `	1st Year	2nd Year	3rd Year	4th Year	5th Year
Replacement of 60 Watt Bulb with 18 watt CFL	64990	120	8	12	16	19	23
Replacement of 100 Watt Bulb with 28 watt CFL	97490	150	15	22	29	37	44
Replacement of T12 Tube Light with EE T5 Tube Light	64990	300	195	29	39	49	58
Replacement of conventional Ceiling Fan with EE ceiling Fan	64990	1500	97	146	195	244	292
Replacement of conventional A.C. with 5 Star EE A.C.	23396	27000	632	948	1263	1579	1895
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	30220	18000	544	816	1088	1360	1632
Replacement of conventional Water Pump with 5 Star EE Water Pump	59141	2200	130	195	260	325	390

7.2 Energy Efficiency Strategies in Commercial and Institutional Sector

Commercial and institutional sector of Jodhpur shares large amount of energy consumption. According to their revenue department, there are more than 20,000 buildings in Jodhpur municipal limit. Some Energy Efficient option and calculation are described below to reduce energy demand:

Replacement of Incandescent Light Bulb with Compact Fluorescent Light

Conventional incandescent bulbs consume large electricity in the commercial and institutional sector due to its low initial cost. During the sample survey, it was found that incandescent bulbs are being used in all households of residential sector. Replacement of incandescent lamps with energy efficient CFL is a feasible option to reduce energy demand in residential sector. The techno feasible calculations for replacement of incandescent bulbs with CFL are given below.

7.2.1 Replacement of 60 watt Incandescent Light Bulb with 18 watt CFL

Table 93: Techno-Economical Analysis of 18 watt CFL

Particulars	Value	Units
Total Number of Users in C & I Sector in Jodhpur City	20043	Nos.
Total number of CFL needed	12026	Nos.
Cost of installation of Compact Fluorescent Light	14	Lacs
Energy saving by replacing Incandescent Bulb with CFL	122	MU
Amount of electricity savings per year	1.3	Lacs
Payback period	0.23	Years
GHG Emission reduction per year	1043.7	MT

7.2.2 Replacement of 100 watt Incandescent Light Bulb with 28 CFL

Table 94 : Techno-Economical Analysis of 28 watt CFL

Particulars	Value	Units
Total No of Users in C & I Sector of Jodhpur City	20043	Nos.
Total number of CFL needed	36077	Nos.
Cost of installation of Compact Fluorescent Light	54	Lacs
Energy saving by replacing Incandescent Bulb with CFL	7.7	MU
Amount of electricity savings per year	385.7	Lacs
Payback period	0.14	years
GHG Emission reduction per year	6326.1	MT

7.2.3 Replacement of 40 watt T 12 tube lights from EE 28 –watt T5 Tube lights

T12 40 watt tube light consumes large electricity in the commercial and institutional sector. During the sample survey, it was observed that T12 40 watt tube lights are used in the sector. Replacement of T12 40 watt tube light with energy efficient T5 32 Watt is a feasible option to reduce energy demand in residential sector. T5 32 Watt illuminates nearly same lumens to T12 40 watt tube light. T5 32 Watt tube lights have much longer life as compared to T12 40 watt tube light. The techno feasible calculations for replacement of T12 40 watt tube light with T5 32 watt are given below.

Table 95 : Techno-Economical Analysis of EE T 5 Tube Light

Particulars	Value	Units
Total No of Users in C & I Sector of Jodhpur City	20043	Nos.
Total number of T5 Tube light needed	12026	Nos.
Cost of installation of T5 Tube light	36.1	Lacs
Energy saving by replacing T 12 Tube light with T5 Tube light	0.7	MU
Amount of electricity savings per year	33.3	Lacs
Payback period	1.08	years
GHG Emission reduction per year	546.7	MT

7.2.4 Replacement of Conventional Ceiling fan with Energy Efficient Ceilings Fan

Table 96: Techno-Economical Analysis of EE Star rated Ceiling Fan

Particulars	Value	Units
Total No of Users in C & I Sector of Jodhpur	20043	Nos.
Total number of Ceiling fans needed	20043	Nos.
Indicative cost of installation	300.6	Lacs
Energy saving by replacing conventional C.F. to star rated EE C.F. per Year	2	MU
Amount of electricity savings per year	75.8	Lacs
Payback period	4.96	years
GHG Emission reduction per year	1242.5	MT

7.2.5 Replacement of Conventional A.C. with Energy Efficient 5 Star rating A.C.

Table 97 : Techno-Economical Analysis of EE 5 Star rated A.C

Particulars	Value	Units
Total No of Users in C & I Sector of Jodhpur City	20043	Nos.
Total number of A.C. needed	2405	Nos.
Indicative cost of installation	649.4	Lacs
Energy saving by replacing conventional A.C.to star rated EE A.C.per Year	2.2	MU
Amount of electricity savings per year	8.8	Lacs
Payback period	7.35	years
GHG Emission reduction per year	1810.8	MT

7.2.6 Replacement of Conventional Refrigerator with Energy Efficient Star rating Refrigerator

Table 98 : Techno-Economical Analysis of EE Star rated Refrigerator

Particulars	Value	Units
Total No of Users in Commercial & Institutional	20043	Nos.

Sector of Jodhpur		
Total number of Refrigerator needed	651	Nos.
Indicative cost of installation	117.3	Lacs
Energy saving by replacing conventional Refrigerator to star reted EE Refrigerator per Year	0.5	MU
Amount of electricity savings per year	22.8	Lacs
Payback period	5.14	years
GHG Emission reduction per year	379.3	MT

7.2.7 Replacement of Conventional Water Pump with Energy Efficient Star rated W.P.

Table 99 : Techno-Economical Analysis of EE star rated Water Pump

Particulars	Value	Units
Total No of Users in C & I Sector of Jodhpur C	20043	Nos.
Target to Replace conventional Water pump to star EE Water pump	1202.6	Nos
Total number of Water pump needed	48	Nos.
Indicative cost of installation	0.3	Lacs
Energy saving by replacing conventional Water pump to star reted EE Water pump per Year	16.23	MU
Amount of electricity savings per year	3.7	Lacs
Payback period	266.3	years
GHG Emission reduction per year	20043	MT

Summary of Energy Saving Target and Investment through Replacement of Conventional System with Energy Efficient System in C & I Sector

Table 100 : Summary of Energy Saving Target through Replacement of Conventional System with Energy Efficient System in C & I Sector

Type of Installation	Energy savings in MU				
	1st Year	2nd Year Cumulative	3rd Year Cumulative	4th Year Cumulative	5th Year Cumulative
Replacement of 60 Watt Bulb with 18 watt CFL	1.3	3.2	5.7	8.9	12.7
Replacement of 100 Watt Bulb with 28 watt CFL	0.7	1.8	3.2	4.9	7.0
Replacement of T12 with EE T5 Tube Light	0.7	1.7	3.0	4.7	6.7
Replacement of conventional Ceiling Fan with EE ceiling Fan	1.5	3.8	6.8	6.8	10.6
Replacement of conventional A.C. with 5 Star EE A.C.	1.8	4.4	7.9	12.4	17.7
Replacement of conventional Refrigerator with 5 Star EE Rftr.	0.5	1.1	2.1	3.2	4.6

Replacement of conventional Water Pump with 5 Star EE W.P.	0.2	0.5	1.0	1.5	2.2
Total Energy savings	6.6	16.5	29.7	42.4	61.4

Table 101 : Summary of Energy Efficient System Installation in C & I Sector

Energy Efficient System Installation in Residential Sector			
Type of Installation	Total Installation	Per Item Cost `	Public Share (in Lacs `)
Replacement of 60 Watt Bulb with 18 watt CFL	12026	120	14
Replacement of 100 Watt Bulb with 28 watt CFL	36077	150	54
Replacement of T12 with EE T5 Tube Light	12026	300	36
Replacement of conventional Ceiling Fan with EE Star rated ceiling Fan	20043	1500	301
Replacement of conventional A.C. with Star rated EE A.C.	2405	27000	649
Replacement of conventional Refrigerator with Star rated EE Refrigerator	651	18000	117
Replacement of conventional Water Pump with Star rated EE Water Pump	1203	4000	48

Year wise investment for replacement of system in C & I Sector

Table 102: Summary of Year Wise Investment of EE System in C & I Sector

Type of System	**Total Number**	**Investment in Lacs `**					
		Item Cost in `	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**
Replacement of 60 Watt Bulb with 18 watt CFL	12026	120	1.4	2.2	2.9	3.6	4.3
Replacement of 100 Watt Bulb with 28 watt CFL	36077	150	5.4	8.1	10.8	13.5	16.2
Replacement of T12 Tube Light with EE T5 Tube Light	12026	300	3.6	5.4	7.2	9.0	10.8
Replacement of conventional Ceiling Fan with EE ceiling Fan	20043	1500	30.1	45.1	60.1	75.2	90.2
Replacement of conventional A.C. with 5 Star EE A.C.	2405	27000	64.9	97.4	129.9	162.3	194.8
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	651	18000	11.7	17.6	23.5	29.3	35.2
Replacement of conventional Water Pump with 5 Star EE Water Pump	1203	4000	4.8	7.2	9.6	12.0	14.4

7.3 Energy Efficiency Strategies in Industrial Sector

Jodhpur city has around 5000 industrial units having huge energy consumption. Some Energy Efficient options and calculations are described below:

7.3.1 Replacement of 100 watt Incandescent Light Bulb with 28 watt CFL

Table 103: Techno-Economical Analysis EE CFL

Particulars	Value	Units
Number of Industrial Users in Jodhpur City	4597	Nos.
Total number of CFL needed	13791	Nos.
Cost of installation of CFL	16.5	Lacs
Energy saving by replacing Incandescent Light Bulb with CFL	2	MU
Cost of electricity savings	104.3	Lacs
Payback period	0.16	years
GHG Emission reduction per year	1709.9	MT

7.3.2 Replacement of 100 watt Incandescent Light Bulb with 28 watt CFL

Table 104 : Techno-Economical Analysis of EE 28 watt CFL

Particulars	Value	Units
Number of Industrial Users in Jodhpur City	4597	Nos.
Total number of CFL needed	9194	Nos.
Cost of installation of CFL	13.8	Lacs
Energy saving by replacing Incandescent Light Bulb with CFL	2.4	MU
Cost of electricity savings	119.2	Lacs
Payback period	0.12	years
GHG Emission reduction per year	1954.1	MT

7.3.3 Replacement of 40-watt T 12 tube lights from EE 28 –watt T5 Tube lights

Table 105 : Techno-Economical Analysis of EE T 5 Tube Light

Particulars	Value	Units
Number of Industrial Users in Jodhpur City	4597	Nos.
Cost of installation of T5 Tube Light	82.7	Lacs
Energy saving by replacing T12 Tube Light with T5 Tube Light	2.2	MU
Amount of electricity savings per year	109.2	Lacs
Payback period	0.76	years
GHG Emission reduction per year	1791.3	MT

7.3.4 Replacement of Conventional Ceiling fan with Energy Efficient Ceilings Fan

Table 106 : Techno-Economical Analysis of EE Star rated Ceiling Fan

Particulars	Value	Units
Number of Industrial Users in Jodhpur City	4597	Nos.
Indicative cost of installation	27582	Nos.

Energy saving by replacing conventional C.F. to 5 star EE C.F. per Year	82.7	Lacs
Amount of electricity savings per year	2.2	MU
Payback period	109.2	Lacs
GHG Emission reduction per year	0.76	years
Target to Replace conventional C.F. to 5 star EE Ceiling fans	1791.3	MT

7.3.5 Replacement of Conventional A.C. with EE star rated A.C.

Table 107 : Techno-Economical Analysis of EE Star rated A.C.

Particulars	Value	Units
Total Number of users in Industrial Sector of Jodhpur City	4597	Nos.
Total number of A.C. needed	1839	Nos.
Indicative cost of installation	496.5	Lacs
Energy saving by replacing conventional A.C. to star rated EE A.C. per year	2.8	MU
Amount of electricity savings per year	13.8	Lacs
Payback period	5.64	years
GHG Emission reduction per year	2257.2	MT

7.3.6 Replacement of Conventional Water Pump with EE star rated Water Pump

Table 108 : Techno-Economical Analysis of EE star rated Water Pump

Particulars	Value	Units
Total Number of users in Industrial Sector of Jodhpur City	4597	Nos.
Total number of water pump needed	965	Nos.
Indicative cost of installation	38.6	Lacs
Energy saving by replacing conventional W.P. to 5 star EE W.P	7.0	MU
Amount of electricity savings per year	314.5	Lacs
Payback period	1.39	years
GHG Emission reduction per year	570.0	MT

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

Table 109 : Energy Saving Target through Replacement of Conventional System with EE in Industrial Sector

Type of Installation	Energy savings in MU				
	1st Year	2nd Year Cumulative	3rd Year Cumulative	4th Year Cumulative	5th Year Cumulative
Replacement of 60 Watt Bulb with 18 watt CFL	0.2	0.5	0.9	1.5	2.1
Replacement of 100 Watt Bulb with 28 watt CFL	0.2	6.0	10.7	16.7	23.8

Replacement of T12 with EE T5 Tube Light	0.2	0.5	14.0	17.2	19.1
Replacement of conventional Ceiling Fan with EE ceiling Fan	0.3	0.7	1.0	1.3	1.9
Replacement of conventional A.C. with 5 Star EE A.C.	0.3	0.7	1.2	1.9	2.8
Replacement of conventional Water Pump with 5 Star EE W.P.	0.1	0.2	0.3	0.5	0.7
Total Energy savings	**1.3**	**8.6**	**28.2**	**39.0**	**50.4**

Table 110 : Energy Efficient System Installation in Industrial Sector

Energy Efficient System Installation in Industrial Sector			
Type of Installation	Total Installation	Per Item Cost `	Public Share (in Lacs `)
Replacement of 60 Watt Bulb with 18 watt CFL	13791	120	17
Replacement of 100 Watt Bulb with 28 watt CFL	9194	150	14
Replacement of T12 with EE T5 Tube Light	27582	300	83
Replacement of conventional ceiling Fan with EE star rated ceiling Fan	27582	1500	414
Replacement of conventional A.C. with Star rated EE A.C.	1839	27000	496
Replacement of conventional Water Pump with Star rated EE Water Pump	965	4000	39

Table 111 : Year Wise Investment of EE System in Industrial Sector

Type of System	**Total Number**	**Investment in Lacs `**					
		Item Cost in `	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**
Replacement of 60 Watt Bulb with 18 watt CFL	13791	120	1.7	2.5	3.3	4.1	5.0
Replacement of 100 Watt Bulb with 28 watt CFL	9194	150	1.4	2.1	2.8	3.4	4.1
Replacement of T12 Tube Light with EE T5 Tube Light	27582	300	8.3	12.4	16.5	20.7	24.8
Replacement of conventional Ceiling Fan with EE ceiling Fan	27582	1500	41.4	62.1	82.7	103.4	124.1
Replacement of conventional A.C. with 5 Star EE A.C.	1839	27000	49.6	74.5	99.3	124.1	148.9
Replacement of conventional Water Pump with 5 Star EE Water Pump	965	4000	3.9	5.8	7.7	9.7	11.6

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 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 through the Sustainable Cities programme indicate that energy savings of up to 40 per cent are both possible and highly cost effective.

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 Jodhpur Municipal Corporation has about nearly 66000 outdoor lights with different wattage, which has been fixed for illumination streets, wards, monuments, etc. The specifications of types of lamps being used in various roads in the city are as following

Table 112: Street Lighting Details of Jodhpur City

Item	Unit Load in Watt	Total Light	Total Load kW	Hours operation	Days	Annual consumption in GWh
Tube Light	40	21629	865.16	11	365	3.5
SV 70/150/250 Watt	150	22756	3413.4	11	365	13.7
MH Light	250	15399	3849.75	11	365	15.5
Decorative Light	70	2216	155.12	11	365	0.6
					Total	33.3

Based on the data collected from the Municipal Corporation of street lighting, it has been observed that the street lighting system currently used in Jodhpur city uses the fixtures with conventional ballasts. There is a good potential of reducing the consumption by installing multi tab ballast with astronomical timer switch. Keeping this in mind, it is suggested to install the multi tab ballast, which varies the load of the lamp according to the traffic load during the night. Multi tab ballast comes with a facility of setting the time for which the lamp will run up to full facility. So during the evening operating hours, the timer is to be set for full loading of the lamp and during midnight onwards it will be set for 50% loading of the lamp. Astronomical timer switch will help in reducing the wastage of lighting consumption as due to seasonal variation the operating hours of street lighting does change. Therefore, the switch does not allow streetlight to get on before the dusk and after the dawn.

Some of the most cost-effective opportunities identified include:

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:

Structural

- Poles
- Pole Bases (foundations)

Optical

- Luminaries

Electrical

- Lamps
- Ballasts
- Service Cabinets (fuse box)

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 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 113: Compression 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

- Replacement of 250 Watt Metal Halide (MH) Lamps with LED Lamps
- Replacement of 150 Watt Sodium Vapour (SV) Lamps with LED Lamps
- Replacement of 40 Watt T12 Tube light with T5 Tube Light
- Installation of Dimmer System for Energy Saving
- Installation of Digital Sensors for on/off of Street Lights
- Installation of Dimmers systems
- Replacement of Conventional water pump with BEE 5 Star Energy Efficient water pump

7.4.1 Replacement of 250-watt Metal Halide (MH) Lamps from EE 112 watts LED Lamps

Table 114: Techno-Economical Analysis of EE 112 watts LED Lamps

Particulars	Value	Units
250 watt MH replace with 112 Watt LED in Jodhpur City	15399	Nos.
Total number of 112 watt LED light	508	Nos.
Cost of installation of 112 watt LED light	26	Lacs
Energy saving by replacing Incandescent light bulb with 112 watt LED light	10.2	MU
Cost of electricity savings	4.96	Lacs
Payback period	2098.9	years
GHG Emission reduction per year	15399	MT

7.4.2 Replacement of 150-watt Sodium Vapour Lamps from EE 60 watt LED Lamps

Table 115: Techno-Economical Analysis of EE 60 watt LED Lamps

Particulars	Value	Units
Total number of 150 watt HPSV Light in Jodhpur city in Municipal Sector	21629	Nos.
Total number of 60 watt LED Light needed	6489	%
Cost of installation of 60 watt LED Light	584.0	Nos.
Energy saving by replacing 150 watt HPSV 60 watt LED Light	2.34	Lacs
Cost of electricity savings	93.8	MU
Payback period	5.53	Lacs

7.4.3 Replacement of 40-watt T 12 Tube Lights from EE 28 –watt T5 Tube lights

Table 116 : Techno-Economical Analysis of EE T5 Tube lights

Particulars	Value	Units
Number of Tube Light in Jodhpur City in Municipal Sector	21629	Nos.
Total number of T5 Tube Light needed	10815	Nos.
Cost of installation of T5 Tube Light	43.3	Lacs
Energy saving by replacing 40 watt T12 Tube Light withT5 Tube Light per year	9.55	MU
Cost of electricity savings	38.2	Lacs
Payback period	1.13	years
GHG Emission reduction per year	783.3	MT

7.4.4 Replacement of 70-watt Decorative Tube Lights from EE 20 watt LED lights

Table 117 : Techno-Economical Analysis of EE 20 watt LED lights

Particulars	Value	Units
Number of Decorative Light in Jodhpur City in Municipal Sector	2216	Nos.
Total number of 20 watt LED lights needed	1108	Nos.
Cost of installation of 20 watt LED lights	16.6	Lacs
Energy saving by replacing 70-watt Decorative tube lights from Energy Efficient 20 watt LED lights per year	2.22	MU
Cost of electricity savings	8.9	Lacs
Payback period	1.87	years

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

Table 118 : Summary of Energy Saving Target through Replacement of Conventional System with Energy Efficient System in Municipal Sector

Energy Efficient System Installation in Municipal Sector			
Type of Installation	**Total Installation**	**Per Item Cost `**	**Public Share (in Lacs `)**
Replacement of 150 Watt Street Light with 60 watt LED	6489	7000	454

Replacement of250 Watt Street Light with 112 watt LED	4620	9500	439
Replacement of conventional Decorative with EE Decorative Light	1108	1200	13
Replacement of T12 with EE T5 Tube Light	10814	300	32

Table 119 : Summary of Energy Efficient System Installation in Municipal Sector

Type of Installation	Energy savings in MU				
	1st Year	2nd Year Cumulative	3rd Year Cumulative	4th Year Cumulative	5th Year Cumulative
T5 tube light	0.1	0.3	0.5	0.8	1.1
60 watt LED	0.2	0.6	1.1	1.7	2.4
112 watt LED	0.3	0.6	1.2	1.9	2.7
Decorative	0.02	0.06	0.10	0.16	0.22
Energy Efficient Water Pumps	7.6	7.6	7.6	7.6	7.6
Total Energy savings	**8.2**	**9.2**	**10.5**	**12.2**	**14.1**

Table 120 : Year Wise Investment of EE System in Municipal Sector

Type of System	Total Number	Investment in Lacs `					
		Item Cost in `	1st Year	2nd Year	3rd Year	4th Year	5th Year
Replacement of 150 Watt Street Light with 60 watt LED	6489	7000	45	68	91	114	136
Replacement of 250 Watt Street Light with 112 watt LED	4620	9500	44	66	88	110	132
Replacement of conventional Decorative with EE Decorative Light	1108	1200	1	2	3	3	4
Replacement of T12 with EE T5 Tube Light	10814	300	3	5	6	8	10

Other Measures for Energy Efficiency in Municipal Sector

Installation of Dimmer System for Energy Saving for Municipal Sector

Although the use of dimming systems yields considerable energy savings and represents a financially justified investment, it should be used with caution. The use of dimming systems for street lighting is recommended when the supply voltage exceeds 220 V. This typically occurs between late night and early morning hours when traffic density is significantly reduced.

Common Types of Lamp Dimming Systems

There are presently following three types of lamp dimming systems in line voltage:

Step-level line voltage dimming circuits work by changing the applied voltage in the street lighting system. A variable voltage transformer is installed at switching points and has timer control and a power factor correcting mechanism.

Bi-level dimming electronically modifies the input voltage into low or high near the lamp by employing electronic low or high frequency switching circuits.

Continuous dimming systems reduces the line voltage continuously through variable step transformers/ variable reactors/wave choppers using electronic circuits.

Dimming High Intensity Discharge Lamps

The exact performance of any HID dimming system or lamp on the system is dependent on the specific dimming

Dimming Guidance

To avoid reduced lamp life, the dimming of HID lamps should not exceed 30% for sodium vapor lamp and 50% for metal halide.

Ideal application of dimming includes:

- Non-critical street lights
- Parking garages
- Warehouses and supermarkets
- Security lighting

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. A 20% saving is assumed for design based energy efficiency of water pumping systems. The techno-economics given below for this initiative is based on this assumption.

Table 121 : Energy Savings through EE Water Pumping System

Energy Efficiency for water pumping	Value	Units
Energy Consumption per year	49.06	MU
Energy Cost per year	1962.6	Lacs
Saving %	20%	%
Energy Saving per year	9.81	MU
Money Saving per	392.52	Lacs
Emission Reduction	8046.6	MT

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 through 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 Moradabad, 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 Jodhpur. Information on technologies and energy saving methods, outlined in this chapter, aims to assist Jodhpur Municipal Corporation to provide tools for innovative design for new and retrofit buildings.

As Jodhpur 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.

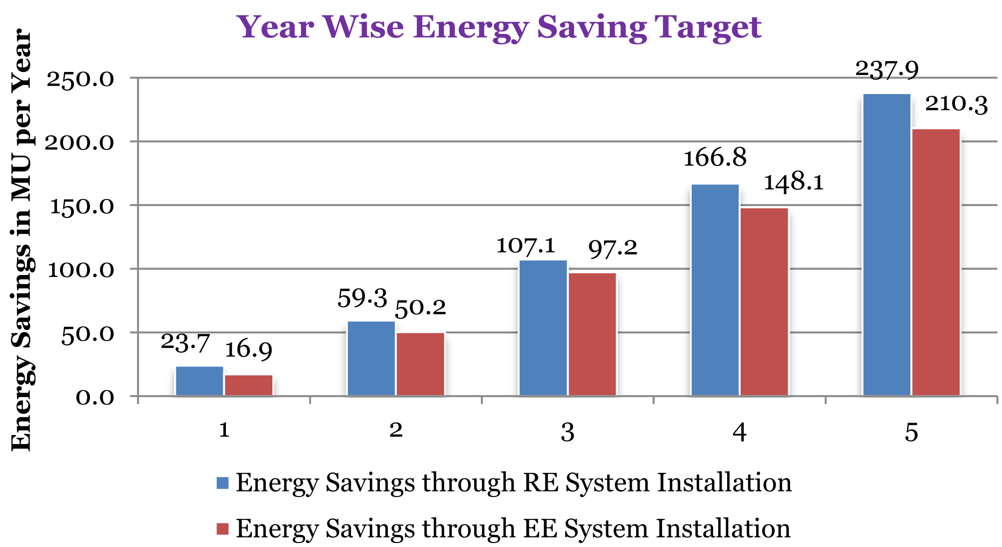
CHAPTER 8 ACTION PLAN

To fulfill the future energy demands in context of current supply and demand of energy and also continuous shortage of energy resources in Jodhpur city, it is necessary to use renewable energy sources and optimize energy conservation, which would thus reduce per capita energy demand and also reduce green house gases GHGs emission. To achieve 10 % energy reduction target up to 2018 for Jodhpur 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 listed below summarizes year wise goals for energy savings through installation of different types of renewable energy and energy efficiency measures for residential , commercial & institutional , Industrial, and municipal sector . The goal is to achieve 10% reduction in projected total demand of 3995 MU in 2017-18 of conventional energy at the end of five years. The master plan sets a goal of total savings of 399.5 MU with 199.6 MU from renewable energy installation and 199.6 MU from energy efficiency measures.

Renewable energy	Sector Wise Yearly Energy saving target for First commitment period 2017-18 in MU					
	1st Year	2nd Year Cumulative	3rd Year Cumulative	4th Year Cumulative	5th Year Cumulative	% of target
Residential Sector	13.8	34.5	62.2	96.7	138.2	34.6%
C & I Sector	5.3	13.4	24.1	37.6	53.6	13.4%
Industrial Sector	3.1	7.9	14.4	22.6	32.0	8.0%
Municipal Sector	1.4	3.5	6.4	9.9	14.1	3.5%
Total RE Saving Target	23.7	59.3	107.1	166.8	237.9	59.6%
Energy Efficiency in %	**1st Year**	**2nd Year Cumulative**	**3rd Year Cumulative**	**4th Year Cumulative**	**5th Year Cumulative**	**% of target**
Residential Sector	6.9	20.6	34.4	57.3	84.7	21%
C& I Sector	6.6	16.5	29.7	42.4	61.4	15%
Industrial Sector	1.3	8.6	28.2	39.0	50.4	13%
Municipal Sector	2.1	4.5	4.9	9.5	13.8	3%
Total Energy Eficiency Saving Target	16.9	50.2	97.2	148.1	210.3	53%
Total Energy Saving Target From RE & EE	41	109	204	315	448	
Year Wise % of Target	10%	27%	51%	79%	112%	



8.2 Five Year Budget Estimate Plan

Table 122 Renewable Energy Installation Budget

Renewable Energy	Budget Estimate in Lac `				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Residential Sector	3459	5189	6918	8648	10377
C& I Sector	1870	2806	3765	4700	5611
Industrial Sector	858	1288	1749	2178	2327
Municipal Sector	361	541	722	902	1082
Total Target Year Wise	6549	9823	13154	16428	19397

Table 123 Energy Efficiency Installation Budget

Energy Efficiency	**Budget Estimate in Lac `**				
	1st Year	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**
Residential Sector	1465	2197	2929	3662	4394
C& I Sector	121	181	242	302	362
Industrial Sector	106	159	212	265	319
Municipal Sector	94	141	188	235	282
Total Investment Year Wise (in Lacs `)	**1786**	**2678**	**3571**	**4464**	**5357**

8.3 Physical Target and Action Plan for Five Years

Different types of renewable energy system will be installed in Jodhpur 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. A list of renewable energy equipments and energy efficient devices has been presented in the table below.

8.3.1 Renewable Energy System Investment Plan

Table 124: RE System in All Sector for Jodhpur City

Renewable Energy System Installation for Jodhpur City						
System	**Total Installation**	**Per Item Cost `**	**Budget in Lac `**			
			Total Cost	**State Share @ 20%**	**MNRE Share @30 %**	**User Share @50%**
Solar Lantern	16247	2000	324.9	Nil	97.5	227.5
Solar Home Light	32495	10000	3249.5	NIL	974.9	2274.7
Solar Water Heater (100 LPD)	64990	18000	11698	2340	3509	5849
Solar Water Heater (500 LPD)	500	85000	425	85	128	213
Solar Water Heater (1000 LPD)	242	170000	411	82	123	206
Solar Water Heater (3000 LPD)	407	480000	1954	391	586	977
Solar Water Heater (5000 LPD)	348	600000	2088	418	626	1044
Solar Community Cooker	500	45000	225	Nil	68	158
Solar Cooker	11373	6000	682	NIL	205	478
Solar Inverter	53806	22000	11837	2367	3551	5919
Solar Power Plant 1kW	13729	90000	12356	2471	3707	6178
Solar Power Plant 3 kW	1863	270000	5030	1006	1509	2515
Solar Power Plant 5 kW	1893	450000	8519	1704	2556	4259
Solar Street Light 18 W LED	10814	8000	865	Nil	260	606
Solar Street Light 28 W LED	1108	10000	111	Nil	33	78
Solar Street Light 48 W LED	2000	16000	320	Nil	96	224
Solar Street Light 60 W LED	14182	20000	2836	Nil	851	1985
Solar Street Light 112 W LED	4620	32000	1478	Nil	444	739
Solar Traffic light	50	14000	7	Nil	2	5
Solar Hoardings	220	6000	13	Nil	4	9
Solar Road studs	10000	250	25	Nil	8	18
Total Investment In Lac `			**64456**	**12891**	**19337**	**32228**
Total Investment In Crore `			**645**	**129**	**193**	**322**

Year Wise Renewable Energy System Investment Plan

Table 125: Year Wise RE System Investment Target for Jodhpur city

Type of System	**Total Number**	**Item Cost in `**	**Budget in Lac `**				
			1st Year	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**
Solar Lantern	16247	2000	32	49	65	81	97
Solar Home Light	32495	10000	325	487	650	812	975
Solar Water Heater (100 LPD)	64990	18000	1170	1755	2340	2925	3509
Solar Water Heater (500 LPD)	500	85000	43	64	85	106	128

Solar Water Heater (1000 LPD)	242	170000	41	62	82	103	123
Solar Water Heater (3000 LPD)	407	480000	195	293	391	488	586
Solar Water Heater (5000 LPD)	348	600000	209	313	418	522	626
Solar Community Cooker	500	45000	23	34	45	56	68
Solar Cooker	11373	6000	68	102	136	171	205
Solar Inverter	53806	22000	1184	1776	2367	2959	3551
Solar Power Plant 1kW	13729	90000	1236	1853	2471	3089	3707
Solar Power Plant 3 kW	1863	270000	503	755	1006	1258	1509
Solar Power Plant 5 kW	1893	450000	852	1278	1704	2130	2556
Solar Street Light 18 W LED	10814	8000	87	130	173	216	260
Solar Street Light 28 W LED	1108	10000	11	17	22	28	33
Solar Street Light 48 W LED	2000	16000	32	48	64	80	96
Solar Street Light 60 W LED	14182	20000	284	425	567	709	851
Solar Street Light 112 W LED	4620	32000	148	222	296	370	444
Solar Traffic light	50	14000	0.7	1.1	1.4	1.8	2.1
Solar Hoardings	220	6000	1.3	2.0	2.6	3.3	4.0
Solar Road studs	10000	250	3	4	5	6	8
Year Wise total investment in Lacs `			**6446**	**9668**	**12891**	**16114**	**19337**
Year Wise total investment in crore `			**64.5**	**97.7**	**128.9**	**161.1**	**193.3**

8.3.2 Energy Efficiency System Investment Plan

Table 126 : EE System Installation in All Sector for Jodhpur City

Energy Efficient System Installation in Jodhpur City			
System	**Total Installation**	**Per Item Cost `**	**Public Share (Lacs `)**
Replacement of 60 Watt Bulb with 18 watt CFL	90806	120	109
Replacement of 100 Watt Bulb with 28 watt CFL	142762	150	214
Replacement of T12 with EE T5 Tube Light	115411	300	346
Replacement of conventional Ceiling Fan with EE ceiling Fan	112615	1500	1689
Replacement of conventional A.C. with 5 Star EE A.C.	27640	27000	7463
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	27640	18000	4975
Replacement of conventional Water Pump with 5 Star EE Water Pump(0.5 kW)	59141	2200	1301
Replacement of conventional Water Pump with 5 Star EE Water Pump(1 kW)	1203	3000	36
Replacement of conventional Water Pump with 5 Star EE Water Pump(2 kW)	965	4000	39
Replacement of 150 Watt Street Light with 60 watt LED	6489	7000	454
Replacement of250 Watt Street Light with 112 watt LED	4620	9500	439
Replacement of conventional Decorative with EE Decorative Light	1108	1200	13

Total Investment	17079

Year wise Energy Efficiency System Investment Plan

Table 127 : Year Wise EE System Investment Target for Jodhpur city

Type of System	Total Number	Item Cost `	Budget in Lacs `				
			1st Year	2nd Year	3rd Year	4th Year	5th Year
Replacement of 60 Watt Bulb with 18 watt CFL	90806	120	11	16	22	27	33
Replacement of 100 Watt Bulb with 28 watt CFL	142762	150	21	32	43	54	64
Replacement of T12 with EE T5 Tube Light	115411	300	346	52	69	87	104
Replacement of conventional Ceiling Fan with EE ceiling Fan	112615	1500	169	253	338	422	507
Replacement of conventional A.C. with 5 Star EE A.C.	27640	27000	746	1119	1493	1866	2239
Replacement of conventional Refrigerator with 5 Star EE Refrigerator	27640	18000	498	746	995	1244	1493
Replacement of conventional Water Pump with 5 Star EE Water Pump	59141	2200	130	195	260	325	390
Replacement of conventional Water Pump with 5 Star EE Water Pump(1 kW)	1203	3000	4	5	7	9	11
Replacement of conventional Water Pump with 5 Star EE Water Pump(2 kW)	965	4000	4	6	8	10	12
Replacement of 150 Watt Street Light with 60 watt LED	6489	7000	45	68	91	114	136
Replacement of250 Watt Street Light with 112 watt LED	4620	9500	44	66	88	110	132
Replacement of conventional Decorative with EE Decorative Light	1108	1200	1	2	3	3	4

8.3.3 Capacity Building and Awareness Program

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. Jodhpur 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 through 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

Jodhpur 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 Jodhpur, 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 Jodhpur as a solar city, the principal government agencies should be committed to:

- Discussing critical energy issues jointly through 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.

8.4 Financial Requirement for Jodhpur Solar City Master Plan and Sharing of Funds

The total indicative budget for the development of Jodhpur as a Solar City is estimated to be Rs. 920

crore, through renewable energy as well as energy efficient system installation, and 13 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 , State and end user . MNRE will share (30 %) for flat RE system and up to 90 % under demonstration projects scheme. 20 % subsidy on roof top Solar PV provided by state government and rest part will be invested by the private users or end user (50 % and 70% for investment in renewable energy sector and 100 % shared by public users for energy efficient system installation). 70 % system cost bear by user where state subsidy of RE system in not available. The budget for implementation of RE strategy and EE strategy is estimated to be Rs. 742crore and Rs.179 crore respectively. Estimated budget for the renewable energy pilot projects is around 95 Crore. Budget for establishment of the Solar City Cell and awareness and publicity is estimated to be Rs. 48.30 Lakhs, which could be enhanced depending upon the requirement. While budget for RE strategy will be shared amongst MNRE, state/city and private users, private investors will primarily drive EE activities.

Table 128 : Sharing of Budget for development of Jodhpur City as Solar City

S.No.	Budget	Budget in Crore `
1	MNRE Share	243
2	State Share	155
3	User Share	522
4	**Total Budget**	**920**

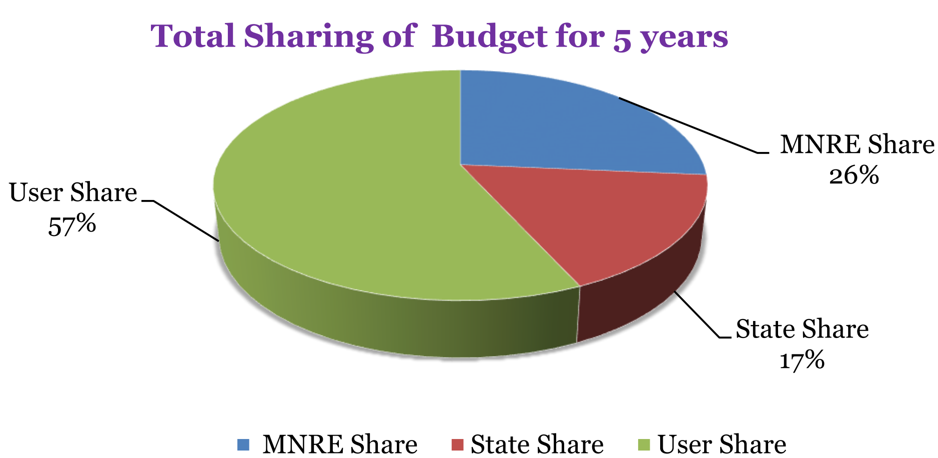


Table 129 : Sharing of Budget for Renewable Energy System Installation (under MNRE plus state subsidy applicable) for development of Jodhpur City as Solar City

	Sharing of Budget in Crore `

Institutional Sharing	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total Budget
State Subsidy @ 20 %	10.9	16.4	21.8	27.3	32.7	**109**
MNRE Share @ 30 %	16.4	24.5	32.7	40.9	49.1	**164**
User Share @ 50 %	27.3	40.9	54.5	68.2	81.8	**273**
Total Budget	**54.5**	**81.8**	**109.1**	**136.4**	**163.6**	

Table 130 : Sharing of Budget for Renewable Energy System (where only MNRE subsidy applicable) for development of Jodhpur City as Solar City

Institutional Sharing	Sharing of Budget in Crore `					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total Budget
MNRE Share @ 30 %	3.0	4.5	6.1	7.6	9	**30.3**
User Share @ 70 %	7.1	10.6	14.1	17.7	21	**70.8**
Total Budget	**10.1**	**15.1**	**20.2**	**25.2**	**30**	

Table 131 : Sharing of Budget for Total RE System (includes Table 128 and Table 129 Budget) for development of Jodhpur City as Solar City

Institutional Sharing	Sharing of Budget in Crore `					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total Budget
State Share	11	16	22	27	33	**109**
MNRE Share	19	29	39	48	58	**194**
User Share	34	52	69	86	103	**343**
Total Budget	**64.6**	**97.0**	**129.3**	**161.6**	**194.0**	

Table 132 : Budget for RE Pilot Project Installation in Jodhpur city for 2013-15

Institutional Sharing	Sharing of Budget in Crore `
MNRE Share	49
State Share	46
Total Budget	95

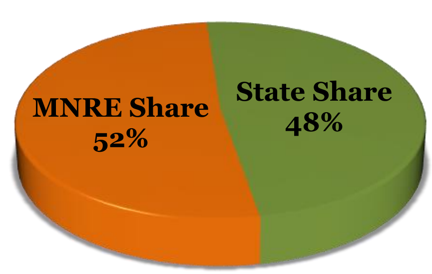


Figure 15 : Budget Sharing for Renewable Energy Pilot Projects for Jodhpur city

Year wise total sharing of budget, which includes renewable energy system installation, energy efficient system installation and renewable energy pilot projects for Jodhpur city are summarized in the following table no. 133.

Table 133: Year Wise Total Budget Sharing (RE Syste, RE Pilot Projects & EE System Installation in all sector) for Jodhpur City

Sharing of Funds	Estimated Investment in Crores `					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total Budget for 5 Year Plan
MNRE Share	68	29	39	48	58	**243**
State Share	57	16	22	27	33	**155**
User/ Private Share	52	78	104	131	157	**522**
Total Budget	**177**	**124**	**165**	**207**	**248**	

8.4.1 Year Wise total sharing of budget (for RE System , EE System Installation and RE Pilot Projects)

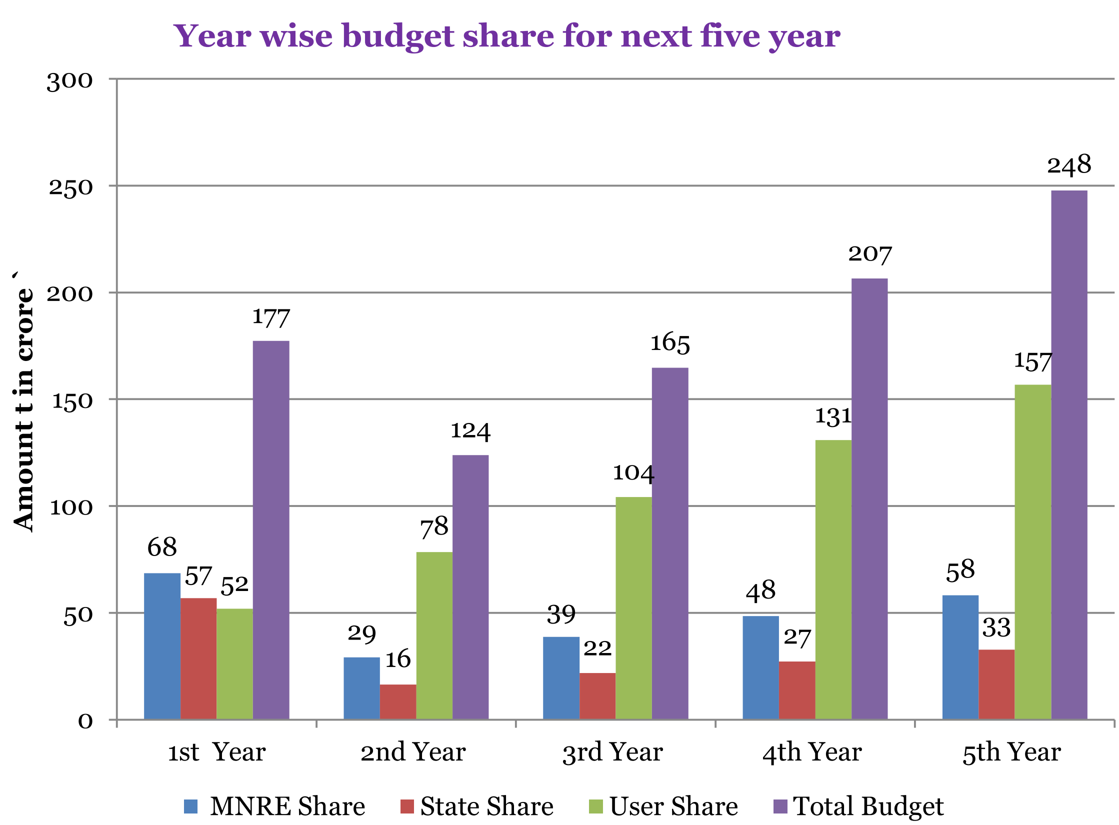


Figure 16: Year Wise Total Sharing of Budget which includes RE System Installation , EE System Installation and RE Pilot Projects

8.4.2 Action Plan for Jodhpur Solar City Master 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 through "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. JMC may take the initiative in this direction.
6. The Solar City Cell may initiate a dialogue with Jodhpur Vidhut Vitran Nigam Limited and Jodhpur 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 through 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 through Energy Services Company (ESCOs) route.
13. As Industrial Sector is the high energy consuming sector in Jodhpur, JMC 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 through 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.

The aims of a fuel switch from coal to district heating are to:

- Increase the efficiency of heat supply by 40%

- Reduce local emissions by 100% by shutting down decentralized coal boilers and switching to a central heating plant outside town
- Reduce overall CO_2 emissions by up to 100% (in the case of renewable energy use)
- Reduce traffic caused by transport of coal to decentralized consumers
- A feasibility study to assess the practicalities of a fuel switch and accurately quantify the possible impacts needs to be carried out.
- A business model can be designed for implementation in PPP model (defining the role of municipality and others, defining funding requirements, incentive for consumers to get connected, outlining the pricing model, etc.)

Benefits of recommendations above

- One measure can reach thousands of consumers
- The project could significantly contribute to the overall energy reduction targets of the Solar City Master Plan
- Reduction of local emissions (direct and indirect through reduced traffic)
- Reduction of energy consumption in the industrial sector

Other Recommendations

- Set goals such as Zero Energy Buildings or 20-30% Savings
- Establish Zero Energy Community and Commercial Zones
- Apply advanced technologies in JMC's operations and use of Green procurement policies and incentives
- Learn from best practices of national and international experiences (e.g. DOE/BNL promoted US-India Cities Partnership)
- Support R&D/businesses to foster new industry and green jobs

Encourage Energy Efficiency and Ecological Symbiosis in Industries

- Encourage industries for eco efficiency, energy efficiency and green accounting at a firm/industry level
- Reduce the energy intensity of industrial production by 30-50% with the help of advanced energy efficient and cogeneration technologies (Industrial cogeneration costs Rs. 4-5 crore/MW)
- Promote industrial symbiosis within the city based industries as well as at regional level for inter-industry/sector integration/cogeneration/reuse of various resources and by products

Performance Evaluation and Improvement Frameworks

- Establish management frameworks for effective operation of urban infrastructure and services
- Design performance evaluation matrix for benchmarking operational efficiencies compared to the planned capacities
- Develop frameworks for continuous improvements in the plans based on the performance of actual systems
- Create a high powered committee to implement the energy plan/ policy (Low Carbon Policy Steering Committee)
- Develop a plan to continuously monitor the progress and provide improvements to the energy plan/ policy
- Provide incentives to city officials for energy efficiency (Champion Awards to departments, zones and individuals)
- Institute and expand peak load management and improved metering
- Tackle urban heat island issues (green/white roofs, other paved surfaces, urban forestation)

Sustainable Energy Plan for Jodhpur – Renewable Energy

- Work with energy providers and all city departments (associated with energy) to provide sustainable energy in Jodhpur and create Energy Plan for 2030 (Stakeholder/Advisory Committee)
- Innovative features such as Geographic Information System (GIS), energy audit, and disaster management must be an integral part of future development plan
- Prioritize five key areas for targeted incentives
    1) Provide incentives to city officials for energy efficiency (Champion Awards to departments, zones and individuals)
    2) Performance based incentives for buildings and facilities
    3) Provide incentives to new green developments (floor-space, development rights, tax
    4) Incentives to new constructions using city based green products, contractors, and services
- Expand peak load management and improved metering
- Tackle urban heat island issues (green/white roofs, other paved surfaces, urban forestation)

Allocate 100% of organic waste (food/garden waste/cellulosic biomass) generated within the satellite town for electricity or energy production with the help of bio-refineries and methane to CNG conversion.

Annexure 1: Solar Radiation Map of India

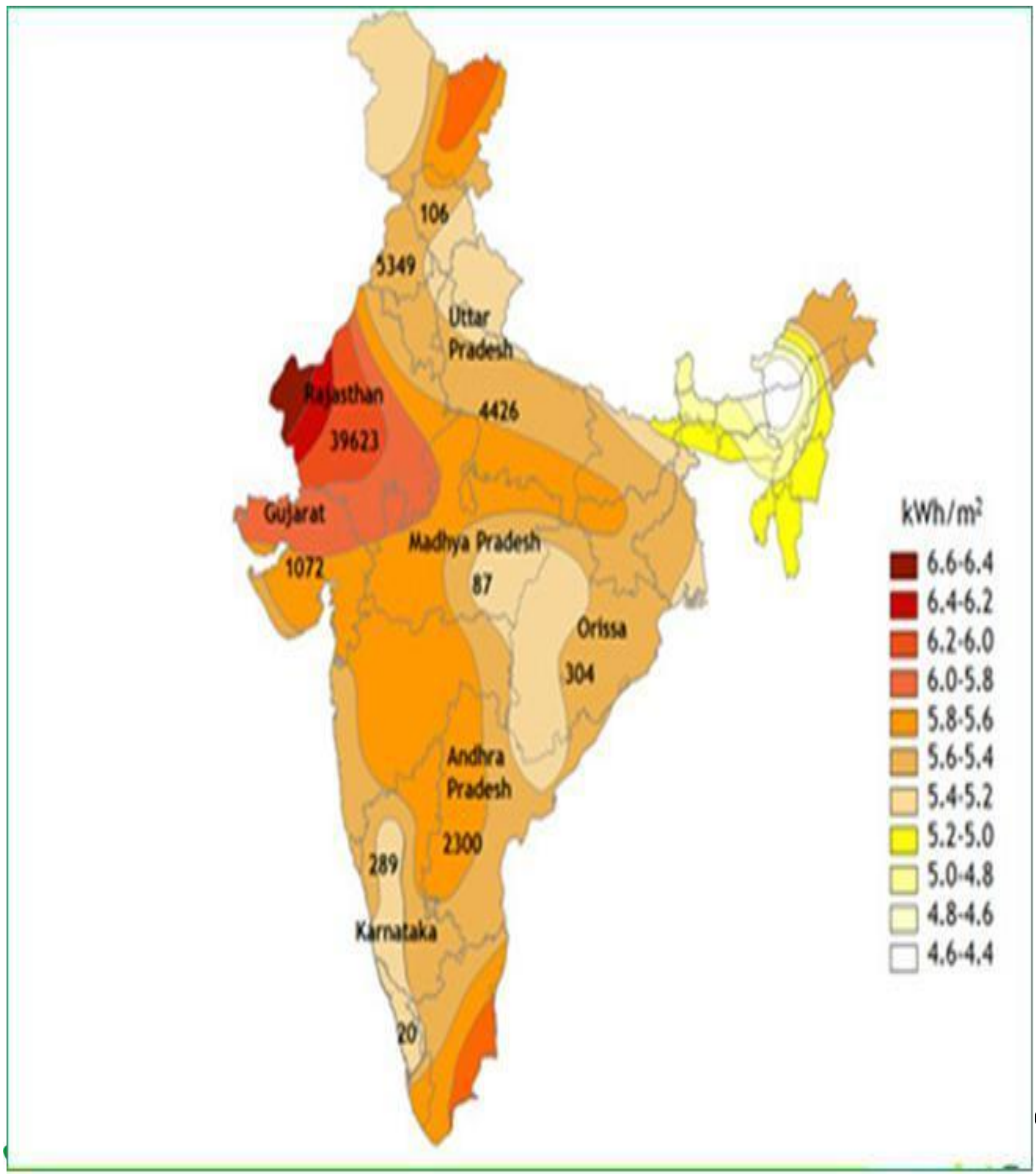


Figure 17: Solar Radiation Map of india

Annexure 2: Wind Power Density Map of India

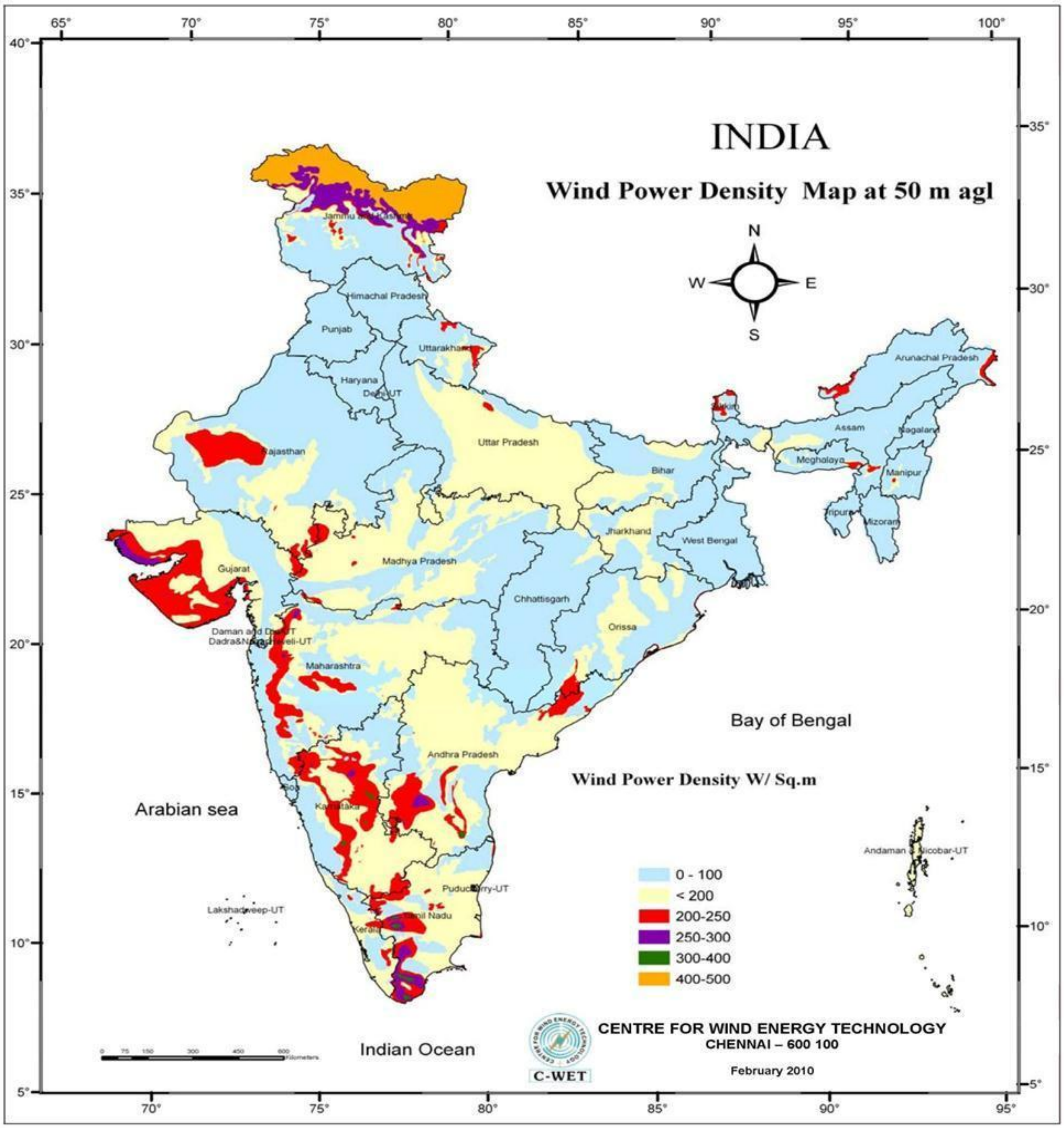
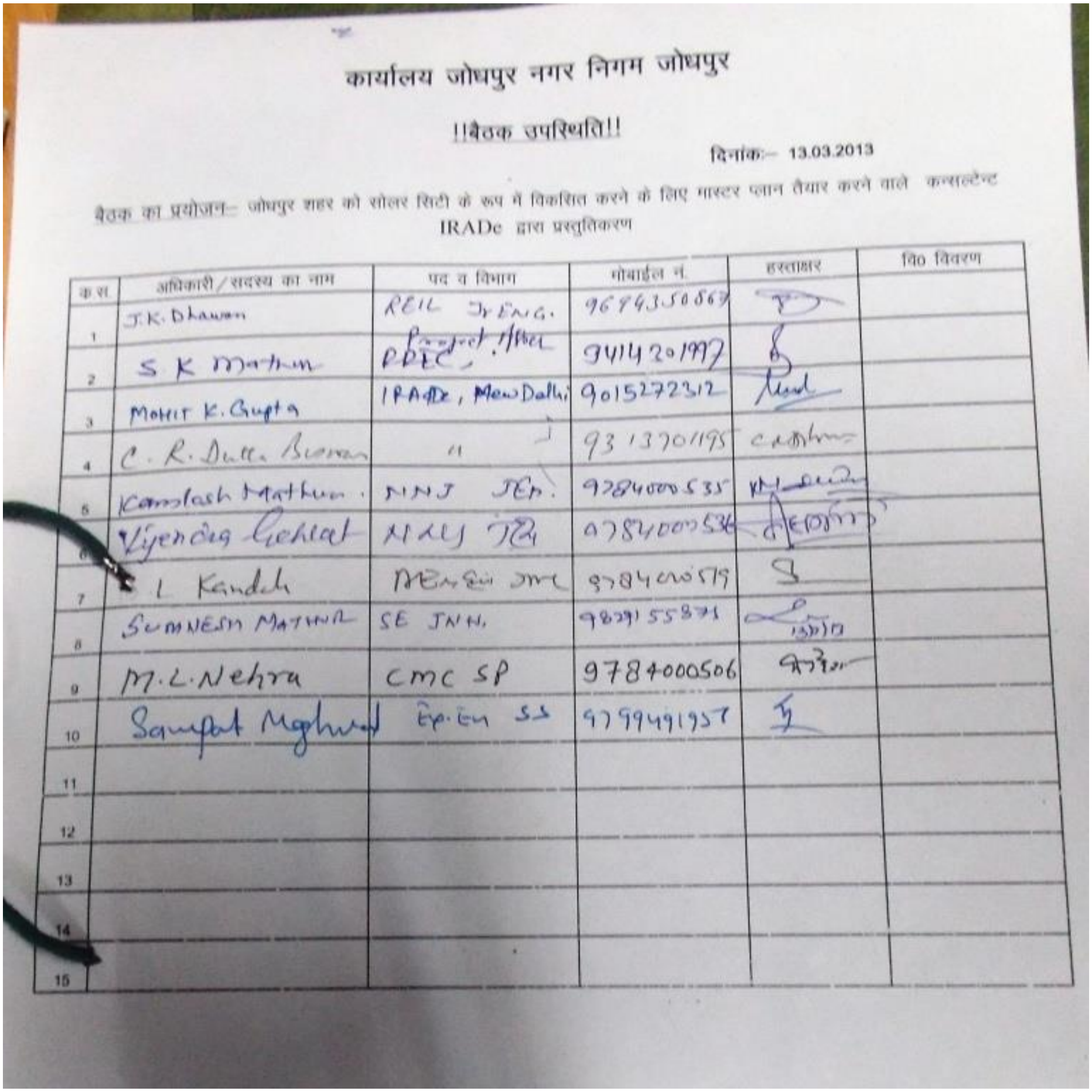


Figure 18 : Wind Power density map of India

Annexure 3: Web link of important web pages

S.No	Description	Web link
1	Ministry of New andRenewable Energy	http://www.mnre.gov.in
2	List of Manufacturers and	http://www.mnre.gov.in/information/manufacturesindust
3	Dealers of Energy Technologies	riesarchitectsconsulting-organisation
4	Central Electricity Regulatory Commission	http://www.cercind.gov.in
5	Rajasthan Renewable Energy corporation Limited Regulatory Commission	http:// www.**rrecl**.com
6	The Indian Renewable Energy Development Agency IREDA	http://www.ireda.gov.in
7	Centre for Wind Energy Technology (C-WET)	http://www.cwet.tn.nic.in
8	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
9	Jawaharlal Nehru NationalSolar Mission (JNNSM):Schemes and Documents	http://www.mnre.gov.in/solar-mission/jnnsm/introduction-2

Annexure 4: Attendance Sheet Stakeholder Meeting at JMC ,Jodhpur on 13th March 2013



कार्यालय जोधपुर नगर निगम जोधपुर

!!बैठक उपस्थिति!!

दिनांक:- 13.03.2013

बैठक का प्रयोजन:- जोधपुर शहर को सोलर सिटी के रूप में विकसित करने के लिए मास्टर प्लान तैयार करने वाले कन्सल्टेन्ट IRADe द्वारा प्रस्तुतिकरण

क.स.	अधिकारी / सदस्य का नाम	पद व विभाग	मोबाईल नं.	हस्ताक्षर	वि० विवरण
1	J.K. Dhawan	REIL Jr. ENG.	9694350867		
2	S K Mathur	Project Officer RDEC	9414201997		
3	MOHIT K. Gupta	IRADe, New Delhi	9015272312		
4	C. R. Dutta Biswas	"	9313701195		
5	Kamlesh Mathur	NNJ JEn.	9784000535		
6	Vijendra Gehlot	NNJ JEn	9784000536		
7	[illegible] L Kandh	[illegible]	9784000579		
8	SUMNESH MATHUR	SE JNN.	9829155871		
9	M.L. Nehra	CMC SP	9784000506		
10	Sampat Meghwal	Ex. En SS	9799491957		
11					
12					
13					
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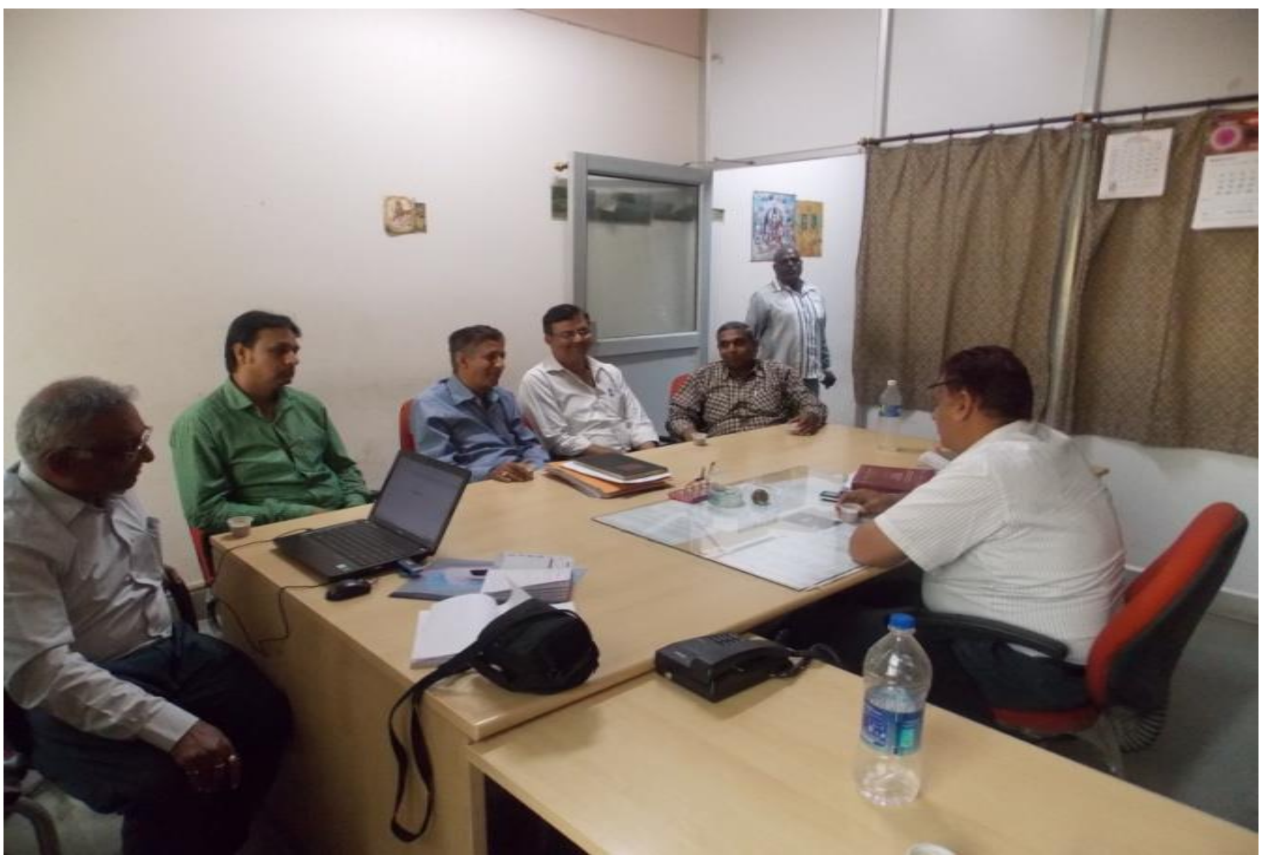
Figure 19 : Attendence sheet of Stakeholder consultation meeting

Annexure 5 : Stakeholder Meeting Photograph at JMC Jodhpur on 13th March 2013



Appendix-I

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 through Municipal Corporations/ Municipalities or in electricity tariff though 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.

Appendix-II

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.

Appendix-III

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 through Municipal Corporations/ Municipalities

   & in electricity tariff though 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 programmes/ 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 through renewable energy and energy conservation devices during five years of implementations for developing their city as Solar City.

Appendix IV

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 through Municipal Corporations/ Municipalities & in electricity tariff though 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.