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ICLEI
Local
Governments
for Sustainability

Integrating Urban Climate Guidelines through Clean Technologies (RE & EE) at the State and City Level to build Sustainable Low Carbon Cities

Tamil Nadu State's Project Cities
GHG Emission Inventory, Energy Consumption Profile & City Specific Low Carbon Action Plans

March 2013

Notes to the Readers

This report is an output of the Project titled "Integrating Urban Climate Guidelines through Clean Technologies (RE & EE) at the State and City level to build Sustainable Low Carbon Cities" prepared by ICLEI South Asia with support from British High Commission. The Report provides the brief city profile, energy consumption status, sectoral GHGs emission inventory, suggested sectoral low carbon implementable actions for project cities namely Coimbatore, Tiruchirapalli and Tirunelveli from Tamil Nadu State. The report also highlights the techno economic feasibility of each suggested low carbon actions. Beneficiaries' contributions and available subsidies are also discussed for each low carbon actions.

Comments and suggestions are welcome and could be sent to ICLEI South Asia at **iclei-southasia@iclei.org**

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Preface

Climate change is a global concern and it's an evident fact that Indian cities in particular are vulnerable to its impacts. As engines of economic growth, cities in India are burgeoning in size due to urbanization and population growth, inevitably becoming consumers of a wide range of resources. As cities grow in size and population, the demand for basic resources and civic services like modern energy, transport, communications and financial services etc grow in parallel. The industrialization that accompanies this demand causes increasing Carbon emissions which eventually make the very engines of the Indian economy vulnerable to threats arising due to Climate change. Realization that cities are where the mitigative and adaptive initiatives against climate change have the highest potential makes the action initiated at local levels crucial. Hence, the urgent need to address climate change is in fact a corollary to sustainable economic growth.

A low Carbon economy presents a sustainable perspective to economic growth and propels innovation and productivity. In order that interventions which facilitate adoption of a low Carbon model of growth and development are considered, the prevailing condition in terms of energy usage and resource consumption needs a comprehensive assessment at the city level. The appraisal of the patterns of energy and resource consumption at a city level helps identify the areas where low Carbon development can have the highest impact while leveraging the policies outlined by the local government.

This report informs both the policy makers and local governments about the current patterns of consumption of energy and resources in the project cities and the line of action that would avail the best results when implemented at the local level. The report highlights the prevailing scenario and suggests local government actions that offer the best mitigative and adaptive results against Climate change and low Carbon development as a result.

Acknowledgement

ICLEI South Asia and the British High Commission wish to thank the following organizations and their utilities for their cooperation in providing the information that made this publication possible.

- Coimbatore District Small Industries Association
- Indian Chamber of Commerce and Industry
- District Industries Center
- Indian Statistical Institute
- District Supply Office
- State Energy Department
- State Forest Department
- Bharat Petroleum Corporation limited
- Indian Oil Corporation limited
- Hindustan Petroleum Corporation limited

Acronyms and abbreviation

WRI	World Resources Institute
WBCSD	World Business Council for Sustainable Development
MMTCDE	Million Metric Tonnes of Carbon Dioxide Equivalents
MSTCDE	Million Short Tonnes of Carbon Dioxide Equivalents
ULB	Urban Local Body
CDP	City Development Plan
CODISSIA	Coimbatore District Small Industries Association
IPCC	Intergovernmental Panel on Climate Change
IEAP	International Local Government Greenhouse Gas Emissions Analysis Protocol
GSDP	Gross State Domestic Product
BHEL	Bharat Heavy Electricals Limited
NLC	Neyveli Lignite Corporation Limited
NTPC	National Thermal Power Corporation
RGGVY	Rajiv Gandhi Gramin Vikas Yojna
DMS	Demand Side Management
SEZ	Special Economic Zone
Lpcd	Liters per capita per day
TPD	Tons per day
MLD	Million Liters per day
STP	Sewerage Treatment Plant
NH	National Highway
UGD	Underground Drainage
MT	Metric Tonnes
TNEB	Tamil Nadu Electricity Board
IOLC	Indian Oil Corporation Limited
HPCL	Hindustan Petroleum Corporation Limited
SLB	Service Level Benchmarking
LPG	Liquid Petroleum Gas
SAPCC	State Action Plan on Climate Change
BEE	Bureau of Energy Efficiency
IMD	India Meteorological Department
INCCA	Indian Network for Climate Change Assessment
MU	Million Units
Mt	Million tons
CAGR	Compounded Annual Growth Rate
NTPC	National Thermal Power Corporation

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Executive Summary

Climate change concern is global and requires a global plan of action for resilience against its imminent impacts. International negotiations have increasingly been driven towards the need for global confluence of climate change adaptation and mitigation strategies that provide tailor-made solutions to individual nations especially to those in South Asia and Africa where the repercussions of climate change, in absence of robust infrastructure and institutions, are expected to be adverse. Cities and local communities is where the 'rubber hits the road' for climate change mitigation and GHG emissions abatement. Cities are also where the impacts of rapid urbanization, infrastructural and institutional inadequacies are rampant and are already increasing the pressure on local governments for sustainable urban living and development. Conflicting demands which are seemingly hard to satisfy are increasing in parallel to a global call for change in a direction that guides us to a sustainable and preferably low Carbon future.

This Project titled 'Integrating Urban Climate Guidelines through Clean Technologies (RE & EE) at the State and City level to build Sustainable Low Carbon Cities' is aimed at driving the City-level use of Clean technologies through Renewable Energy and Energy Efficiency initiatives that impart local low Carbon development while addressing the increasing demand for energy which is expected to take manifold proportions in the coming years. Guided by strategies that abate GHG emissions based on the Energy Consumption profile of the Project cities, the project presents a basket of tailor-made solutions for each Project city achieved through City profiling, Emissions inventorization and creation of Local Action Plans that leverage the city-level development strategies of local governments for sustainable results.

This report is a culmination of the study undertaken by ICLEI-Local Governments for Sustainability in three Project cities in Tamil Nadu namely Coimbatore, Tiruchirapalli, and Tirunelveli. The cities have been chosen in order to represent the socio-economic diversity within the State and hence the varying infrastructure and civic facilities in each of these cities. Representing a range from a metropolitan to an urbanizing town, the cities of Coimbatore, Tiruchirapalli and Tirunelveli are representative of the diverse facets of the State.

Introduction to the Project, methodology followed and tools used are outlined in Chapter 1 and 2. Elucidation of the variations in social, economic and administrative facets of the State is made in Chapters 3. Chapter 4 presents the Coimbatore city's social, economic and administrative profile, energy consumption profile, GHG emission inventory and suggested low carbon action plans. Chapter 5 presents the Trichy city's social, economic and administrative profile, energy consumption profile, GHG emission inventory and suggested low carbon action plans. Chapter 6 presents the Tirunelveli city's social, economic and administrative profile, energy consumption profile, GHG emission inventory and suggested low carbon action plans followed by relevant references and annexes.

1. About the Project

Rapid urbanization and urban economic growth have led to emergence of a number of complex issues such as degradation of natural resources and increase in green house gas emissions that threaten sustainability of our cities. With Indian cities projected to rapidly urbanize between 2010 and 2030, the per capita carbon dioxide emissions are expected to increase from 1.0 -1.2 tonnes to 3.0 - 3.5 tonnes (Atkins, 2011). According to the McKinsey Global Institute, Indian cities have the potential to contribute approximately 70 percent of the country's Gross Domestic Product (GDP) by 2030 thus putting stress on the already overburdened urban systems which will be further aggravated on account of climate change factors (MGI, 2010). Managing greenhouse gas emissions, water consumption and waste management are some of the national priorities that present major investment opportunities in the coming years. The challenge of climate change and the need for a low carbon development model are well accepted by both policy makers and business leaders. Fuelled by economic liberalization and globalization, India aims to sustain its rapid economic growth, as well as protect the vulnerable segments of its society and climate sensitive sectors. India, with declining fossil fuel resources, needs to work towards transition to a more energy efficient, low carbon economy.

British High Commission (BHC) has initiated the project "Integrating Urban Climate Guidelines through Clean Technologies at the State and City Level to build Sustainable Low Carbon Cities" through ICLEI South Asia, funded under the Prosperity Fund of the UK's Foreign and Commonwealth Office. The objective of the project is to notify guidelines on urban low carbon actions and to leverage national/international finance for urban low carbon action for Tamil Nadu and Rajasthan States. The project will work towards building the capacity of state and city governments to successfully integrate urban climate guidelines on low carbon actions into major urban processes and systems. Activities will be initiated and monitored in 7 cities: Jaipur, Udaipur, Kota and Jodhpur in Rajasthan; and in Tiruchirapalli, Coimbatore and Tirunelveli in Tamil Nadu. Based upon this experience, the project aims to form well informed, comprehensive guidelines for state governments to implement.

1.1 Project Activities & Outputs

1. A Report on Financing Opportunities for Low Carbon Urban Growth for States in India including an analysis of funding opportunities under various national and international financing schemes.
2. Knowledge online portal with (a) relevant guidance information for cities to identify and leverage international/ central/ state level programmes/funding schemes and (b) about low carbon technologies/ measures that can be implemented for city level low carbon actions.
3. Green House Gases (GHGs) Inventorization for all 7 project cities in Tamil Nadu and Rajasthan State
4. Preparation of City specific Action Plans focusing on Climate Change mitigation for selected 7 cities covering solid waste management (SWM), lighting, water and

sanitation pumping systems, housing, energy efficiency etc by incorporating feedback and suggestions from the city level stakeholder consultations.

5. An India specific Local Government GHG Protocol based on principles drawn from ICLEI's International Local Government GHG Emissions Analysis Protocol
6. City-level monitoring, reporting and verification (MRV) system framework for state governments
7. State-level guidelines on urban low carbon actions
8. Capacity building of city staff on GHG inventory and financial proposal writing for funds generation.

Report on "Urban Low Carbon Growth: Financing Opportunities for Indian Cities" prepared under this project is available on project web portal http://urbanlowcarbonfinance.iclei.org/. This report provides the details on the available financing opportunities for Low Carbon Urban Growth for States in India including analysis of funding opportunities under various national and international financing schemes relevant to urban low carbon actions. This report also informs both policy makers and local governments about the financial opportunities available to them to move towards the low carbon path. It helps to understand how the funding organizations, private partners can support climate action at the urban and local levels. Thus, the report highlights the ways in which existing financial mechanisms can be perceived by the city decision- makers, reveals barriers to the local government action and record processes through which local governments can pursue mitigation activities.

An online knowledge portal is being developed to guide cities to identify and leverage international/central/state level programmes/funding schemes to enable them to implement city level low carbon actions have been developed. The web portal will be updated as and when required to provide up to date information.

The web link for the project information is http://urbanlowcarbonfinance.iclei.org/.

This Report provides the brief profile of Tamil Nadu State and 3 project cities namely Tiruchirapalli, Coimbatore and Tirunelveli. The project cities' baseline energy consumption status and sectoral carbon emission inventory covering Residential, Commercial, industrial, Transport and waste has also been covered.

2. Methodology

One of the major outputs of the project is to come out with a GHG inventorization of 3 cities namely Coimbatore, Tiruchirapalli and Tirunelveli from Tamil Nadu State. The report includes the sector wise carbon emissions from the various energy and other sources. The emission inventory follows the principle drawn from WRI/WBCSD/ICLEI GHG Protocol (IEAP Protocol). The basic approach to calculate the carbon emissions is based upon the fuel & electricity consumption in various sectors (Residential, Commercial, Industrial, and Transportation, etc) and waste disposal.

ICLEI – South Asia has developed an in house software tool called Harmonized Emissions Analysis Tool (HEAT) Plus to calculate the GHG inventory from the energy consumption and waste disposal in the urban areas. This software tool is specifically designed for the urban local governments considering the type of energy used in the urban sector and the services delivered by the urban local bodies. The software covers the operations owned by Government as Government Operation Emissions (that includes all the services such as street lighting, water supply system, sewage system, etc.) and the Community Level emissions that includes the rest of the city information (such as residential, transportation, commercial, etc.).

Measures and Metrics

Carbon Dioxide (CO_2): CO_2 is the reference of comparison of all GHGs.

Carbon Dioxide Equivalent (CDE): A metric measure used to compare the emissions from GHGs based on their GWP. Carbon dioxide equivalents are usually expressed as "Million Metric Tonnes of Carbon Dioxide Equivalents (MMTCDE)" or "Million Short Tonnes of Carbon Dioxide Equivalents (MSTCDE)".

Notes and Assumptions

Data has been collected from various sources, a few of which have been mentioned in the sections below. However, some information was not available, so the study used various methodologies and assumptions to create most probable values.

2.1 Project Boundaries

The various services like – Street lighting, Water Supply and Water Treatment, Sewage Treatment Plants and Sewage Pumping Stations, Waste Management etc are maintained by respective ULBs like Municipal Corporations and Municipalities in Coimbatore, Tiruchirapalli and Tirunelveli. Study area has been limited to respective Corporation jurisdiction areas.

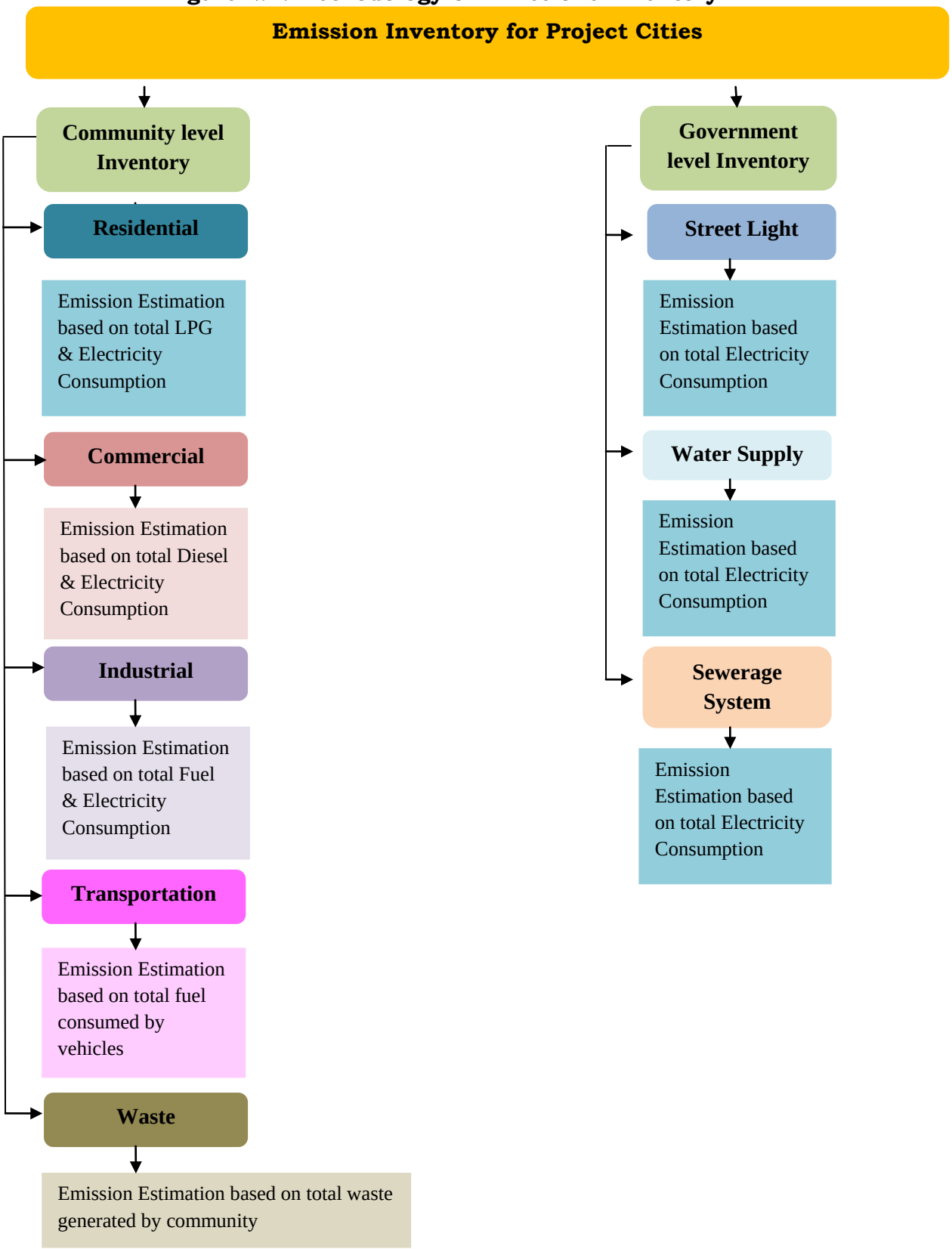
2.2 Methodology Followed

For the purpose of study estimations of GHG emissions for project cities have been done at two levels:

- Government operations inventories include emissions from all of the operations that a local government owns or controls. Common sectors in a government operations inventory include local government buildings and other facilities, streetlights, and water delivery facilities.
- Community-level inventories include emissions from all community activities within the local government's jurisdiction, including emissions from residential, commercial, transportation, industrial and waste sectors.

The complete methodology followed for the project is represented graphically below:

Figure 2.1: Methodology of Emissions Inventory



2.3 Data Collection

For the purpose of data collection and GHG inventory each of the urban area identified has been divided into two parts namely – Community Area and Government Area.

Community area is basically the total area falling under municipal corporation jurisdiction and includes all the energy consumption in that area in form of electricity consumption, fuel consumption for different sectors including the consumption of fuel for waste management.

Government area and the energy consumption includes the energy consumption for maintaining the various services of the municipal corporation whether it is street lighting, water supply and treatment, sewage treatment and supply and the waste management.

Coimbatore Municipal Corporation

Coimbatore municipal corporation area is the jurisdictional region under the administrative control of CMC and spread over 100 wards covering an area of 257 sq km. The Corporation limits were recently expanded in July 2011 to restructure 72 wards into 60 and add an additional 40 wards. The Corporation now has 5 zones in which these 100 wards are divided for ease of administration. While each zone has a Zonal officer, the city activities are administered by the Corporation.

The 100 wards are divided into 5 zones as:

- North Zone comprises wards No. 1 to 4, 26 to 31, 38 to 44, 46, 47 and 55.
- South Zone comprises wards No. 76 to 79, 85 to 100.
- East Zone comprises wards No. 32 to 37, 56 to 67, 69 and 75.
- West Zone comprises wards No. 5 to 24.
- Central Zone comprises wards No. 5, 45, 48 to 54, 68, 70 to 74 and 80 to 84.

The main functions of the Corporation are: Sanitation and solid waste management, provision and maintenance of street lights, development of city infrastructure, community development projects, slum improvement schemes, physical environment improvement projects, employment generation schemes, public health projects, maintenance of fire services, tax collection, and registration of birth and deaths etc. The Mayor is directly elected for five years.

Tiruchirapalli Municipal Corporation

Municipal Corporation of Tiruchirapalli has its jurisdictional control spread over 4 zones consisting of 60 wards covering an area of 147 sq km. The Corporation was upgraded to this level in 1994 with Mayor as head elected directly. The activities of the Corporation are executed by Commissioner who is facilitated by Zonal officers and additional commissioners for departments like Public Health, Accounts, and Town Planning etc. The Corporation is mainly responsible for provision of basis services like Roads, Street Light , Solid waste management , Sanitation, Storm water Drainage, Etc.

The 60 wards are divided into 4 zones as:

- Srirangam Zone comprises wards No. 1 to 6, 8 to 13, 16 and 18.
- Ariyamangalam Zone comprises wards No. 7, 14, 15, 19 to 29, 33,61,62,64
- Ponmalai Zone comprises wards No. 30 to 32, 34 to 39, 42 to 44, 46 to18, 63 and 65.
- K. Abhishekapuram Zone comprises wards No. 40,41, 45, 49 and 60

Tirunelveli Municipal Corporation

Municipal Corporation of Tirunelveli has administrative control of an area that extends to 108.65 sq km covering 55 wards divided into 4 zones. The Corporation was upgraded to this level in 1994 with Mayor as head elected directly. The activities of the Corporation are executed by Commissioner who is facilitated by Zonal officers and additional commissioners for departments like Public Health, Accounts, and Town Planning etc. The Corporation is mainly responsible for provision of basis services like Roads, Street Light , Solid waste management , Sanitation, Storm water Drainage, Etc.

The data is collected from different departments pertaining to energy consumption in project cities. The data collected from different departments is then analyzed and GHG inventory has been prepared for each city.

Following table list the different departments from where data has been collected for the study:

Table 2.1: List of Departments/Organizations Consulted for Data Collection

Department/Organization
CODISSIA
Indian Chamber of Commerce and Industry
District Industries Center
Indian Statistical Institute
District Supply Office
Bharat Petroleum
IOCL

Department/Organization
HPCL
Town Planning Department, CMC
TNEB, State Government

2.4 Tool Used

ICLEI – South Asia has developed an in house software tool called Harmonised Emissions Analysis Tool (HEAT) to calculate the GHG inventory from the energy consumption in the urban areas. This software tool is specifically designed for the urban local governments considering the type of energy used in the urban sector and the services delivered by the urban local bodies. This software tool is equipped with multiple features which not only calculates the emissions for the cities but also provides the cities with number of reports for different sectors and also identifies the priority sector for immediate action plan. For more information on HEAT software please login www.heat.iclei.org.

2.4.1 The HEAT Plus Methodology/Formula

The HEAT Plus software estimation of GHGs Gases from Residential, Commercial, Industrial, Transport and Waste, etc is on the basis of the secondary data collected from the various city departments listed in Table 1 and the published reports of the respective Govt. Departments (City Development Plan, Coimbatore, Tiruchirapalli, Tirunelveli, Master Plan of Coimbatore (before jurisdictional restructure in 2011), Master Plan for Tirunelveli, Agricultural Research Databook 2002, CODISSIA, Tamil Nadu State Energy Department, Tamil Nadu State Forest Department etc).

2.4.2 Community Inventory Module

The HEAT Plus uses the IPCC methodology approach (based on fuel and electricity consumption in the source sectors) for GHG gases emission estimation.

A. Residential, Commercial and Industrial Sectors*:*

Data required on:

- Fuel and electricity consumption

HEAT plus use the following formula to calculate the emissions at the residential/commercial/industrial sectors:

Stationary	Fuel Consumption	Fuel Usage(Tonnes)*Emission Factor(Kg/Gj)*Energy Density(Gj/Tonnes)
Electricity	Grid Electricity Consumption	Energy Input(eKWh)*Emission Factor(Gms/KWh)

B. Transportation Sector:

Data required on:

- Fuel consumed by vehicle type OR total annual vehicle miles/kilometers traveled in your community by vehicle type Or Vehicle miles/kilometers (VMT/VKT) traveled, passenger miles/kilometers traveled (PMT/PKT)
- Costs of fuel consumption (optional)
- Fuel economy by vehicle type (optional)

The Transportation sector includes all fuel use associated with the movement of goods and people within the boundaries of your community. This sector calculates emissions based on either vehicle miles/kilometers traveled or fuel consumption data by vehicle type.

HEAT plus use the following formula to calculate the emissions at the transportation sector

Transportation	Fuel Consumption Based (Considering Fuel Efficiency)	Emission Factor (Gm/Km)*Fuel Efficiency (Km/Mj)*Energy Density (Gj/Ltr)*Fuel Usage (Ltrs)
	Fuel Consumption Based (Considering Energy Density)	Fuel Usage (ltrs)*Emission Factor (Kg/Gj)*Energy Density (Gj/Ltr)
	Distance Based (Considering VKT/VMT) – No Fleet Makeup	Emission Factor (Kg/Km)*Distance Travelled (Km)
	Distance Based (Considering Fuel Economy) – No Fleet Makeup	(Distance Travelled(Km)*Fuel Consumption(Ltr/Km))/Occupancy Factor*Emission Factor(Kg/Gj)*Energy Density(Gj/Ltr)

C. Waste Sector

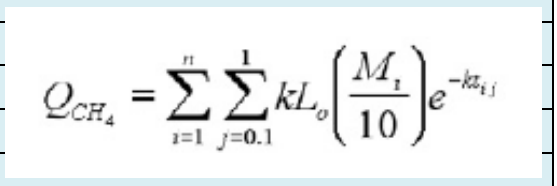
Data required on:

- Total annual amount of waste hauled to landfill OR known quantities of emissions
- Percentage composition breakdown of landfill waste
- Cost of land-filled waste by type (optional)
- Estimate of the percent of landfill methane recovered
- Amount of waste present in local landfills
- Cost of local landfills
- Landfill opening and closing dates
- Emission from the waste sector has been estimated using default method by using the total waste reaching the landfill sites annually and its organic content.

The Waste sector covers all waste generated by the community, as well as any waste that is brought to landfills or other waste management facilities that are wholly or partly owned or controlled by the local government. As it decomposes, waste creates emissions (e.g., methane) that can be significant in the context of your inventory.

HEAT PLUS calculates emissions from waste based on the amount and composition of waste in your community, waste management strategies employed, and the rate of methane recovery (if any) at local landfills. Using the Methane Commitment calculator, HEAT PLUS calculates the methane emissions that will eventually occur due to waste production in the base year, and assigns them to the base year. HEAT PLUS can also calculate methane emissions occurring from waste already present in landfills using the Waste-in-Place calculator.

HEAT PLUS uses the Following Formula to Calculate the Emissions in the Waste Sector

<table>
<tr><td rowspan="3">Waste</td><td rowspan="3">Landfill (Managed or Unmanaged)</td><td>Methane Commitment</td><td>[(1-R)A+B+C+D]*Quantity of Waste
R - Methane Recovery Factory,
A - eCO2 emissions of methane per tonne of waste at the disposal site,
B - eCO2 sequestered at the disposal site, in tonnes per tonne of waste,
C - eCO2 sequestered in the forest as the result of waste reduction and recycling measures Forest Sq,
D - Upstream emissions from manufacturing energy use saved as the result of waste reduction or recycling, in tonnes of eCO2 per tonne of waste</td></tr>
<tr><td rowspan="2">Waste Site Closure - FOD</td><td>  </td></tr>
<tr><td>QCH4= annual methane generation in the year of the calculation (m3/year)
i = 1 year time increment - goes from 0 to n and not 1 to n
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1 year time increment
k = methane generation rate (year-1)
Lo = potential methane generation capacity (m3/Mg)
Mi = mass of waste accepted in the ith year (Mg)
tij = age of the jth section of waste mass Mi accepted in the ith year (decimal years, e.g., 3.2 years)</td></tr>
</table>

2.4.3 Government Inventory Module

The Government Inventory module is designed to help you create an inventory of greenhouse gas and criteria air pollutant emissions produced directly by government's own operations (e.g., from local government-owned and local government-operated buildings, vehicles, streetlights, water pumping and sewage treatment operations). Operationally similar to the Community Inventory module, the Government Inventory module is organized into following sectors: Buildings, Facilities (Streetlights, Water/Sewage),

Transportation, Waste and Other. Based on information you provide about fuel and electricity use and waste production, this module calculates greenhouse gas and criteria air pollutant emissions resulting directly from your local government's operations.

A. Buildings, Streetlights, Water/Sewage Sector

These sectors cover fuel and electricity use (owned and/or occupied by your local government) in the respective sectors.

HEAT plus use the following formula to calculate the emissions in building sectors:

Stationary	Fuel Consumption	Fuel Usage(Tonnes)*Emission Factor(Kg/Gj)*Energy Density(Gj/Tonnes)
Electricity	Grid Electricity Consumption	Energy Input(eKWh)*Emission Factor(Gms/KWh)

B. Transportation (Vehicle Fleet Sector, Employee Commute Sector)

The Vehicle Fleet sector consists of all the vehicles owned and/or operated by your local government, including road vehicles, construction equipment, boats, aircraft, etc. You should include both owned and leased vehicles.

The Employee Commute sector calculates energy use and greenhouse gas emissions associated with travel to and from work by employees of the local government.

HEAT plus use the following formula to calculate the emissions in the transportation sector:

Transportation	Fuel Consumption Based (Considering Fuel Efficiency)	Emission Factor (Gm/Km)*Fuel Efficiency (Km/Mj)*Energy Density (Gj/Ltr)*Fuel Usage (Ltrs)
	Fuel Consumption Based (Considering Energy Density)	Fuel Usage (ltrs)*Emission Factor (Kg/Gj)*Energy Density (Gj/Ltr)
	Distance Based (Considering VKT/VMT) – No Fleet Makeup	Emission Factor (Kg/Km)*Distance Travelled (Km)
	Distance Based (Considering Fuel Economy) – No Fleet Makeup	(Distance Travelled(Km)*Fuel Consumption(Ltr/Km))/Occupancy Factor*Emission Factor(Kg/Gj)*Energy Density(Gj/Ltr)

2.4.4 Emissions Factors

HEAT PLUS contains thousands of emissions factors and energy densities for a wide range of fuels, combustion technologies and waste types. HEAT PLUS uses these values to calculate the greenhouse gas emissions and criteria air pollutants resulting from electricity usage, fuel consumption and waste decomposition. HEAT PLUS maintains one set of default emission factors and energy densities, and allows for the creation of one user modifiable set of emission factors and energy densities per account. You are able to view the values in the default set, but you cannot change these values. You can both view and change the values in the user modifiable set.

2.4.5 Energy Densities

HEAT PLUS contains energy densities for three different fuel types: solid, liquid, and gaseous. Solid fuels only have a weight (mass) density. Liquid fuels have both a weight (mass) and volume (liquid volume) density. Gaseous fuels only have a gas (gaseous volume) density. HEAT PLUS maintains one set of default energy densities and allows for the creation of one user modifiable set of energy densities per account. You are able to view the values in the default set, but you cannot change these values. You can both view and change the values in the user modifiable set.

2.5 How HEAT PLUS Calculates Emissions?

HEAT PLUS calculates the greenhouse gas and criteria air pollutant emissions produced and avoided based on energy use, waste production and other sources. The pollutants that HEAT PLUS tracks are carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), volatile organic compounds (VOCs) and coarse particulate matter (PM10). In addition to reporting emissions of these individual gases, HEAT PLUS also aggregates the emissions of the three primary greenhouse gases—CO2, N2O and CH4—and reports them in carbon dioxide equivalence (eCO2), a commonly used unit that combines greenhouse gases of differing impact on the earth's climate into one weighted unit.

HEAT PLUS calculates emissions from energy use on an end-use basis. For example, HEAT PLUS attributes the emissions associated with a kilowatt-hour of electricity to the jurisdiction using the electricity, not the power plant at which the electricity is generated. For emissions from energy use, the software converts energy use data into emissions using specific emission factors (coefficients) that relate the emissions of a particular pollutant (e.g., carbon dioxide and nitrous oxide) to the quantity of the fuel used (e.g., kilograms of coal or therms of natural gas) and the technology in which the fuel is combusted (e.g., a two-stroke internal combustion engine).

HEAT PLUS calculates methane emissions from the waste sector based on the way in which the biomass component of the waste decomposes over time. The amount of methane generated by waste depends on its composition and on the waste disposal technology. In addition, for measures that reduce waste generation or divert waste to more productive uses (e.g., composting and recycling), HEAT PLUS calculates upstream energy and non-energy emissions reductions from manufacturing.

3. Tamil Nadu State Profile

The South Indian State of Tamil Nadu has a unique identity and was formed on the basis of the Tamil language and culture which is a matter of esteem for the citizens of the State. Situated on the eastern section of the Indian peninsula, Tamil Nadu shares its borders with neighboring States of Andhra Pradesh, Karnataka, Kerala and the Union Territory of Pondicherry. The State occupies 11th position in terms of area and 7th position in terms of population and population density according to the 2011 census findings[1]. It is the fourth largest contributor at 7.49% to the national GDP[2] and is one of the most urbanized regions in the country.

Formed on 26th January 1950 and renamed as Tamil Nadu in 1969, Tamil Nadu has Chennai as its capital city. The State has 32 districts, 10 city corporations, 125 municipalities, 529 town panchayats and 12,524 village panchayats. It comprises of 39 Lok Sabha constituencies and 234 Legislative Assembly constituencies.

3.1 Details of Location, Geography and Climate of Tamil Nadu

3.1.1 Location

Tamil Nadu is located at 13° N lat and 80° E long and borders with three other States on the north, North West and western sides and one Union Territory. About 12 districts of the State have a coast line which extends the length of the State bordering with Bay of Bengal to the east, Gulf of Mannar and Palk Strait to the south east and Indian Ocean to its south.

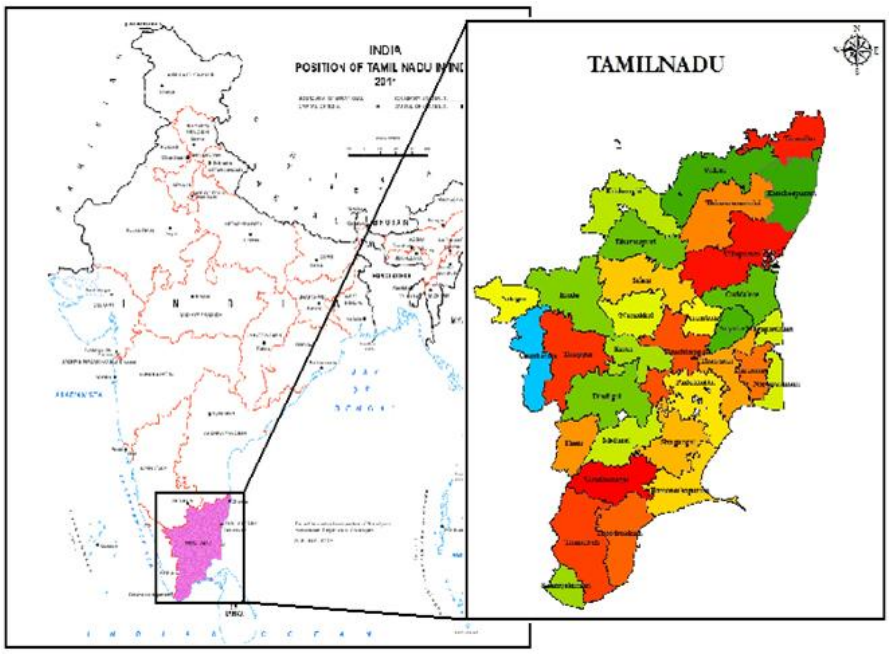


Figure 3.1: Position of Tamil Nadu

[1] Tamil Nadu population Census of India 2011
[2] Tamil Nadu national GDP contribution percentage- http://unidow.com/india%20home%20eng/Statewise_gdp.html

3.1.2 Geography

Covering an area of 130,058 sq km, Tamil Nadu has a varied geography consisting of hills and plateaus, rivers and lakes. While the Eastern and Western Ghats culminate in the State near the Nilgiri mountain range effectively blocking the border it shares with Kerala, the Eastern part of the State is green as a result of the coastal plains receiving the life-giving water from the rivers that emerge from the mountains to the west in the State.

The fertile coastal plains are fed by River Kaveri, River Bhavani, River Thamirabarani that emerge from the mountains in the Western Ghats and culminate either by draining into the Bay of Bengal or split into several tributaries creating reservoirs along the way before draining into the bay. The fertile coastal plains support agricultural activities in the State that generate produce like Rice, Banana, Mango, Coconuts, and Cotton etc. The region surrounding the Kaveri delta is renowned for paddy cultivation and is considered as the Rice Bowl of South India.

3.1.3 Climate

The climate in Tamil Nadu ranges over seven agro-climatic zones (see area under each zone below) and has varying climate experiences depending on the geographical location and altitude. On an average, the plains in the State experience a temperature range from 13° C min to 43° C max. The temperature at higher altitudes is in the range of 3° C min and 32° C max.

Tamil Nadu is heavily dependent on Monsoon which inevitably renders the State vulnerable to delays and absence of Monsoon rains. The normal annual rainfall the State receives is about 945 mm of which 48% is received during the North West Monsoon season and only 32% during South West Monsoon. The description of each zone is as follows:

Table 3.1: Climatic zones in Tamil Nadu[3]

Agro-Climatic zone	Area (sq.kms)	Description
Kaveri Delta	24943	50% area under agriculture. The region has rich fertile soils that support paddy cultivation. Also known as Rice Bowl of South India
North East Zone	32194	50.5% area under agriculture. Also known for good agricultural produce with area irrigated via lakes and dams
West Zone	15678	44.5% area under agriculture. This region is relatively more arid and dry
North West	18271	23% agriculture area and 30% forest area. Moderately drought prone region
High Altitude	2549	58.9% covered by forest area. Absence of major irrigation systems due to absence of rivers. Thriving agricultural activities are tea, coffee and vegetable cultivation near the Nilgiris mountain ranges
South Zone	36655	45% area under agriculture. The zone is drought prone and irrigated through dams, lakes and canal systems

[3] Planning Commission of India- *planningcommission.nic.in/reports/sereport/ser/7vgtn/v3_ch3.pdf*

Agro-Climatic zone	Area (sq.kms)	Description
High Rainfall	1684	62% area under agriculture. Offers a varied agricultural produce of Banana, Sugar, Coconut, Rubber and Paddy.

3.2 Administrative profile

The Governor is the constitutional head and the Chief Minister is the head of the government who presides over the council of ministers. The judiciary is headed by the Chief Justice. The State is divided into 32 districts and further subdivided into Corporation areas and municipalities and so on. For the purpose of administration, the State revenue and developmental activities are discharged by district divisions into Taluks and Blocks separately as shown below:

Table 3.2: Administrative profile of Tamil Nadu[4]

Districts	32
Revenue Divisions	76
Taluks	215
Revenue Villages	16564
Municipal Corporations	10
Municipalities	148
Panchayat Unions (blocks)	385
Town Panchayats	559
Village Panchayats	12620
Constituencies	
- Lok Sabha	39
- Assembly	234

Administrative control is discharged from Chennai (formerly Madras) which is the fourth most populous metropolitan city is India and 30th largest city in the world. The city covers an area of 426.7 sq. km and is populated by 6.2 million inhabitants in the main city region itself.

3.3 State Economy profile of Tamil Nadu

The general economic trend in Tamil Nadu has been an increasing inclination of growth towards the secondary and tertiary sectors as opposed to the primary sector. The State registered an overall annual average growth rate of 6.21%[5] in 2000-2001. In 2011, the GSDP of the State contributed 7.49% towards the total national GDP with a per capita income of INR 72,993[6].

Primary Sector

The State has a varied agro-based output with primary produce consisting of Rice, Coconut, Sugarcane and a wide range of food grains. The State registers an annual food

[4] Department of Economics and Statistics-Tamil Nadu
[5] Development Commissioner-Ministry of Micro, Small and Medium enterprises-http://dcmsme.gov.in/publications/traderep/sptnadu.pdf
[6] Economy of federal States in FY2011- http://unidow.com/india%20home%20eng/Statewise_gdp.html

grain production of 10 million tonnes with Rice alone exceeding 8 million tonnes. The State stood 5th in 2008 in terms of paddy output. Agriculture is practiced in about 58.2% of total area of the State. In addition, animal husbandry and livestock farming are other major primary activities and Tamil Nadu is the leading State in livestock, poultry and fisheries output.

Secondary sector

Tamil Nadu has been regarded as one of the most important States in terms of industrial and engineering output in the country. Heavy industry, Pump manufacturing, Textile machinery, Automobile parts, Electronics and others have made a considerable impact on the growth rate of economy in the State which stood at 11%[7] in 1999-2000. In 2008-09, the State rendered a total value of INR 12807432 lakh in production and employed about 1245928 workers out of the total workforce of 4,05,24,545[8]. In addition, the Khadi and Cottage industries generated INR 161735.03 lakh in profits in 2009-10. Following table indicates the breakdown indicating the industry subsectors and their contribution to national output.

Table 3.3: Secondary sector industry's share in national output[9]

Industry subsector	% of total national output
Heavy commercial vehicles	27
Railway coaches	49
Newsprint	17
Power driven pumps	50
Safety matches	90
Auto components	35
Motor cycles & mopeds	26
Cotton yarn	32
Leather products	70

Tertiary Sector

Tamil Nadu has a resurging share of software companies, financial service companies, tourism, hospitality, real estate, and communication and consultancy services. Tamil Nadu held a substantial share in software exports from India and grew by 29% in 2008-09 to INR 366 billion[10]. The Tourism industry in Tamil Nadu was second largest in India.

[7] Development Commissioner-Ministry of Micro, Small and Medium enterprises-http://dcmsme.gov.in/publications/traderep/sptnadu.pdf
[8] Development Commissioner-Ministry of Micro, Small and Medium enterprises-http://dcmsme.gov.in/publications/traderep/sptnadu.pdf
[9] Tamil Nadu Government-Urban Scenario assessment-*www.tn.gov.in/cma/urban-report.pdf*
[10] TN logs 29% growth in software exports-http://timesofindia.indiatimes.com/tech/techhome/5880659.cms

3.4 Demographic trends

According to 2001 census, Tamil Nadu had a population of 62, 405,679 and the State registered a decadal growth rate of 11.7%[11]. In 2011, Tamil Nadu's population grew to 72, 138, 958 and the decadal growth rate was 15.6%[12]. Tamil Nadu had a literacy rate of 73.47% which increased to 80.33%. In 2001 the sex ratio in the State was 987 females per 1000 males and this figure increased to 995 in 2011[13]. Following tables indicate the population growth and current demographic profile.

Table 3.4: Population growth in Tamil Nadu[14]

Year	Population	Decadal Growth %
1961	33687000	-
1971	41199000	22.3
1981	48408000	17.5
1991	55859000	15.4
2001	62405678	11.7
2011	72138958	15.6

Table 3.5: Population data of Tamil Nadu[15]

Total Persons	72138958
Males	36158871
Females	35980087
Sex ratio	995
Total Persons below 6 years in age	6894821
Males below 6 years in age	3542351
Females below 6 years in age	3352470
Sex ratio(0-6)	947
Total literates	52413116
Literate Males	28314595
Literate Females	24098521
Male Literacy rate	86.81%
Female Literacy rate	73.86%

3.5 Ecological and Forest profile

Forests cover in the Western and North Western regions of the State in 2010 was 16.47% of the total State area which increased to 28.1% in 2011[16]. The State Forest department aims to increase forest cover to the nationally prescribed 33.33% through several initiatives[17]. The current forest cover and produce details are indicated in the tables below:

[11] Census of India 2001
[12] Census of India 2011
[13] Census of India 2011
[14] Census of India 2011
[15] Census of India 2011
[16] Planning Commission of India- *planningcommission.nic.in/reports/sereport/ser/7vgtn/v3_ch3.pdf*
[17] Tamil Nadu Forest Department http://www.forests.tn.nic.in/aboutus.html

Table 3.6: Tamil Nadu forest cover*

Forest Area	21431 sq. km
Reserved Forests	19214 sq. km
Reserved Areas	1552 sq. km
Unclassified Forests	665 sq. km

**Department of Economics and Statistics 2010*

Forest produce from Tamil Nadu*

Teak Wood	2271 Metric Tonnes (MT)
Firewood	3427.2 MT
Pulpwood	13054 MT
Sandalwood (sapwood and heartwood)	16.5 MT
Bamboo	1254.3 MT
Tamarind	13670.5 MT

**Department of Economics and Statistics 2010*

3.6 Energy profile of Tamil Nadu State

As mentioned earlier, the total installed capacity of power generation from conventional sources in Tamil Nadu is 10, 237 MW. However, the actual availability is about 8000 MW on an average giving rise to a sharp deficit of 2500 MW to 3500 MW for a demand that often reaches a maximum of 11,500 MW. These shortages are attributed to the prevalent congestion in the transmission corridors that were designated to provide power to Tamil Nadu and inordinate delays in power projects by BHEL, NLC and NTPC[18]. The State is foremost in wind energy capacity with total installations at 6007 MW making India rank 5th in the world with a cumulative installed wind capacity of 13 GW[19] at the end of 2010.

3.7 Actions at State level

Table 3.7: Actions undertaken at State level

Action/Initiative	Initiative type	Description
Reduction in AT&C losses[20]	EE	Lowest in the country, AT&C losses in Tamil Nadu are 18.5% which are further being reduced to 18.1% through strengthening Transmission systems and checking for energy thefts
Phased segregation of feeders to curb distribution power losses[21]	EE	Converting LT lines into HT lines to reduce losses in parallel to feeder separation with an estimated investment of INR 6000 Crores
Bachat Lamp Yojana (BLY)[22]	EE	BEE supported Ministry of Power scheme to replace incandescent light bulbs with energy efficient CFLs to result in peak demand reduction of 500-600 MW
Restructured Accelerated Power Development and	EE	To improve power quality, reliability and curb AT&C losses. Initiated by Ministry of Power to

[18] Jayalalithaa writes to PM over power shortage-http://zeenews.india.com/news/tamil-nadu/jayalalithaa-writes-to-pm-over-power-shortage_762850.html
[19] Indian Wind Energy Outlook 2011-report by GWEC-*www.**gwec**.net/fileadmin/images/.../IWEO_2011_FINAL_April.pdf*
[20] Tamil Nadu Energy department-http://www.tn.gov.in/policynotes/pdf/energy.pdf
[21] Tamil Nadu Energy department-http://www.tn.gov.in/policynotes/pdf/energy.pdf
[22] Tamil Nadu Energy department-http://www.tn.gov.in/policynotes/pdf/energy.pdf

Action/Initiative	Initiative type	Description
Reforms Program (RAPDRP)[23]		comprehensively restructure transmission system and modernize power management via SCADA, DMS.
Tamil Nadu Solar Policy[24]	RE	Aims to generate 3000MW of solar power by 2015-16, more than 33% of national target. Aims to power 100,000 streetlights and 300,000 houses with SPV devices and encourage use of wind-solar hybrid systems and aerogenerators for captive power generation on educational institutions and official buildings. National Clean Energy Funds will be leveraged.
Tamil Nadu State Action Plan on Climate Change (SAPCC)[25]	Comprehensive	Development oriented integrated framework for addressing climate change. The Action Plan laid out in context of sectoral development as follows: Water Resources, Sustainable Agriculture, Coastal Area Management, Forest and biodiversity, RE/EE proposals, Solar Mission, Sustainable Habitat, Knowledge Management

[23] Tamil Nadu Energy department-http://www.tn.gov.in/policynotes/pdf/energy.pdf
[24] Tamil Nadu's new solar energy policy to add 3000 MW-http://articles.economictimes.indiatimes.com/2012-03-12/news/31153069_1_solar-power-national-solar-mission-renewable-energy
[25] Tamil Nadu State Government-Policy Notes on Environment-www.tn.gov.in/policynotes/pdf/environment.pdf

4. Coimbatore City

4.1 City Profile

Also known as Kovai, Coimbatore is regarded as the Manchester of South India owing to its significance as an important industrial city second only to the capital city Chennai. Situated to the west of the state, Coimbatore forms a focal point located conveniently for the cities of Chennai, Bangalore and Kochi. Its vicinity to the famous hill station Ooty also makes it a popular destination visited by many. The region historically having exchanged control through struggle among various kingdoms like Chalukyas, Pandya and Cholas found its way eventually into British control in 1799 soon after the fall of Tippu Sultan. After several territorial and administrative reorganizations, Coimbatore was aligned with the state of Tamil Nadu upon independence.

Traditionally famous for its cotton textile industry, Coimbatore has emerged as a resurging entrepreneurial city in the heart of South India. Encouraged by the allocation of lucrative incentives for development of IT parks and IT SEZs, the state government has successfully evinced the interest of national and international developers. Due to the thriving talent pool of graduates from its universities and several engineering colleges, Coimbatore has attracted growth and furthered its economic standing in the state. A vast human resource and a conducive business atmosphere has enabled multinational companies like TCS, Spheris, Bosch to set shop in Coimbatore adding to its profile of successful businesses in addition to the flourishing textile and automobile industry.

4.1.1 Details of Location, Geography and Climate of Coimbatore

Location

Coimbatore forms a focal point for Chennai, Bangalore and Kochi in southern India. Located to the west of Tamil Nadu bordering with the neighbouring state of Kerala

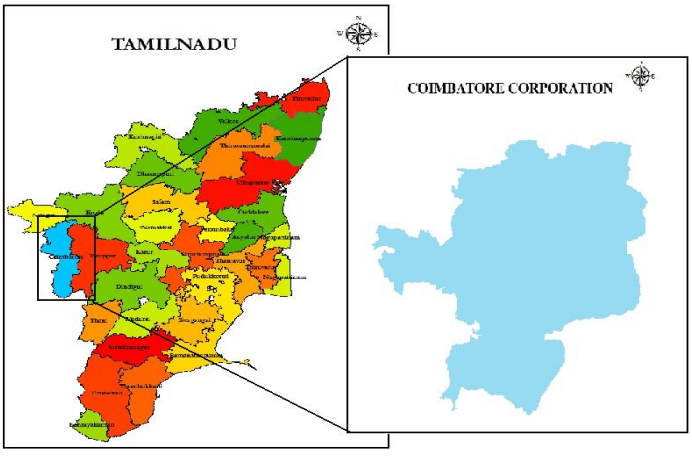


Figure 4.1: Location of Coimbatore

Coimbatore acts as an exit and entry point for Udhgamandalam or Ooty, and a world famous tourist destination visited all year round. The city is located at 11° N lat and 76° E long and is 411.2 meters above the sea-level.

Geography

Coimbatore is flanked by the Western Ghats on its North and North West and the Nilgiri forest reserve covers most of its Northern borders. Located on the northern banks of River Noyyal, the city experiences a salubrious climate throughout the year. The city extends over an area of 257 square km after jurisdictional changes in July 2011 downsized the original number of wards from to 60 and added 40 new ones from the neighboring regions. The corporation now controls 100 wards.

Coimbatore sits on rich and fertile black cotton soil that although doesn't extend deep into the surface is spread all over the city. The surface topography is mainly flat and undulating at the slopes especially for the elevated regions lying to the North and North West of the city. Scattered around with water bodies like Narsapathi lake, Perur lake, Periya Kulam and the Singnallur lake which is especially famous for spot-billed Pelicans, the topography of the city and its vicinity to the Western Ghats and Nilgiris make it a conducive region where a variety of flora and fauna thrive.

Climate

Because of its location, Coimbatore's climate remains pleasant all through the year. The typical temperature range of the city is 18° C minimum and 39°C maximum and it receives a rainfall of 600mm to 700mm annually. The presence of the 25km Palaghat pass enables the elevated parts to receive rains of the South-West monsoon and soon after the main monsoon hits the city during the months of October and November which are the wettest months during a year.

Table 4.1: Temperature and Rainfall profile of Coimbatore

Temperature Profile (° C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	31	34	36	36	35	32	31	32	33	32	30	29
MIN	19	20	22	24	24	23	22	22	22	22	21	19

Rainfall Profile												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
in mm	6	11	23	44	66	38	27	31	50	64	138	43

Source: http://www.worldweatheronline.com/Coimbatore-weather-averages/Tamil-Nadu/IN.aspx

Administrative profile

Coimbatore city municipality was upgraded to Municipal Corporation level in 1981. After jurisdictional restructuring in July 2011, the Corporation currently oversees the administration in 100 wards. The Corporation is headed by the Mayor, elected directly by the citizens of the city while its duties are executed by the Commissioner who presides over Senior Officers in charge of different departments of the Corporation like Administration, Engineering, Public Health, Accounts, Planning and Revenue. Following are brief notes on the civic services undertaken by the Corporation.

Water Supply

The city receives water through schemes like Siruvani, Pilloor and Athikadavu. Despite a generous Monsoon downpour, the city fails to cover up the deficit of 25 liters per capita per day (lpcd). Proposals for increasing water supply through the Pilloor scheme are currently underway which would convey about 130 lpcd to the city taking care of future water demand as well.

Solid Waste Management and Sewerage

Coimbatore city currently has four waste transfer stations at locations such as Peelemedu, Sathy road; Ukkadam and Ondipudur and each have a total design capacity of 650 tons per day (TPD). This capacity will suffice for not just the current quantity of waste generated in the city which is about 635 TPD but also the anticipated increase in the future. A Sewer Treatment Plant at Ukkadam caters to the city's sewer management system. The STP designed for 70 MLD is expected to cover the city's demand for the next 15 years.

Street Lighting

In 2011, Coimbatore's streets were lit by 65,194 street lights[26] of which 34,000 are in the old jurisdictional area consuming about 10 million kWh annually[27]. Corporation's energy conservation initiatives have resulted in 12% reduction in energy consumption charges. With 80% of such measures already completed, the Corporation aims to accomplish 100% energy saving measures in its street lighting systems by 2016.

Roads and Transport

Coimbatore city is internally well connected through the large network of roads maintained by the Corporation. The NH 47 runs through its centre and the extent of the road network is 635.52 km. Currently the road network covers 8 km/sq.km of the city.

Public Health

Ensuring public health in the community, the Coimbatore city Corporation maintains 16 dispensaries, 2 maternity hospitals and 20 urban health posts which cater through qualified doctors, nurses and paramedical staff. In addition, the city has more than 850 private hospitals and dispensaries.

[26] CMC Street lights distribution as per new jurisdictional arrangement, 2012
[27] Corporation's power conservancy measures yield dividends
http://www.thehindu.com/news/cities/Coimbatore/article2720112.ece

Infrastructure and Facilities

In addition to a fairly efficient road network, Coimbatore's Municipal Corporation which aims to increase the length of its roads already has an airport and a well established rail network running through the city, increasing its visibility and connectivity.

Demographic trends

According to the 2001 census finding, Coimbatore within its previous jurisdictional boundaries had a population of 9, 30,882. Based on the 2011 census finding; the city had a population of 2,151,466. The city registered a decadal growth rate of 15.51% in 2001. Until 2011, the average annual growth rate has been calculated as 56.54% and annual growth rate was 5.7%. Also, according to 2011 census, the sex ratio in Coimbatore city has been estimated at 996 and the literacy rate which is among the highest in the country is 89.23%. Following the population trends since 1961 until 2011:

Table 4.2: Population growth in Coimbatore

Year	Population	Decadal Growth %
1961	286305	-
1971	356368	24.47
1981*	700923	96.68
1991	806321	15.04
2001	930882	15.45
2011**	2151466	131

**Upgraded to Municipal Corporation level*
***Neighbouring areas included and ward size increased from 72 to 100*

Table 4.1.3: Population data*

Total Persons	2151466
Males	1077812
Females	1073654
Sex ratio	996
Total Persons below 6 years in age	193497
Males below 6 years in age	98499
Females below 6 years in age	98998
Sex ratio(0-6)	964
Total literates	1747178
Literate Males	912408
Literate Females	834770
Male Literacy rate	93.17%
Female Literacy rate	85.30%

**Census of India 2011*

Socio-economic profile

Coimbatore, as one of the most important industrial cities of southern India, has evolved into a manufacturing hub featuring not just textile mills, which it is famous for, but also a diverse assortment of industries ranging from auto component based to agro based and in recent years IT based. Besides textiles Coimbatore is famous for pump manufacturing and its resurging software market with incidence of international companies.

The city attracts a large number of people from within the district and neighbouring regions and is a major employment hub in southern India. Because of the presence of a large number of colleges and universities, the city boasts of a talent pool which suffices for the growing job market. While culturally inclined towards entrepreneurship, the city has about 89% of people working in the tertiary sector. Following is the workforce participation breakdown in context of the sectors.

Table 4.3: Workforce participation*

Sector	Number of Persons
Primary	6507
Secondary	15340
Tertiary(inclusive of Livestock and Mining, HH and Industry)	336407
Total Workforce	358254
Non-Workers	572628
Workforce participation rate	38.9%

**Census of India 2001*

Industry profile*

Type of Industry	Capacity
Cotton Textiles:	
- Textile Mills	794 units (55,73,384 Spindles)
- Power looms	30,000 units (133000 Nos.)
- Handlooms	17,000 units (50000 Nos.)
Hosiery Units	8250 units
Electric Motors, Pump sets and allied Industries	2140 units
Wet Grinder and Accessories	700 units
Coir Industries	350 units
Jewellery Industry	150 tonnes /annum
Textile Machinery, Automobile parts Industries	4000 units

**National Information Centre-Industries in Coimbatore district 2006*

Ecological and Forest profile

Sitting amidst the Western Ghats on the North and Northwest, Coimbatore is surrounded by the Nilgiri Forest Reserve that contributes to the rich ecology around the city. In addition to this, the fertility of the region has been a catalyst to the thriving agricultural practices around the city. Although the land used for agriculture has reduced to a large extent mainly as a result of population increase, the city still covers a substantial percentage of land under agricultural activities. The land use pattern according to the most latest available stats are as follows:

Table 4.4: Land use pattern*

Sector	% of total area
Residential	59.84
Commercial	2.65
Industrial	4.65
Educational	6.26
Public & Semi public use	2.57
Agricultural	24.03

**2002 statistics, Master Plan Coimbatore City*

Table 4.1.7: Green cover*

Forest Cover	1586 square kilometers
Forest produce	Timber, Mango, Walnut, Silk
Urban and Suburban plants	15384
Lakes (wetlands)	9

**CDP Coimbatore city and Coimbatore Forest division*

Actions at City level

Following is a brief overview of the host of actions undertaken towards RE and EE development affecting GHG abatement in Coimbatore city.

Table 4.5: Actions undertaken at City level[28]

City level Action	Description	Impact
Local Renewables	City wide Energy consumption assessment in different sectors	Overview of the energy status and identification of actionable initiatives
	Street lights energy saving project on 34,000	30% reduction in energy consumption and related GHG emissions
	Tubewell energy audit for 700 tubewells	Reduction of 1 to 5 tCO_2e per tubewell
	Installation of Wind Solar Hybrid system on Mettupalayam bus terminal	Reduction in 136,000 kWh per year with approx. reduction of 12,096 kg CO_2 emissions per year
Roadmap for South Asian Cities and Local Governments for post 2012 Global Climate agreement and Actions	Profiling of Coimbatore Energy profile and comprehensive Carbon Emissions inventorization	Feasible Action plans suggested that were discussed with participating cities including Coimbatore like Building and Facilities EE program, Demand Side Management programs, Transport management etc

4.2 Energy Consumption Profile of Coimbatore

Introduction

This section deals with the assessment of the energy consumption patterns in Coimbatore city. The identification of energy sources specific to each sector in Coimbatore i.e., Residential, Commercial, Industrial and Municipal is being dealt with as follows.

Total Electricity Consumption in Coimbatore

[28] ICLEI SA-Local Governments for Sustainability-http://www.iclei.org/index.php?id=971

The main source of energy consumption in Coimbatore is electricity which is consumed in the residential, commercial, industrial as well as municipal sectors of the city. Electricity is generally used for lighting, cooling, heating and powering other appliances of general use in domestic sector. In commercial sector also, electricity is the main source of energy for lighting, cooling, heating and other commercial activities. There are a lot of industries in Coimbatore that use electricity for certain kinds of processes in their day to day work. Coimbatore is known for textile industry and electricity is the main source of energy for running those industrial units. In municipal sector, electricity is being used for maintaining certain services like – street lighting, water supply, sewage treatment plant and office buildings of the municipal corporation. The table below shows the total energy consumption for a period of five years in different sectors.

Table 4.6: Sector-wise electricity consumption in Coimbatore

Sector	Electricity Consumption (Million kWh)				
	2006-07	2007-08	2008-09	2009-10	2010-11
Domestic	318.68	239.69	446.73	473.52	379.34
Commercial	133.81	91.87	170.17	187.60	150.56
Industrial	60.82	40.02	76.61	87.26	65.07
Municipal Sector	17.63	25.94	36.24	32.34	34.49
Other Government & Educational Sector	4.91	3.89	7.11	4.03	1.57
Total Electrical Energy consumed	535.86	401.41	736.87	784.76	631.04

(Source: TNEB, Coimbatore 2012)

The domestic and commercial sectors in the city are the main consumers followed closely by the industrial sector. The city attained peak consumption last year with 784.76 million kWh.

Sector-Wise energy consumption in Community sector

A. Domestic Sector

The sources of fuel that find most usage in this sector are kerosene and LPG. While use of kerosene has seen a downward trend in Coimbatore, LPG usage has risen drastically as indicated by the data below.

Table 4.7: Fuel consumption domestic sector in Coimbatore

Fuel	2007-08	2008-09	2009-10	2010-11
Kerosene (kL)	11501	12377	12368	11497
LPG (MT)	7888.8	38595.14	42903.34	46281.25

Source: District Supply Officer, Coimbatore 2012

B. Commercial Sector

In the commercial sector, there is extensive usage of LPG and kerosene in hospitality enterprises. For companies in the transport sector, diesel and petrol are the main sources of fuel which are also used in the industrial sector. Following is the usage trend of these energy sources.

Table 4.8: Fuel consumption commercial sector in Coimbatore

Fuel	2007-08	2008-09	2009-10	2010-11
Kerosene* (kL)	7667	8251	8245	7665
LPG* (MT)	415.2	6962.37	7729.647	8738.444
Diesel (kL)	16722.7	19639.2	15096.6	17384.2

**commercial and industrial as segregation not available*
(Source: District Supply Officer, Coimbatore; IOLC, HPCL, Coimbatore 2012)

C. Industrial Sector

Extensively used sources of fuel in industrial sector are petrol, diesel, kerosene and LPG. Following table lists the usage trends in Coimbatore over a period of four years.

Table 4.9: Fuel consumption industrial sector in Coimbatore

Fuel	2007-08	2008-09	2009-10	2010-11
Diesel (kL)	33445.4	39278.4	30193.2	34768.4
Petrol (kL)	15344	17139	14601	15700

**commercial and industrial as segregation not available*
(Source: District Supply Officer, Coimbatore; IOLC, HPCL, Coimbatore 2012)

D. Transport Sector

As a focal point of entry and exit into Tamil Nadu from Kerala and Karnataka, transport forms a major source of revenue and local employment. The fuel sources that the sector depends on are Diesel and Petrol. The usage trends in the past four years are listed below.

Table 4.10: Fuel consumption transport sector in Coimbatore

Fuel	2007-08	2008-09	2009-10	2010-11
Petrol (kL)	61374	68558	58402	62802
Diesel (kL)	117058.9	137474.4	105676.2	121689.4

(Source: IOLC, HPCL, Coimbatore 2012)

E. Waste

The solid waste and effluents generated from the community are collected by the sanitary authorities as a part of the services. Coimbatore city lacks the basic infrastructure as of now for waste to energy generation capability and the Corporation has taken initiatives in order achieve this through scientific closure of dump sites and replaced them with four transfer stations with a design capacity to handle 650 tons of waste per day. The waste water treatment or sewerage treatment plant at Ukkadam which has a design capacity of 70 million liters per day (MLD) and currently is the only STP that serves the city. Following is a composition of the solid waste content in Coimbatore city and its chemical composition.

Table 4.11: Physical Composition of Solid Waste

Bio- degradable	**% of total**
Organic/Bio-mass	71.70 %
Woody mass	11.20 %
Paper	2.30 %
Non-Biodegradable	**% of total**

Plastics	6.90 %
Glass	2.20 %
Metal	0.10 %
Rubber	3.00 %
Leather	0.50 %
Synthetics	2.10 %

(Source: CMC, Coimbatore)

Table 4.12: Chemical Composition of Solid Waste

Parameters	Values
Density (Kg/m3)	0.67
Moisture	74.18%
Ph	7.03
Total Organic Matter	35.77%
Total Nitrogen as N	1.17 %
Phosphorous as P_2O_5	0.40 %
Potassium as K_2O	0.73 %
C:N Ratio	1:17.1
Gross Calorific Value (Kcal/Kg)	2369

(Source: CMC, Coimbatore 2012)

Table 4.13: Waste generated in Coimbatore

Type	2007-08	2008-09	2009-10	2010-11
Solid Waste (MT/day)	631.05	662.60	695.73	730.52

(Source: ICLEI data, 2012)

Energy Consumption in Government sector

The Corporation consumes energy through usage of electricity, fuels like petrol and diesel to execute and undertake the various activities under its portfolio of duties. The activities are mainly energy intensive are the power consumption in streetlights, water supply and illumination of Government buildings and equipments. Liquid fuels like petrol and diesel are mainly used to facilitate mobility of Municipal authorities and for transport of during maintenance and repair activities. Following is a broad breakdown of these activities.

A. Energy used in Street Lighting

There are approximately about 30,730 street lights within the Corporation limits. The Corporation's energy conservancy measures that resulted in replacement of incandescent bulbs to LED enabled street lights brought about 12% reduction in energy consumption charges to the Corporation. A similar conservancy measure by dimming of street lights late in the night and switching of alternate lights helped save 40 lakh units until 2011 and a further 86 lakh this year[29]. With new areas added under the Corporation's control, more such measures are anticipated to the street lighting system in these regions. With 80% of such measures already completed, the Corporation aims to accomplish 100% energy saving measures in its street lighting systems by 2016[30]. In 2010, the Corporation

[29] *Corporation's power conservancy measures yield dividends*- http://www.thehindu.com/news/cities/Coimbatore/article2720112.ece

[30] Coimbatore City Development Plan (page 4)

consumed about 17927 kWh of energy Following is the breakdown of street lighting systems currently in place.

Table 4.14: Street lights in Coimbatore

Street Lights	Number
Tube Lights	4602
Sodium Lamp	25220
High mast Lamp	208
Energy Saver Yes/No	700
Total	**30730**

(Source: CMC, Coimbatore 2009)

In the Municipal sector, the usage of electricity is mainly for illumination purposes like street lighting as detailed above and also for lighting of municipal buildings and public buildings like stadiums, parks and hospitals and schools. Following is a detailed list of lighting equipments in use and also the places where electricity is used for lighting.

Table 4.15: Lighting equipments and sites of usage

Equipment	Number	Total Wattage
40 watts tube lights	22925	917
70 watts SV lamps	21474	1503
250 watts SV lamps	14998	3750
400 watts SV lamps fittings	113	45.2
250 watts MHL fittings	307	77
400 watts MHL fittings	534	214
2*24 watts T-5 Fitting	534	26
5*24 watts T- 5 Fitting	194	23.3
150 watts SV lamps	259	39
36 watts CF lamps	358	13
72 watts CF Lamps	75	5.4
250 watts CF lamps	3358	840
4*24 watts CF lamps	41	2
High mast (400 watts SVL fittings)	16	6.4

(Source: ICLEI 2012)

Table 4.16: Energy consumed by Street Lights in Coimbatore

	2006-2007		2007-2008		2008-2009		2009-2010	
	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)
Street Lights	11,382.73	375.63	22,073.64	728.43	15,882.42	524.12	17,972.73	593.10

(Source: ICLEI 2012)

B. Energy used in Water Supply

Water in Coimbatore is scarce and Monsoon dependant. Due to infrequent rains and delay of the Monsoon, the city has been battling water issues since the past few years. There are currently two major schemes that convey water to the city. One of these, Pilloor scheme is not facilitated by gravity like the other Siruvani water scheme and hence requires use of pumping equipments which utilize energy. With a proposal of expansion of the conveying

canals under this scheme, the electricity consumption under this scheme is expected to rise. Following is the data available with the Corporation provided to ICLEI. The data also indicates the electricity consumed by STP stations under Municipal control.

Table 4.17: Energy consumed by Water Supply in Coimbatore

	2006-2007		2007-2008		2008-2009		2009-2010	
	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)
Water supply; Sewerage	7,283.03	240.34	9,968.18	328.95	9615.76	317.32	7,437.27	245.43

(Source: ICLEI 2012)

C. Energy used in lighting of Corporation Buildings

Corporation ensures illumination of Government buildings and other public venues like stadiums and parks etc, besides street lights. Following are the sites of electricity usage by the Corporation of Coimbatore.

Table 4.18: Site of electricity usage by Corporation

Government buildings	Number
No of municipal office buildings	4
Stadiums owned by the corporation	2
Parks, recreation centers maintained by the corporation	52
Hospitals, clinics maintained by the corporation	38
Schools maintained by the corporation	98
Other buildings	174

(Source: ICLEI, 2012)

Following is the data regarding electricity usage.

Table 4.19: Electricity used in Corporation buildings and facilities

	2006-2007		2007-2008		2008-2009		2009-2010	
	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)	Quantity (kWh)	Rate (in lacs)
Building and Facilities	1935.64	106.46	2523.09	138.77	3183.64	175.1	2716.18	149.39

(Source: ICLEI 2012)

D. Energy used in Corporation Transport

Petrol and diesel are the main fuels for powering the Corporation vehicles that help in performance of its duties. Currently, the Corporation has 181 vehicles of which majority run on diesel. In addition, the Corporation also maintains 160 vehicles that facilitate the waste collection in the city. These usually run on diesel. Following table details the Corporation vehicles.

Table 4.20: Corporation vehicle characteristics

Type of Vehicles	No. of Vehicles		
	Petrol	Diesel	Others
Car	3	-	-
Auto-rickshaw	15	-	-
Light-duty vehicles	-	97	-
Heavy-duty vehicles	-	64	-
Omni van/Ambulance	2	-	-
Waste collecting vehicles	-	160	-
Total	**20**	**321**	**-**

(Source: ICLEI 2012)

The data from the Corporation regarding expenses over fuel usage was obtained in a consolidated form without clear break-up between usage of petrol and diesel. Following are the details of the same.

Table 4.21: Corporation vehicle characteristics

	2006-2007	2007-2008	2008-2009	2009-2010
	Rate (Rs in Lacs)	Rate (Rs in Lacs)	Rate (Rs in Lacs)	Rate (Rs in Lacs)
Light-duty vehicles	16.64	48.28	326.73	121.96
Heavy duty vehicles	233.95	328.94	243.66	530.01
Total	**250.59**	**377.22**	**570.39**	**651.97**

In 2010, the fuel used for 161 diesel vehicles and 20 petrol vehicles, cost the Corporation about 652 lacs. Based on this, fuel usage has been evaluated as shown in the table below:

Table 4.22: Fuel usage by Corporation vehicles

Fuel type	Total cost (Rs in Lacs)	Cost of fuel per litre (Rs/Litre)	Fuel Usage (kL)
Petrol	38.25	51.59*	741.5
Diesel	614.75	37.78*	1627.2

4.3 GHG Emissions profile of Coimbatore

Based on this inventory, the total emissions from the city for the year 2010-2011 were 1.469 million tonnes of carbon dioxide equivalents (CO_2e) which contributed to about 99% of the total emissions from the city indicating carbon efficiency of the Corporations activities as a result of the various efficiency measures undertaken by it in the previous years.

Community level GHG emissions

The total emissions from the Community sector in Coimbatore is 1,469,552.33 tCO_2e

Table 4.23: Community level Carbon Emissions (tCO_2e)

Sector	Equiv. CO_2 tonnes	% of total emissions
Residential	458,043.56	31.17
Commercial	195,627.70	13.31
Industrial	198,192.48	13.49
Transport	496,430.96	33.78
Waste	121,257.63	8.25
Total Community level Emissions	1,469,552.33	100.00

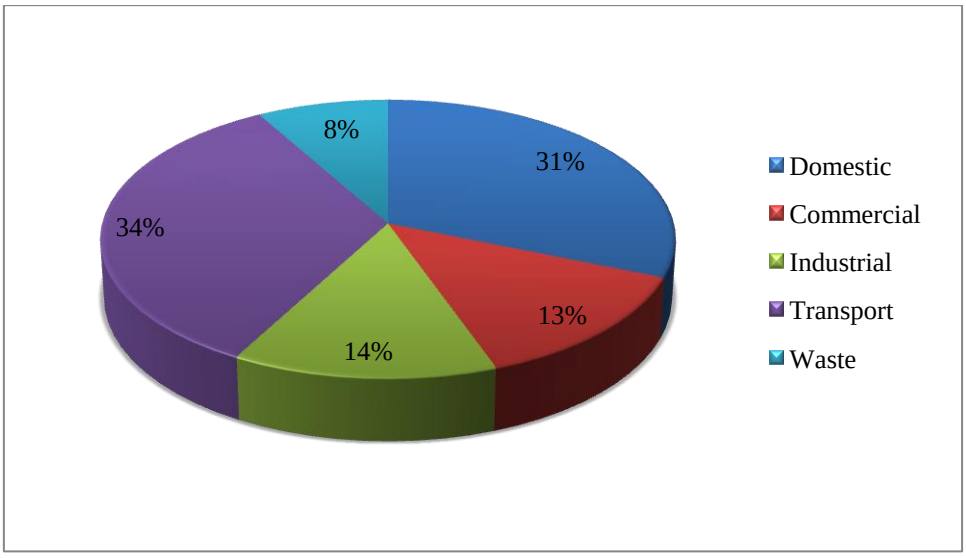


Figure 4.2: Coimbatore city Carbon Emissions (2010-2011)

Residential

The residential sector GHG emission was 458043.56 tonnes (31.17 %) to total emissions from community level activities in 2010-11. The major contribution is coming from electricity consumption; it has 63.31 % share of total residential emissions. The next major

source of emissions after electricity is due to LPG consumption. A small fraction comes from Kerosene consumption used for several purposes like kerosene lamps, cooking etc. The Kerosene consumption contributes less than 3 % to the total residential emissions. The details of residential emissions are given below.

Table 4.24: Residential Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Electricity	289,975.43	63.31
LPG	138,338.05	30.20
Kerosene	29,730.08	6.49
Subtotal Residential	**458,043.56**	**100.00**

Commercial

The commercial sector GHG emission was 195627.7 tonnes (13.31%) to total emissions from community level activities in 2010-11. The major contribution is coming from electricity consumption; it has 59 % share of total commercial emissions. The next major source of emissions after electricity is due to diesel consumption and its share in total emissions is just about 3.4 %. The source wise equiv CO_2 details are given below:

Table 4.25: Commercial Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Electricity	115,227.08	58.90
Diesel	49,553.26	25.33
LPG	17,030.91	8.71
Kerosene	13,816.46	7.06
Subtotal Commercial	**195,627.70**	**100.00**

Industrial

The industrial sector GHG emission was 198192.48 tonnes (13.48%) to total emissions from community level activities in 2010-11. The major contribution is from diesel consumption; it has 50 % share of total industrial emissions. The next major source of emissions after diesel is due to electricity consumption followed by petrol. Their share in total emissions however is just about 3.36% and 2.44% respectively. The source wise equiv CO_2 details are given below:

Table 4.26: Industrial Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Diesel	99106.52	50.01
Electricity	49,601.06	25.03
Petrol	36072.64	18.20
LPG	7405.23	3.74
Kerosene	6007.04	3.03
Subtotal Industrial	**198192.48**	**100.00**

Transport

The transportation sector GHG emission was 496430.96 tonnes (33.78%) to total emissions from community level activities in 2010-11. The major contribution is from diesel consumption; it has 69% share of total transport emissions. The next major contributor to emissions after diesel is due petrol whose consumption is on the rise. Its share in total emissions is 31% of the total transport emissions. Petrol and diesel together contribute to 34% of the total GHG emissions from the city.

Table 4.27: Transport Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Diesel	340,683.35	68.63
Petrol	155,747.61	31.37
Subtotal Transport	**496,430.96**	**100.00**

Waste

The metropolitan of Coimbatore is served by 4 transit stations for solid waste generated by the city at the rate of 730.52 MT/day. The following table details the contribution to GHG emissions by this waste that is disposed off in a managed landfill maintained at different locations in the city. The data obtained from the Corporation was latest until 2010.

Table 4.28: Waste Greenhouse Gas Emissions (2009-10)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Municipal Solid Waste	121,257.63	100
Subtotal Waste	**121,257.63**	**100**

Government Level GHG emissions

The total emissions arising from Corporation activities are about 6415.95 tonnes of CO_2.

Table 4.29: Government level Carbon Emissions (tCO_2e)

Sector	Equiv. CO_2 tonnes	% of total emissions
Facilities	19.42	0.30
Buildings	2.07	0.03
Transport	6,394.45	99.67
Total Government level Emissions	6,415.94	100.00

Facilities

Facilities like illumination of public precincts through street lights and traffic lights are some of the service that the Corporation is responsible and that generates greenhouse gasses. Water supply and sewerage pumping are other activities that cause emissions. Following table details the activities and the emissions arising from each. The data from Corporation is from 2009-10 and was the latest available.

Table 4.30: Facilities Greenhouse Gas Emissions (2009-10)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Street lighting	13.71	70.63
Water supply	5.70	29.37
Subtotal Facilities	19.42	100.00

Buildings

Corporation buildings and the equipments therein also become a source of GHG emissions when powered through electricity. The following table details the relevant emissions from this activity.

Buildings Greenhouse Gas Emissions (2009-10)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Illumination	2.07	100
Subtotal Buildings	2.07	100

Transport

In Coimbatore, the emissions due to Corporation owned transport are more than the emissions from facilities or buildings. Transport owned by the Corporation is responsible for almost 99% of the emissions from this sector as detailed in the table below. Of these, diesel which serves as fuel for most Corporation vehicles contributes to about 71% of the emissions from Corporation owned transport.

Table 4.31: Transport Greenhouse Gas Emissions (2009-10)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Petrol	1,838.90	28.76
Diesel	4,555.55	71.24
Subtotal Transport	6,394.45	100.00

4.4 Suggested Low Carbon Action plans

Renewable energy strategies

The main objective of this chapter is to identify available renewable energy resources in Coimbatore city and carry out techno-economic feasibility of different renewable energy options for residential, commercial, industrial and municipal sector and making a priority listing of the options.

A renewable energy resources assessment has been done to identify the potential renewable energy sources for the Coimbatore city. This includes assessment of solar radiation, wind power density and availability, biomass resources and municipal/industrial wastes etc. The strategy has been prepared for each sector identifying most techno economically viable renewable energy options considering wide range of potential consumers in the particular sector. An implementation target for development of solar city project in 5 years period has been set with an objective to meet at least 5% energy consumption from renewable energy on completion of the project in Coimbatore with substantial decrease in Carbon emissions from all sectors in the city.

For the residential sector, potential for introducing the following renewable energy devices has been worked out based on present energy use pattern of the residents, economic level, availability of such products and economic feasibility.

(i) Solar Water Heaters
(ii) Solar Cooker
(iii) Solar Lanterns
(iv) Solar Home System
(v) Solar PV system for Home Inverters
(vi) Small Wind Turbines
(vii) Solar PV Wind Hybrid Systems

Commercial and Institutional Sector has been divided in to four broad categories as below and these categories again sub divided into further categories based on their capacity and functional differences.

(i) RE Strategy for Hotels
(ii) RE Strategy for Restaurants
(iii) RE Strategy for Hospitals
(iv) RE Strategy for Educational Institutes

On the spot assessments have been carried out visiting each of these sub categories to identify present energy demand, energy and fuel used, load shedding occurs, standby power supply provision, space available for installation of solar arrays and collectors etc. Based on the site visit and energy demand assessment, preliminary design/sizing of appropriate renewable energy devices have been worked out for each category establishment. An indicative budgetary financial implication, energy savings, payback period and GHG emission reduction has been estimated for each renewable energy option that has been suggested. Based on the energy utilization pattern, the following renewable energy systems have been recommended followed by energy efficiency measures in this sector.

(i) Solar Water Heaters for all hotels, hospitals, restaurants & residential institutes
(ii) Solar Steam cooking for hostels and restaurants
(iii) Solar PV system for captive use and peak load reduction
(iv) Biogas system from food waste
(v) Solar PV wind hybrid systems
(vi) Small Wind turbines for institutional campuses

Industrial sector is broadly divided into five categories. Suitable renewable energy technologies have been suggested for each of the category.

(i)	Metal products	(35%)
(ii)	Textile & textile products	(19%)
(iii)	Machinery and Equipments	(15%)
(iv)	Food products and beverages	(4%)

(v) Rubber and Plastics (3%)
(vi) Service Industries (12%)
(vii) Other Manufacturing Industries (12%)

The following renewable energy systems have been proposed for the industrial sector based on industrial process and type and quantum of energy demand for these industries.

(i) Solar Water Heaters for process heat and boiler feed water preheating
(ii) Solar Steam generating system for process heating
(iii) Solar PV system for captive use and peak load reduction
(iv) Biogas system for food processing industries

Government & Municipal Sector is divided into three categories and options for appropriate renewable energy technologies have been recommended based on the assessment made on each category of the sector.

(i) Government and Municipal Corporation Office Buildings
(ii) Outdoor lighting for public places like parks, bus shelters, monuments etc
(iii) Outdoor lighting Road safety- Street light, road blinkers, road studs etc

4.4.1 Renewable Energy Resource Assessment

A preliminary assessment has been done for solar, biomass resources and energy recovery potential from municipal solid waste and sewage treatment plant. While biomass data is for entire Coimbatore district, there is no hydro potential in the city. A pre feasibility study on wind potential in Coimbatore City and its surrounding area has been conducted by ICLEI-SA during 2011 under Urban Climate Project. A summary on wind potential, site classification and suitable types of wind turbine for Coimbatore city has been incorporated in this report.

Solar Radiation

Coimbatore (76° E and 11° N) receives good amount of solar radiation with an annual average of 4.98 kWh/ m^2/day. Following is the typical solar insolation data for Coimbatore for an entire year.

Table 4.32: Monthly Averaged Insulation (kWh/m²/day) incident on a horizontal surface in Coimbatore

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NASA SSE Satellite data	4.62	5.5	6.22	6.8	6.59	5	3.9	3.7	4.4	5.1	4.8	4.5	5.09
MNRE Solar Radiation Handbook-2008	4.49	5.34	6.09	6.7	6.55	5.2	4.1	4.1	4.87	5.2	4.5	4.3	5.09

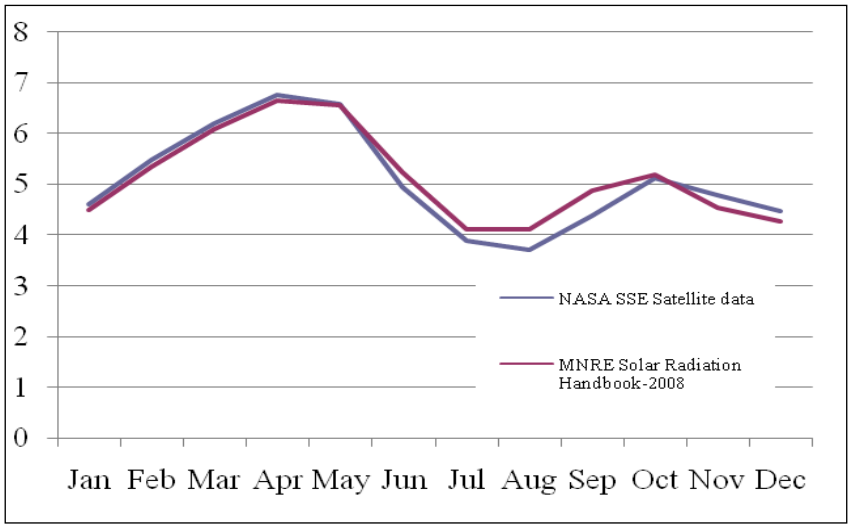


Figure 4.3: Annual Solar Radiation Profile of Coimbatore

Wind Energy Potential

The state of Tamil Nadu has one of the best wind potentials in the country. The total identified wind power potential is 5374 MW[31] and the total installed wind power capacity is about 5533MW as on February 2011. Coimbatore district of Tamil Nadu has very good wind energy potential. There are 12 wind monitoring mast installed all over the district to monitor wind power potential and all of them shows more that 200W/m^2 mean annual wind power density which is considered as good wind power potential. The table below shows mean annual wind power density measured in the different wind mast across the district.

Table 4.33: Designated wind sites near Coimbatore city

Site Name	Latitude		Longitude		Elevation in meters	Mean annual wind speed at 20m/25m in m/sec	WPD at 20m/ 25m	WPD at 50m in W/sqm
	Deg	Min	Deg	Min				
Andhiyur	10	36	77	11	380	5.2	177	271
Arasampalayam	10	51	77	3	370	5.5	195	291
Edayarpalayam	10	55	77	7	445	6.1	273	398
Kethanur	10	54	77	17	403	5.7	259	376
Mettukadai	10	52	77	23	350	4.9	184	281
Myvadi	10	36	77	19	341	5.3	251	376
Pongalur	10	58	77	21	388	5.2	213	309
Poolavadi	10	44	77	17	321	5.7	283	445
Poosaripatti	10	40	77	7	380	5.2	168	254
Pushpathur	10	33	77	25	340	4.3	128	254
Sultanpet	10	52	77	11	380	5.1	203	206
Thannirpandal	10	57	77	19	400	4.9	216	>330

Source: http://www.windpowerindia.com/statwind2.asp

[31] Indian Wind Energy Outlook 2011-http://www.indianwindpower.com/pdf/iweo_2011_lowres.pdf

Wind data for Coimbatore City

The monthly average wind speed data from Atmospheric science data center, NASA and Peelamedu Airport are presented below. The same wind speed data is represented graphically in the table below. It can be clearly seen that there is high level of similarity in the two data set and the wind speeds are at highest in May-September.

Table 4.34: Wind speed data

Months	Monthly Averaged Wind Speed At 10 m above The Surface Of The Earth – NASA data	Monthly Averaged Wind Speed At 10 m above The Surface Of The Earth – Peelamedu airport data
	m/s	m/s
January	3.12	1.90
February	2.69	2.10
March	2.81	2.50
April	2.76	2.80
May	3.26	3.90
June	4.72	5.30
July	4.54	5.30
August	4.29	5.10
September	3.33	4.20
October	2.57	2.50
November	2.74	1.60
December	3.47	1.80
Annual Average	**3.12**	**3.25**

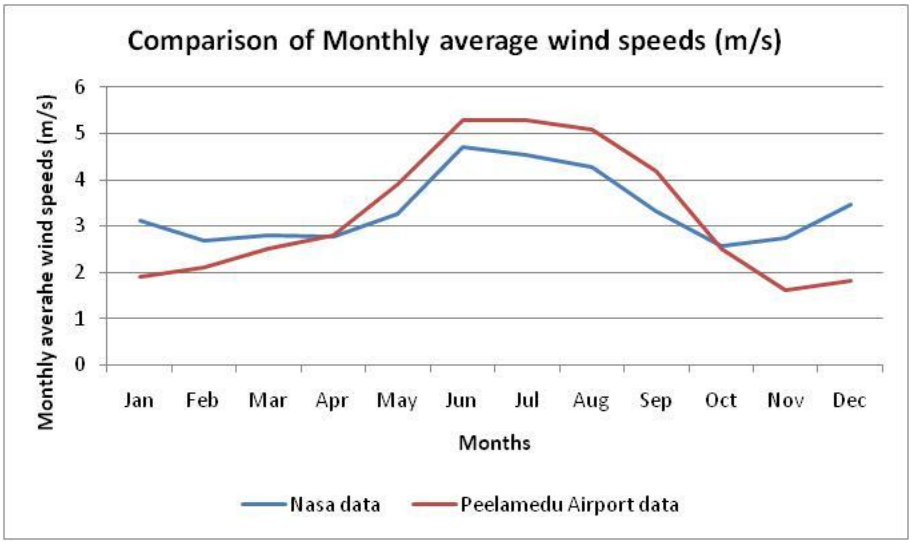


Figure 4.4: Comparison of wind speed data

Waste generation[32]

Vellaluru Compost yard

About 600 MT of waste is generated in Coimbatore daily with the major generation points being households, hotels, restaurants, industries, hospitals, market places, slums, bus-stands and community halls. Most of city's waste comes from domestic and commercial sectors collected in dustbins around the city and transported via lorries, carts or tractors to transit stations located at Gandhipuram, Peelamedu, Ondiputhur, Ukkadam and Vellaluru. Currently, the transfer stations at Peelamedu and Ukkadam have a waste handling capacity of 200 tonnes per day (TPD) while transit stations at Ondiputhur and Gandhipuram operate at 125 TPD. With increasing waste generation from the city in future, the four stations are expected to run at their optimal capacities of 650 TDP for which each has been designed.

Transit Station	Operating capacity	% of design capacity (650 TPD)
Gandhipuram	125	19.23
Ukkadam	125	19.23
Peelamedu	200	30.76
Ondiputhur	200	30.76

Liquid Waste from Sewage Treatment Plant

The Sewerage Treatment at Ukkadam serves as the sole STP under Coimbatore Corporation. The STP has been designed to operate at a capacity of 70 MLD. Currently operating at less than 30% of its design capacity, the STP is estimated to suffice the city's needs for another 15 years. The plant has been constructed based on Sequential Bach Reactor (SBR) process which has a stringent quality standard known for rendering very low fecal Coli form and turbidity levels. It has decided to adopt the very same technology at the Nanjundapuram sewage treatment plant, yet to become operational.

Biomass Resources[33]

Coimbatore district has agro, forest and wasteland based biomass reserve and has one the highest biomass potential within the state. The total average crop production in 2000-04 was 904 kT/year. During the same period biomass generated was about 823 kT/year and

[32] Solid Waste Management report-Coimbatore Municipal Corporation-*www.indiaurbanportal.in/pdf/**swm_sess2_1**.pdf*

[33] Biomass Resource Atlas India-http://lab.cgpl.iisc.ernet.in/atlas/Default.aspx

surplus was 372 kT/year. The city had a power generation capacity of 51 MWe during this time which was the 10th highest in production of power from biomass.

RE Strategy for Residential sector

With projected population of 28.32lakh (2016), the residential sector is the highest energy consumer in non-transport activities in the Coimbatore city. Different renewable energy options have been proposed based on technology available and economic feasibility. Only those renewable energy devices are recommended which are technically proven, commercially available and attractive in terms of financial benefit from energy savings.

(i) Installation of Solar Water Heating System

The State government offers subsidies for installation of SWH on VVIP quarters and residences and the national subsidy from MNRE covers 30% of the capital costs of domestic and commercial users. The target for residential users that are currently using geysers has been set at 80%. Such an introduction would save up to 41.9 MU in 5 years. Cost implication and energy savings potential is presented in the table below.

Table 4.35: Potential for SWHs installation in Coimbatore City

Single Household		**Unit**
Average size of domestic SWH (2 sqm collector area)	100/125	LPD
Total energy saved per year	1575	kWh
Indicative cost of installation	25000	INR
MNRE subsidy @3300.00 per m^2	6600	INR
Cost of energy savings	5513	INR
Payback period	3	Years
Target for entire city		**Unit**
Total Residential household	312983	Nos.
Total Residential household after being accounted for in apartments	302183	
Residential household using geysers	11%	
Target to replace electric geyser by SWH in 5 years	80%	
Average size of domestic SWH (2 sqm collector area)	100/125	LPD
Number of SWH to be installed in five years	26592	Nos.
Total collector area in sqm	53184	Sqm
Total energy saved in five years	41.9	MU
Indicative cost of installation	6648.03	Lakh
MNRE subsidy @Rs.3300.00 per sqm	1755.08	Lakh
Cost of energy savings	1465.89	Lakh
Payback period	3	years
Emission reduction per year	**33925**	**Tonnes**

(ii) Use of Solar cookers (Box and dish type)

Both box type 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. It however cannot be used for frying or chapatti making. It is durable and simple to operate. 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 300oC depending upon the weather conditions. The temperatures attained with this cooker are sufficient for roasting, frying and boiling. Regular 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. A target of 15% in the domestic sector could save 14.33 MU of energy that occurs with use of a typical LPG cylinder. Considering the specific emission value of 0.24 per kWh per kg of CO_2, the emissions reduction of about 3440 tonnes can be brought about in 5 years. Cost implication and energy savings potential is presented in the table below.

Table 4.36: Introducing solar cooker in Coimbatore City

Calorific Value of LPG		12500	kcal/kg
	1 kcal=	0.001163	kWh
		14.54	kWh/kg
I Domestic Gas Cylinder		14	kg
		203.53	kWh
Specific emission per kWh Kg CO2		0.24	

Solar Cooker for Residential use		**Unit**
Total Residential household	312983	Nos.
Household having facility to install a solar cooker[34]	30%	
Target for introducing of solar cooker in 5 years[35]	15%	
Number of Solar Cooker to be installed in 5 years plan	14084	Nos.
Average savings of LPG domestic cylinder per year per solar cooker (14kg)	5	Nos.
Total LPG saved in five years	985896	kg
Total energy saved in five years	14.33	MU
Indicative cost of installation (75% box type & 25% SK-14)	369.71	Lakh
MNRE subsidy for solar cooker @30%	110.91	Lakh
Cost of energy savings	246.47	Lakh
Payback period	1.05	years
Emission reduction in five years	**3440**	**Tonnes**

(iii) Solar lanterns to replace kerosene lamps/ candles

The use of kerosene lanterns is fairly considerable in Coimbatore. The emissions reduction that can be brought about by the replacement of kerosene/candles with solar lanterns contributes to about 0.3% towards the overall reduction target of 15% in conventional energy demand. Nevertheless, this replacement brings about emissions reduction in lieu of 335 tonnes of CO_2 within a mere 5 year period. The relevant techno-commercial details are provided in the table below.

Table 4.37: Introducing solar lanterns in Coimbatore City

Density of kerosene	0.7782	
Calorific Value of Kerosene	11110	kcal/kg
1 kcal=	0.001163	kWh

[34] Based on ICLEI Survey
[35] ICLEI Analysis

Single Household		Unit
Capacity of residential Solar Home System	10	Wp
Number lights per Solar Home System	1	Nos.
Number of Kerosene lamp replaced by SL	1	Nos.
Consumption of kerosene per lanterns/month	3	Liters
Cost of kerosene per liter in the market	20	INR
Cost of kerosene per year per household	720	INR
Indicative cost of installing a SL	3000	INR
MNRE subsidy @Rs.81.00 per Wp	810	INR
Payback period when replacing the kerosene lamps	3.0	years
Target for entire city		**Unit**
Total Residential household	312983	Nos.
Residential household use kerosene lamps	8%	
Target to replace kerosene lamp in 5 years	15%	
Number of SL to be installed in 5 years plan	3662	Nos.
Total kerosene lamp replaced	3662	Nos.
Indicative cost of installation	109.86	Lakh
Kerosene saved	131828	Litres
Savings in terms of Electricity	1.33	MU
Cost of kerosene savings	26.37	Lakh
MNRE subsidy @Rs.81.00 per Wp	29.66	Lakh
Payback period	3.0	years
Emission reduction per year	**335**	**Tonnes**

(iv) Use Solar Home Systems (SHS)

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 capacities 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 by 8% population in Coimbatore Corporation 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 13 litres per month per household. If a 20% replacement target is considered within the next 5 years, then energy savings of 8 MU result and emissions reductions are expected to be 1950 tonnes in 5 years. The potential of kerosene replacement with Solar Home Systems and financial implication thereon is indicated in the table below.

Table 4.38: Introducing solar home system in Coimbatore City

Single Household		Unit
Capacity of residential Solar Home System	74	Wp
Number lights per Solar Home System	4	Nos.
Number of Kerosene lamp replaced by SHS	4	Nos.
Consumption of kerosene per household/month	13	Litres
Cost of kerosene per litre in the market	20	INR
Cost of kerosene per year per household	3144	INR
Indicative cost of installing a SHS	16000	INR

Single Household		Unit
MNRE subsidy @Rs.81.00 per Wp	5994	INR
Payback period when replacing the kerosene lamps	3.2	years
Target for entire city		**Unit**
Total Residential household	312983	Nos.
Residential household use kerosene lamps[36]	8%	
Target to replace kerosene lamp in 5 years[37]	20%	
Number of SHS to be installed in 5 years plan	4883	Nos.
Total kerosene lamp replaced	19530	Nos.
Indicative cost of installation	781.21	Lakh
Kerosene saved	768	KL
Savings in terms of Electricity	8	MU
Cost of kerosene savings	154	Lakh
MNRE Subsidy @Rs.81.00 per Wp	293	Lakh
Payback period	3.2	years
Emission reduction in five years	**1950**	**Tonnes**

(v) Using Solar PV for Home Inverters

Coimbatore has been battling with power cuts and load shedding for some time now. The power deficits run up from 2500 MW to 3000MW in the entire State. About 13% in the residential sector use inverters during load shedding. A 15% replacement target in Coimbatore city in 5 years duration yields a reduction in emissions of about 1854 tonnes of CO_2. The city would have a total installed capacity of PV units of 1526 kWp which will abate carbon emissions, reduce load demand and also generate savings of about INR 80 lakh. The potential of energy savings, green house gas emission reduction and budgetary financial implication is indicated in the table below.

Table 4.39: Target for introducing Solar PV for Home Inverters in Coimbatore City

Solar PV for Home Inverters		Unit
Capacity of solar PV system for Home Inverter	250	Wp
Indicative cost of incorporating Solar PV to Home Inverter	43750	INR
Total Residential household	312983	Nos.
Residential household use Inverter during load shedding	13%	
Target to introduce solar charger for inverter in 5 years	15%	
Number of solar inverter to be installed in 5 years plan	6103	Nos.
Total PV capacity installed	1526	kWp
Total Energy generated by PV arrays in five years	2	MU
Cost of energy saved	80	Lakh
Indicative cost of installation	2670	Lakh
MNRE subsidy @Rs.57.00 per Wp	870	Lakh
Payback period	22	years
Emission reduction in five years	**1854**	**Tonnes**

[36] Based on ICLEI Survey
[37] ICLEI Analysis

(vi) Using Solar PV for Generator sets

The replacement if DG sets with SPV units is being encouraged as a means of limiting their use during load shedding periods that the city is oft presented with. Currently, about 6% of the households in the city use DG sets during load shedding. At a replacement target of 10% within 5 years, there occurs an increase in installed capacity of SPV units by 1878 kWp and a substantial saving in diesel consumption in the residential sector of about 1502 KL. The total reduction in emissions that results from this replacement is 3816 tonnes in 5 years.

Table 4.40: Target for replacement DG/Kerosene Generator sets with Solar PV units for Coimbatore City

Calorific Value of Diesel	11840	kcal/kg
Density of diesel	0.8263	
Calorific Value of LPG	12500	kcal/kg
1 kcal=	0.00116	kWh
Average use of Gen-set	200	days/year

Solar PV for replacement of DG/Kerosene Generator sets		Unit
Capacity of solar PV system	1	kWp
Indicative cost of incorporating Solar power pack	2.60	Lakh
Total Residential household	312983	Nos.
Total Residential household after being accounted for in apartments	302183	Nos.
Residential household use generators during load shedding	6%	
Target to introduce solar power pack in 5 years	10%	
Number of solar power pack to be installed in 5 years plan	1813	Nos.
Total PV capacity installed	1813	kWp
Total Energy generated by PV arrays in five years	2.72	MU
Typical generator set used	5-10	kW
Average fuel consumption per day for 4-6 hours load shedding	4	liters
Amount of diesel saved in five years for entire city	1450	KL
Cost of Diesel saved	580.19	Lakh
Indicative cost of installation	4714	Lakh
MNRE subsidy @Rs.57000.00 per kWp	1033	Lakh
Payback period	6.34	Years
Total Emissions reduction in five year for replacement of diesel	3684	Tonnes

(vii) RE systems for residential Apartments/ housing complexes

Coimbatore city has about 3000 apartment building and an average of 30 flats or residences in each building. Solar water heaters and solar PV power plants are considered to be most viable renewable energy devices for the existing and well as new residential complexes.

Table 4.41: RE system for residential apartments

Total number of apartment in the city	3000	
Total number of apartment in the city	3000	
% of residential apartment suitable for installation of RE system[38]	30%	
% of residential apartment targeted for RE system integration[39]	40%	
Number of target residential apartment buildings in the city	360	
Average number of Residence in each building	30	
Solar Water Heater System		
Average size of Solar water heaters each building	3000	LPD
Total capacity of SWH to be installed in 5 years plan	1080000	LPD
Total collector area in sqm	21600	Sqm
Total energy saved in five years	12.8	MU
Indicative cost of installation	1530.00	Lakh
MNRE subsidy @Rs.3300.00 per sqm	712.80	Lakh
Beneficiary/ State/ CMC share	817.20	Lakh
Cost of energy savings	446.51	Lakh
Payback period	1.83	years
Emission reduction in five years	**10800**	**Tonnes**
Solar PV Power Plant for Back-up power		
Capacity of solar PV system for single apartment of 20 Residence	15	kWp
Indicative cost of incorporating Solar PV to Home Inverter	35	Lakh
Total capacity of PV systems for targeted apartments for 5 years	5400	kWp
Total Energy generated by PV arrays in five years	8.10	MU
Cost of energy saved	284	Lakh
Indicative cost of installation	12600	Lakh
MNRE subsidy @Rs.57 per Wp	3078	Lakh
Beneficiary/ State/ CMC's share	9522	Lakh
Payback period	34	years
Emission reduction in five years	**6561**	**Tonnes**

(viii) Summary of RE strategy for Residential Sector

Adoption of above recommended RE strategy in the residential sector will avail the Coimbatore city energy savings of about 91.12 MU and emissions reduction of 62548 tonnes per year. It is highly recommended that the city lays more importance on installation and use of SWH in the city which can be proved to show beneficial in context of energy saved and emissions reduced.

The total investment for these strategies to be applied and implemented is about INR 294 Crore within the 5 year period of which the contribution from MNRE is expected to be around INR 78.8 Crore. Following is a summary of the RE strategy for residential sector in Coimbatore city.

[38] Based on ICLEI Survey
[39] ICLEI Analysis

Table 4.42: Summary of RE Strategy for Residential sector in Coimbatore City

RE Strategy for residential sector	Target Capacity	Units	Investment (Lakh)	MNRE subsidy (Lakh)	Beneficiary's contribution (Lakh)	Energy Saved (MU)	Emissions Reductions (Tonnes)
Solar water Heaters	27592	Nos.	6648	1755	5893	41.88	33925
Solar cookers	14084	Nos.	370	111	259	14.33	3440
Solar Lantern	3662	Nos.	110	30	80	1.33	335
Solar Home System	4883	Nos.	781	293	489	7.72	1950
Solar Home inverter	6103	Nos.	2670	870	1800	2.29	1854
PV for replacing DG sets	1813	Nos.	4714	1033	3681	2.72	3684
SWHS for Residential Apartment	1080000	LPD	1530	713	817	12.76	10800
PV for Residential Apartment	5400	kWp	12600	3078	9522	8.10	6561
			29423	**7882**	**21541**	**91.12**	**62548**

4.4.2 RE Strategy for Commercial and Institutional Sector

The commercial & institutional sector owns substantial part in energy consumption in Coimbatore city. The sector consumes about 24% of total electricity consumed in the city with its 333 educational institutes, 288 health care facilities including clinics, hospitals and medical supply stores, 52 hotels and restaurants and 88 odd restaurants[40]. Different strategies are prepared for different categories of consumers based on type and quantum of energy consumed and availability of resource and space to generate renewable energy in their premises. While preparing the strategy, only techno economically viable and commercially available renewable energy options are considered.

It is estimated that introduction of RE system in commercial and institutional sector in Coimbatore city as described in the table 30 below will save 44.11MU of energy in five years and reduce GHG emission by 37496 Tons per year. Introduction of solar water heater system should be given prime importance in the hospitality, health care sector and educational campus.

4.4.3 RE Strategy for Hospitality Sector

Coimbatore has 52 hotels including twelve 5-star category hotels and twenty seven 3-star category hotels. Major energy requirement such as hot water and electricity during load shedding/ peak load could be partially met by solar energy. Solar thermal system can be used to generate hot water or steam for cooking. Solar PV power plant can be used to reduce or eliminate use of diesel generators which are being used during load shedding hours. Apart from that hotels also generate bio waste which can be used to produce biogas through bio-methanation process. Solar pumps and solar garden lights can be used for sprinkling water and beautification.

[40] ICLEI Survey

Table 4.43: Recommended Renewable Energy Systems for Hotels

Hotels	Nos.	Steam generating system (sqm)		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (CuM)	
5 star hotels with 100+ rooms	12	200	2400	15000	180000	25	300	20	240
3 star hotels with 100+ rooms	12	100	1200	10000	120000	10	120	10	120
3 star hotels < 100 rooms	15	50	750	5000	75000	5	75	5	75
Budget hotels	13	0	0	3000	39000	2	26	0	0
Aggregate	52		4350		414000		521		435
Target in 5 years		50%	2175	50%	207000	50%	261	50%	218
Energy Savings (MU)			1.41		3.11		0.39		0.4616
Total Emission reduction			1202		2639.25		332		392.4
Investment (Lakh INR)		15000	326	200	414	1.75	456	15000	33

4.4.4 Renewable Energy Systems for Restaurants

Coimbatore has a number of restaurants and eateries. The city has more than 88 restaurants and which are categorized as large, medium and small restaurants. Solar water heaters and solar steam generating systems can be introduced in these restaurants to meet their hot water demand for cooking and utensil cleaning. Since all the restaurants are using DG sets as standby power supply source during load shedding, PV power plant will be an attractive and profitable option for the restaurants. Introduction of RE system in 25% of restaurants in Coimbatore city as described in the table below will save 4.88 MU of energy per year and reduce GHG emission by 3337 Tons per year. Introduction of solar water heater system should be given prime importance followed by biogas system and solar PV system for diesel abatement.

Table 4.44: Recommended Renewable Energy Systems for Restaurants

Restaurants	Nos.	Steam generating system for Cooking (sqm)		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (Cu M)	
Large restaurants	5	200	1000	15000	75000	25	125	50	250
Medium Restaurants	14	100	1400	10000	140000	10	140	20	280
Small Restaurants	69	50	3450	5000	345000	5	345	10	690
Aggregate	88		5850		560000		610		1220
Target in 5 years		25%	1463	25%	140000	25%	153	25%	305
Energy Savings (MU)			0.95		2.10		0.23		0.65
Total Emission reduction			808		1785		194		550
Investment (Lakh INR)		15000	219	200	280	1.75	267	15000	46

4.4.5 Renewable Energy Systems for Health care Sector

The Coimbatore city has about 288 health care facilities, which includes 20 urban health posts, 2 maternity homes, 16 corporation dispensaries and 250 private hospitals[41]. Apart from that the city has other health care facilities like dispensaries, dental clinic, microsurgery, day care centre and pathological laboratories. Recommended renewable energy systems have been shown in the table below.

Table 4.45: Recommended Renewable Energy Systems for Health Care Sector

Type of Health Care establishment	Nos.	Solar Water Heating System (LPD)		Solar PV System (kWp)	
		Per unit	Recommended unit		
Urban Health Posts	20	2000	40000	2	40
Maternity Homes	2	10000	20000	5	10
Corporation Dispensaries	16	5000	80000	10	160
Private Hospitals	250	10000	2500000	10	2500
Aggregate	288		2640000		2710
Target in 5 years		50%	1320000	50%	1355
Energy Savings (MU)			19.80		2.03
Total Emission reduction			16830		1728
Investment (Lakh INR)		200	2640	1.75	2371

4.4.6 Renewable Energy Systems for Educational Institutes

Coimbatore is known for its higher educational institutes. Coimbatore city has 60 primary/ nursery schools, 13 intermediate and high schools, 109 secondary schools and 150 colleges for arts, science and engineering education. The government primary schools provide free mid-day meal to its students. Community solar cookers can be used to cook mid-day meal in these schools. The institutes having hostels can use solar water heater to supply hot water to the bathrooms and solar steam cooker for the hostel mess. Suitable renewable energy devices considered for educational institutes are:

(i) Steam Cooking for hostel mess
(ii) Solar Water Heating System for hostels
(iii) Biogas from Kitchen waste of Hostels mess
(iv) Use of Solar cookers for cooking mid-day meals in primary schools
(v) Solar PV system

[41] ICLEI Survey

Table 4.46: RE Strategy for Educational sector in Coimbatore City

Type of Establishment	Nos.	RE System Proposed							
		Steam generating system for Cooking (sqm collector area)		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (Cu M)	
		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Unit Capacity	Total Capacity
Primary School	60	20	1200	0	0	1	60	0	0
Middle Schools	13	0	0	0	0	2	26	0	0
Higher Secondary	109	0	0	0	0	2	218	0	0
Special Needs	1	0	0	5000	5000	2	2	0	0
Colleges	150	200	30000	10000	1500000	10	1500	20	3000
Aggregate	333		31200		1505000		1806		3000
Target in 5 years		25%	7800	25%	376250	25%	452	25%	750
Savings (MU)			5.07		5.64		0.68		1.59
Total Emissions reduction			4310		4797		576		1353
Invest (Lakh INR)		15000	1170	200	753	1.75	790	15000	113

4.4.7 Summary of RE strategy for Commercial and Institutional Sector

RE strategy for commercial and institutional sector, once implemented fully will save 44.11 MU of energy in five years and reduce GHG of 37496 Tons per year. The primary focus should be given to introduction of solar water heaters for hotels, restaurants, hospitals and other residential institutes, which will save 30.65 MU per year. Solar PV power plant should be introduced for captive diesel abatement in the establishments that are using diesel sets as standby power supply source. The restaurants and hotels that has considerable amount of food and organic waste, should introduce biogas system. Use of solar cooker for preparing mid-day meal in primary schools will be an attractive option to save LPG for cooking and creation of awareness and demonstration about use of renewable energy devices among school children.

Table 4.47: Summary of RE Strategy for Commercial and Institutional Sector

RE Strategy for Commercial and Institutional sector	Units	Target Capacity	Total Investment (Lakh INR)	MNRE subsidy (Lakh INR)	Beneficiary's contribution	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Solar Steam Cooker for Cooking in Schools, Hostels, Hotels, Restaurant	sqm	11438	1715.63	617.63	1098.00	7.43	6319.22
Solar Water Heaters for Hotels, Restaurants,	LPD	2043250	4086.50	1348.55	2737.96	30.65	26051.44

RE Strategy for Commercial and Institutional sector	Units	Target Capacity	Total Investment (Lakh INR)	MNRE subsidy (Lakh INR)	Beneficiary's contribution	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Hospitals							
Solar PV Power Plant for Hotels, Restaurants, Hospitals.	kWp	2220	3884.13	1265.12	2619.01	3.33	2829.86
Biogas for Hotels and Restaurants	CuM	1273	190.88	133.61	57.26	2.70	2295.72
			9877.13	**3364.90**	**6512.23**	**44.11**	**37496.24**

4.4.8 RE Strategy for Industrial Sector

Renewable energy devices are suggested for different categories of industrial consumers based upon their type and quantum of energy demand. Low temperature solar thermal application for boiler feed water preheating is a highly feasible and economically beneficial for low heat process industries like diary, textile, food process industries etc. Concentrated Solar Thermal application can be directly used to meet medium temperature process heat for textile, dying and food processing industries.

Solar PV system based uninterrupted power supply system will increase productivity and profitability for small industries. For medium and large industries using diesel generator can use solar PV for reduction of expensive diesel fuel. The industries having large roof can install solar PV power either to meet their own Renewable Purchase Obligation (RPO) or make investment to take benefit under REC mechanism.

Table 4.48: Summary of RE Strategy for Industrial Sector

Type of Establishment	Nos.	RE System Proposed							
		Steam generating system		Solar Water Heating System		Solar PV System		Biogas System	
		Average Capacity (sqm)		Average Capacity (LPD)		Average Capacity (kWp)		Average Capacity (Cu M)	
		Unit	Total	Unit	Total	Unit	Total	Unit	Total
Metal products	3151	0	0	0	0	10	31510	0	0
Textile & textile products	1718	1000	1718000	10000	17180000	10	17180	0	0
Machinery and Equipments	1309	0	0	0	0	5	6545	0	0
Food products and beverages	335	500	167500	5000	1675000	5	1675	50	16750
Service Industries	1117	0	0	0	0	5	5585	0	0
Other Manufacturing Industry	1032	0	0	0	0	5	5160	0	0
Aggregate	8662		1885500		18855000		56910		16750
Target in 5 years		10%	188550	20%	3771000	10%	5691	5%	838
Energy Savings (MU)			122.56		56.57		8.54		1.78
Total Emission reduction			104174		48080		7256		1511
Investment (Lakh INR)		15000	28283	200	7542	1.75	9959	15000	126

4.4.9 RE Strategy for Government and Municipal Sector

The municipal and government building sector of Coimbatore city consumes about 6% of total electrical energy in the city[42]. The primary consumers in this sector are streetlights, outdoor lights in parks and monuments, markets, office buildings of the Municipal Corporation, water supply, sewerage treatment plant etc. Renewable energy devices are suggested to all categories of consumers depending upon the energy demand. The sector has ample opportunity to save energy through introducing renewable energy and energy conservation measures and could show case these initiatives to encourage people to adopt further.

Table 4.49: RE System for Outdoors lighting (Streets, Traffic, Road safety etc.)

	Potential	Target	Investment (Lakh)	MNRE subsidy (Lakh)	Sate/ CMC (Lakh)	Energy Saved (MU per year)	Emissions Reductions per year (Tonnes)
Solar Street Lights 1x 74Wp	21729	10864	2173	651	1522	1.21	977
Solar PV Traffic Lights (2x74Wp)	46	23	11.50	5.75	5.75	0.0051	4.14
Solar Blinkers (37Wp)	120	60	9.00	4.50	4.50	0.0033	2.70
Road Stud @ 1 stud in 2m for 50% of main road	25000	6250	75.00	37.50	37.50	0.03	22.78
			2268.37	**698.96**	**1569.41**	**1.24**	**1006.43**

Table 4.50: RE Strategy for Municipal and Government Building Sector

Type of Establishment	Nos.	RE System Proposed							
		Steam generating system for Cooking		Solar Water Heating System		Solar PV System		Biogas System	
		Average Capacity (sqm)		Average Capacity (kWp)		Average Capacity (sqm)		Average Capacity (kWp)	
		Unit	Total	Unit	Total	Unit	Total	Unit	Total
Municipal buildings	4	0	0	0	0	10	40	0	0
CMC Stadiums	2	0	0	0	0	50	100	0	0
CMC Parks & Centres	52	0	0	0	0	10	520	0	0
CMC Health Care	38	0	0	2000	76000	5	190	0	0
CMC Schools	98	0	0	0	0	5	490	0	0
Other buildings	174	0	0	0	0	5	870	0	0
Bus Stands	4	0	0	0	0	5	20	0	0
Kaliyanamandapam	9	0	0	5000	45000	5	45	20	180
Boat House	1	0	0	0	0	2	2	0	0
Market Complexes	17	0	0	0	0	10	170	0	0

[42] ICLEI Survey

Type of Establishment	Nos.	RE System Proposed							
		Steam generating system for Cooking		Solar Water Heating System		Solar PV System		Biogas System	
		Average Capacity (sqm)		Average Capacity (kWp)		Average Capacity (sqm)		Average Capacity (kWp)	
		Unit	Total	Unit	Total	Unit	Total	Unit	Total
Daily Market	9	0	0	0	0	5	45	10	90
Weekly Market	1	0	0	0	0	2	2	10	10
Pay and use toilets	43	0	0	0	0	2	86	5	215
Reading Rooms	2	0	0	0	0	1	2	0	0
Noon Meals Centres	88	200	17600	2000	176000	1	17600	5	440
Aggregate	452		17600		297000		20182		935
Target in 5 years		10%	1760	20%	59400	20%	4036	10%	94
Energy Savings (MU)			1.14		0.89		6.05		0.20
Emission reduction			972		757		5146		169
Investment (Lakh INR)		15000	264	200	119	1.75	7064	15000	14

The Municipal sector can contribute 9.53 MU energy savings in five years through introducing RE devices in the different municipal utilities and services reducing GHG emission by 8051 tonnes in five years.

Table 4.51: Summary of RE Strategy for Municipal and Government Building Sector

RE Strategy for Municipal and Government sector	Units	Target Capacity	Total Investment (Lakh INR)	MNRE subsidy (Lakh INR)	Sate/ CMC/ contribution (Lakh INR)	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Solar Steam generating system	sqm collector area	1760	264.00	95.04	168.96	1.14	972.40
Solar Water Heaters	LPD	59400	118.80	39.20	79.60	0.89	757.35
Solar PV Power Plant	kWp	4036	7063.70	2300.75	4762.95	6.05	5146.41
Biogas	Cu M	94	14.03	9.82	4.21	0.20	168.68
Solar Street lights 1x74Wp	Nos.	10864	2173	651	1522	1.21	977
Solar PV Traffic Lights (2x74Wp)	46	23	11.50	5.75	5.75	0.0051	4.14
Solar Blinkers (37Wp)	120	60	9.00	4.50	4.50	0.0033	2.70
Road Stud @ 1 stud in 2m for 50% of main road	25000	6250	75.00	37.50	37.50	0.03	22.78

4.4.10 Energy Efficiency Strategies

While renewable energy technologies would provide clean energy, EE and DSM 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 as well as 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:

Residential Sector

- Replace Incandescent Lamps with Fluorescent
- T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast
- Efficient ceiling fans to replace conventional ceiling fans
- Replacement of conventional air-conditioners with EE star rated ACs
- Replacement of conventional refrigerators with EE star rated refrigerators
- Replacement of conventional water pumps with EE water pumps
- Reduce energy consumption in existing private buildings
- Reduce energy consumption in all new construction

Commercial and institutional building Sector

- Replace Incandescent Lamps with Fluorescent
- T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast
- Efficient ceiling fans to replace conventional ceiling fans
- Replacement of conventional air-conditioners with EE star rated ACs
- Replacement of conventional refrigerators with EE star rated refrigerators
- Replacement of conventional water pumps with EE water pumps

Industrial Sector

- Replace Incandescent Lamps with Fluorescent
- T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast
- Efficient ceiling fans to replace conventional ceiling fans
- Replacement of conventional air-conditioners with EE star rated ACs
- Energy efficiency in motors, furnaces, boilers, etc.

Municipal Sector

- Replacement of 150 watt HPSV with LEDs
- Replacement of 40 watt T8/T12 tube lights with T5 tube lights
- Sensors for automatic on/off of street lights
- Proper pump-system design (efficient Pump, pumps heads with system heads
- Installation of variable speed drivers
- 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

A sector-wise techno-economic analysis of potential energy efficiency and DSM measures has been carried out.

4.4.11 EE Strategy for Residential sector

Residential sector consumes largest amount of energy. Important proven and cost effective measures for the sector are described in this section. Based on the survey, it was found that incandescent lights are still used a lot in the residential sector. Utilizing the survey data the savings due to replacement of incandescent lamps with CFL are calculated and are presented in the table below.

(i) Replace Incandescent Lamps with Fluorescent

Incandescent bulbs are the major and the most common source of high-energy consumption in the residential area. Replacement of incandescent lamps has acquired a substantial precedence in all the energy efficiency strategies as the most feasible option. The techno-commercial details for replacement of incandescent bulbs with CFL are given below. 100% households using incandescent bulbs have been considered as target group for replacements.

Table 4.52: Replacement of incandescent lamps with fluorescent

Particulars		Unit
Total Residential household	312983	Nos.
Household using incandescent bulb	42%	
Target to replace incandescent bulb with CFL	100%	
Number of incandescent bulb to be replaced per household	4	Nos.
Total number of incandescent bulb to be replaced	521355	Nos.
Indicative cost of installation	782	Lakh
Energy saved by replacing 60W bulb with 15W CFL	51379492	kWh
Cost of electricity savings	1798	Lakh
Payback period	0.43	Years
Emission reduction per year	41617	Tonnes

(ii) T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast

A conventional tube light (with magnetic ballast consuming 15W) consumes around 55 watts. It can be replaced with T5 tube (28W) with electronic ballast (4W) which will require around 32W. The calculations have been done for a period of 5 years assuming replacement of T 12 /T8 tube lights in 80% households using T12/T8 tube lights.

Table 4.53: T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast

Particulars		Unit
Total Residential household	312983	Nos.
Household using T8/T12 tube lights	94%	
Target to replace T8/T12 by T5 tube lights	80%	
Number of T8/T12 to be replaced per household	2	Nos.
Total number of T8/T12 tube lights to be replaced	470311	Nos.
Indicative cost of installation	2352	Lakh
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	15793036	kWh
Cost of electricity savings	553	Lakh
Payback period	4.25	Years
Emission reduction per year	12792	Tonnes

(iii) Efficient ceiling fans to replace conventional ceiling fans

Replacing conventional fans with star rated fans can save substantial amount of electrical energy and money. The financial and technical analysis for replacement of conventional ceiling fans in residential sector of Coimbatore city assuming replacement of old ceiling fans with star rated ones for 50% households.

Table 4.54: Efficient Ceiling Fans to Replace Conventional Ceiling Fans

Particulars		Unit
Total Residential household	312983	**Nos.**
Household using Conventional Fans	91.44%	
Target to replace CF by EE Fans	50%	
Number of Conventional fan to be replaced per household	300	Nos.
Total number of Conventional Fans to be replaced	429306.26	Nos.
Indicative cost of installation	6440	Lakh
Energy saved by replacing Conventional Fans by EE Fans	23182538	kWh
Cost of electricity savings	811	Lakh
Payback period	8	Years
Emission reduction per year	18778	Tonnes

(iv) Replacement of conventional air-conditioners with EE star rated ACs

Due to moderate to cold weather, use of air conditioner is not common in Coimbatore. Survey results show that 14% of residential households use air conditioners. These air conditioners can be replaced by start rated energy efficient air conditioners. The replacement target is 50% households using air conditioners.

Table 4.55: Replacement of conventional air-conditioners with EE star rated ACs

Particulars		Unit
Total Residential household	312983	Nos.
Household using Conventional AC	14%	
Target to replace Conventional ACs by EE star rated AC	50%	
Number of Conventional ACs to be replaced per household	1	Nos.
Total number of Conventional ACs to be replaced	21236	Nos.
Indicative cost of installation	5838	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	8600538	kWh
Cost of electricity savings	301	Lakh
Payback period	19	Years
Emission reduction per year	6966	Tonnes

(v) Replacement of conventional refrigerators with EE star rated refrigerators

One of the most common appliance used in homes are the refrigerators. With increasing affordability refrigerators have become an indispensable item in most Indian households. They come in the capacity range of 200-400 liters. These days many BEE star rated energy efficient refrigerators are available in the Indian market. About 59% households use refrigerator and replacement of 50 % of those refrigerator with star rated ones will save on average 44MU electricity every year.

Table 4.56: Replacement of Conventional Refrigerators with EE Star Rated Refrigerators

Particulars		Unit
Total Residential household	312983	**Nos.**
Household using Conventional Refrigerators	58.96%	
Target to replace Conventional Refrigerators by EE Star Rated Refrigerators	50%	
Number of Conventional Refrigerators to be replaced per household	1	Nos.
Total number of Conventional Refrigerators to be replaced	92263	Nos.
Indicative cost of installation	10380	Lakh
Energy saved by replacing Conventional Refrigerators by EE Star Rated Refrigerators	43732517	kWh
Cost of electricity savings	1531	Lakh
Payback period	7	Years
Emission reduction per year	35423.3	Tonnes

(vi) Replacement of conventional water pumps with EE star rated water pumps

Survey in Coimbatore has shown that residential households use water pumps of 1.5 HP capacities which have an approximate electrical consumption of 2.2 kWh. Assuming 45% households in Coimbatore use water pumps, 50% replacement of conventional pumps by energy efficient pumps have been targeted for energy savings that have been estimated to be 10.7MU in one year.

Table 4.57: Replacement of conventional water pumps with EE star rated water pumps

		Unit
Total Residential household	312983	Nos.
Household using Water Pumps	45%	
Target to replace Conventional Water Pump by EE Pump	50%	
Number of Conventional Pumps to be replaced per household	1	Nos.
Total number of Conventional Pumps to be replaced	98121	Nos.
Indicative cost of installation	1962.42	Lakh
Energy saved by replacing Conventional Water Pumps by EE Water Pumps	10744227	kWh
Cost of electricity savings	376.05	Lakh
Payback period	5.22	Years
Emission reduction per year	8703	Tonnes

(vii) Summary of EE Strategy in Residential Sector

The estimated potential of energy savings in the residential sector through energy efficiency measures is 153MU per year which is alone can meet 31.81% of the target of 482.35MU energy savings in five years in Coimbatore City. The reduction of emission through EE measures in residential sector is 124280 tonnes per year. Replacement of incandescent bulbs with CFL, conventional fans, refrigerators and air conditioners with star rated one is the most potential scope for energy savings.

Table 4.58: Summary of EE Strategy in Residential Sector

EE Measures in residential sector	Unit	Target Capacity	Investment (Lacs INR)	Amount of Energy Saved (MU)	Emissions Reduction (Tonnes)
Replacement of 60 watt incandescent with 15 watt CFL	Nos.	521355	782	51	41617
Replacement of T12/T8 with T5 FTL	Nos.	470311	2352	16	12792
Replacement of conventional Fans with EE star rated fans	Nos.	429306	6440	23	18778
Replacement of conventional AC with EE star rated AC	Nos.	21236	5838	9	6966
Replacement of conventional refrigerator with EE star rated refrigerator	Nos.	92263	10380	44	35423
Installation of EE water pump	Nos.	98121	1962	11	8703
			27753	**153**	**124280**

4.4.12 EE Strategy for Government and Municipal Sector

Government establishments and Municipal services annually incur huge expenditures on electricity consumption. Hence energy efficiency has become the call of the day for municipal organizations in India, owing to growing city needs. The Bureau of Energy Efficiency in India has already come out with the Manual for development of Municipal Energy Efficiency Projects. Energy conservation drives in government buildings and municipal utilities will become an exemplary initiative for similar activities in the city. As a high visibility and administration center Municipal bodies across India should go ahead in implementing the strategies and replicating the success stories. Tamil Nadu government has already taken few initiatives to save energy in government buildings. It is now mandatory that all government establishment to have CFLs in place of incandescent bulbs. The following efficiency measures are suggested in government and municipal sector.

EE measures in Street Lighting

(i) Replacement of 250 W HPSV with 200 W Induction lamps

Replacement of about 15000 250W HPSV lamps with 200W Induction lamps to be used in Street lights can save 3.3MU of electricity per year reducing 2660 tonnes of GHG per year.

Table 4.59: Replacing 250 W HPSV with 200W Induction lamps

		Unit
Total number of 250 watt HPSV	14998	Nos.
Target to replace HPSV lamp with Induction Lamp	100%	
Total number of 200 watt Induction Lamp needed	14998	Nos.
Indicative cost of installation	3802	Lakh
Energy saved by replacing 250 watt HPSV with 200 watt Induction Lamp	3284562	kWh
Cost of electricity savings	164	Lakh
Payback period	23.15	Years
Emission reduction per year	2660	Tonnes

(ii) Replacement of 150 W and 125 W HSPV with 100 W Induction lamps

Replacement of about 300 150 W and 125 W HPSV lamps with 100W Induction lamps to be used in Street lights can save 0.06MU of electricity per year reducing 46 tonnes of GHG per year.

Table 4.60: Replacing 150 & 125 W HPSV with 100 W Induction lamps

		Unit
Total number of 150 & 125 watt HPSV	259	Nos.
Target to replace 150 & 125 watt HPSV with 100 watt Induction lamp	100%	
Total number of 100 watt induction lamp needed	259	Nos.
Indicative cost of installation	54	Lakh
Energy saved by replacing 150 & 125 HPSV with 100 watt induction lamp	56721	kWh
Cost of electricity savings	3	Lakh
Payback period	19.18	Years
Emission reduction per year	46	Tonnes

Street lighting is one of the major sources of energy consumption in municipal area. HPSV lamps of 400W, 250W, 150W, 70W and 40W fluorescent tubes are mostly used as streetlights to lighten the city area. Different energy conservation measures could be taken up for electricity savings in street lighting systems. Commonly practiced energy conservation measures are discussed below.

(iii) Replacement of 40 W tube lights with 25 W LED lamps

The extended jurisdictional area under the CMC limits will be implemented with energy conservancy measures through replacements of 40W tube light with 25 W LED street lights. The area currently has 22925 numbers of street lights and a target of 100% replacement is proposed with an investment of INR 4956 Lakh. The payback period for such an investment considering the savings in cost of energy, reduction in O&M cost of LED etc is evaluated at 14.7 years. A summary of potential savings, investment, payback and potential reduction of GHG from power savers are given in the table below

Particulars		Unit
Total number of 40 W tube lights	22925	Nos.
Target to replace 40 W tube lights by 25 W LED lamps	100%	
Total number of 25 watt LED lamp needed	22925	Nos.
Indicative cost of installation	4856	Lakh
Savings in lower replacement costs in 25 W LED	282	Lakh
Energy saved	1380658	kWh
Cost of electricity savings	48	Lakh
Total cost savings	330	Lakh
Payback period	14.70	Years
Emission reduction per year	45.94	Tonnes

(iv) Use of Power savers for HPSV Street Lights

Using power savers can save about 30% electricity in the HPSV street lighting systems. There are 21603 numbers of HPSV street lights in Coimbatore excluding those under proposal for being replaced as detailed above. A summary of potential savings, investment, payback and potential reduction of GHG from power savers are given in the table below.

Table 4.61: Power saver for HPSV streetlights

Wattage	Unit	400 W (High mast SVL)	400W	70 W	Total
Total no of street lights	No.s	16	113	21474	21603
Load	KW	6	45	1503	1555
Electricity Consumption	kWh	25696	181478	6035268	6242442
No of 25 KVA Power Saver Required	No.s	0.32	2.26	75.16	78
Cost of each 20 KVA Power Saver is INR 0.85 Lakh each	INR Lakh	0.3	1.9	63.9	66
Energy Saved	kWh	7708.8	54443.4	1810580.31	1872732.5
Cost of Energy Saved	INR Lakh	0.3	1.9	63.4	66
Payback Period	years	1.01	1.01	1.01	
Emissions Saved	**Tonnes**	**6.24**	**44.10**	**1466.57**	**1517**

(v) Use of Power savers for MHL fittings

Metal Halide Lamp fittings are generally used at traffic junctions where they're mounted in a tall pole for illumination. These are compact and can be subjected to efficient use when used with a power saver pack. A summary of potential savings, investment, payback and potential reduction of GHG from power savers are given in the table below

Table 4.62: Power saver for MHL fittings

Wattage	Unit	400 W	250 W	Total
Total no of street lights	No.s	534	307	841
Load	KW	214	77	291
Electricity Consumption	kWh	857604	308151	1165755
No of 25 KVA power Saver Required	No.s	10.68	3.84	15
Cost of each 20 KVA power saver is INR 0.85 Lakh each	INR Lakh	907800	326187.5	1233987.5
Energy Saved	kWh	257281.2	92445.38	349727
Cost of Energy Saved	INR Lakh	900484.2	323558.8	1224043
Payback Period	years	1.01	1.01	
Emissions Saved	**Tonnes**	**208.40**	**74.88**	**283.3**

(vi) Use of Power savers for CFLs

Under the energy conservation measures of the Corporation of Coimbatore, CFLs were extensive replacements for street lights in the recent past. Use of power saver packs on these equipments renders them more efficient and increases their life. A summary of potential savings, investment, payback and potential reduction of GHG from power savers are given in the table below.

Table 4.63: Power saver for CFLs

Wattage	Unit	250 W	4*24 W	72 W	36 W	Total
Total no of street lights	No.s	3358	41	75	358	3832
Load	KW	840	4	5	13	862
Electricity Consumption	kWh	3370593	15803.0	21681	51745	3459822
No of 25 KVA power Saver Required	No.s	41.975	0.1968	0.27	0.6444	43.0862
Cost of each 20 KVA power saver is INR 0.85 Lakh each	INR Lakh	3567875	16728	22950	54774	3662327
Energy Saved	kWh	1011177.8	4740.912	6504.3	15523.6	1037946.6
Cost of Energy Saved	INR Lakh	3539122	16593.19	22765.05	54332.59	3632813
Payback Period	years	1.01	1.01	1.01	1.01	
Emissions Saved	**Tonnes**	**819.05**	**3.84**	**5.27**	**12.57**	**840.74**

(vii) Use of Power savers for T5 Tube Lights and Other tubes

A summary of potential savings, investment, payback and potential reduction of GHG from power savers are given in the table below.

Wattage	Unit	T 5 Tube Lights		Total
Total no of street lights	No.s	534	194	728
Load	KW	51	23	74
Electricity Consumption	kWh	205825	93469	299294
No of 25 KVA power Saver Required	No.s	2.5632	1.164	3.73
Cost of each 20 KVA power saver is INR 0.85 Lakh each	INR Lakh	217872	98940	316812
Energy Saved	kWh	61747	28041	89788
Cost of Energy Saved	INR Lakh	216116	98143	314259
Payback Period	years	1	1	-
Emissions Saved	**Tonnes**	**50**	**23**	**73**

(viii) Sensors for automatic on/off of street lights

Automatic streetlights ensure that lights turned on during daytime do not waste energy. Many streetlights in India face this predicament due to faulty manually controlled streetlights. Manual control involves labor costs, energy wastes and poor efficiency; hence Municipal street lights should hasten the process of installing automatic sensors. Solar sensors are the new and upcoming products in the market today and should be applied by municipalities for higher efficiency in the operation and maintenance of municipal streetlights. Coimbatore city showed predominantly manual control of municipal streetlights and hence it is highly recommended for switch over to automatic sensors preferably solar automatic sensors.

(ix) 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 state in its Manual for Development of Municipal Energy Efficiency Projects states that 25% energy savings can be obtained from initiatives in water systems alone. In Karnataka Municipal energy efficiency Improvement initiatives, water pumping has been

addressed. This has been further taken up as a Municipal Energy efficiency CDM project. The effort can be replicated throughput other municipalities sin India. This would bring about a lot of energy savings in water pumping utilities.

(x) Proper pump-system design (efficient Pump, pumps heads with system heads)

Proper water pumping design can bring about lots of 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 and the height it needs to be raised to. Fluid piping soft wares 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 4.64: Proper pump-system design (efficient Pump, pumps heads with system heads)

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	16.95
Annual Energy Cost in Rs. (lacs)	593.25
Saving %	20%
Total Annual Saving in MU	3.39
Annual Saving in Rs. (lacs)	118.65
Emission Reduction	**2745.9**

(xi) Installation of variable speed drivers

Dimension and adjustment losses are two of the major energy loss sources in pumping processes. Adjusting pump speed or using Variable Speed Driver to adjust speed is one way to decreasing both the aforementioned losses in pumping processes. An assumption of 5% savings is taken to provide the financial and technical details of installing variable speed drivers in municipal water pumping systems in Coimbatore City.

Table 4.65: Variable Speed Drivers

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	16.95
Annual Energy Cost in Rs. (lacs)	593.25
Saving %	5%
Total Annual Saving in MU	0.8475
Annual Saving in Rs. (lacs)	29.6625
Emission Reduction	**686.475**

(xii) Power saver installation in pump house

An assumption of 15% savings is taken as the energy saving potential for installing power saver in municipal pump houses. The following techno-economics is based on this assumption.

Table 4.66: Power saver installation in pump house

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	16.95
Annual Energy Cost in Rs. (lacs)	593.25
Saving %	15%

Standard/Recommended Condition	Value
Total Annual Saving in MU	2.5425
Annual Saving in Rs. (lacs)	88.9875
Emission Reduction	**2059.43**

Energy Efficiency measures in Sewerage plants

(i) Installation of variable speed drives

Assuming savings of about 5% the financial and technical details of installing variable speed drivers in municipal sewer pumping systems in Coimbatore City is calculated below

Table 4.67: Variable speed drives

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	2.14
Annual Energy Cost in Rs. (lacs)	74.9
Saving %	5%
Total Annual Saving in MU	0.11
Annual Saving in Rs. (lacs)	3.75
Emission Reduction	**87**

(ii) Power saver installation in pump house

It is assumed that 15% of saving is obtained when power savers are installed in the sewerage pumping systems. The following techno-economics is based on this assumption.

Table 4.68: Power saver installation in pump house

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	2.14
Annual Energy Cost in Rs. (lacs)	74.9
Saving %	15%
Total Annual Saving in MU	0.321
Annual Saving in Rs. (lacs)	11.24
Emission Reduction	**260**

4.4.13 Summary of EE Strategy for Government and Municipal Sector

The energy savings potential through energy efficiency measures in municipal sector is 15.71MU in five years through reduction of 11651.2 tonnes of GHG emissions per year.

Table 4.69: Summary of EE Strategy for Government and municipal sector

EE Measures	No. of replacements	Investment (Lakh)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Indicative cost of replacing 250 watt HPSV with 200 watt induction lamps	14998	3802	3.28	2660
Indicative cost of replacing 150/125 watt HPSV with 100 watt induction lamps	259	54	0.06	46
Indicative cost of replacing 40W tube lights with 25 W LED lamps	22925	4856	1.38	46

EE Measures	No. of replacements	Investment (Lakh)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Pumping system improvement in existing water supply facility	-	-	6.78	5491.8
Pumping system improvement in existing sewage system facility	-	-	0.86	693
Use of power saver in street lighting	139	118.21	3.35	2714
			15.71	**11651.20**

4.4.14 EE Strategy for Commercial and Institutional Sector

The commercial and institutional sector comprises primarily of institutes, shops, markets, hotels and restaurants. Thus efficiency and conservation have to be addressed in existing and new buildings to affect overall demand and consumption reduction. Energy efficiency in the commercial sector is also hugely dependent on replacement of conventional equipment with more energy efficient appliances. All kinds of building sectors are available in Coimbatore ranging from hotels, hospitals, shops, malls, hostels, educational institutes and restaurants. The strategies here target all these building types in Coimbatore.

(i) Replace Incandescent Lamps with Fluorescent

CFL usage has been widespread in the last few years and it is high time that all commercial establishments should voluntarily replace the high energy consuming incandescent lamps with CFLs. From survey results we have assumed that 16% of the commercial sector establishments use incandescent bulbs and 100% of establishment use T8/T12 tube lights. A target to replace 80% of the incandescent bulbs and 80% of T8/T12 tubes in these households with CFLs is assumed to give the calculations below.

Table 4.70: Replacement of incandescent lamps with fluorescent

Particulars		Unit
Total Commercial Consumers	98056	Nos.
Consumers using incandescent bulb	16%	
Target to replace incandescent bulb with CFL	80%	
Number of incandescent bulb to be replaced per consumer	10	Nos.
Total number of incandescent bulb to be replaced	125512	Nos.
Indicative cost of installation	188	Lakh
Energy saved by replacing 60W bulb with 15W CFL	10166446	kWh
Cost of electricity savings	508	Lakh
Payback period	0.37	years
Emission reduction	**8235**	**Tonnes**

Table 4.71: Replace T12/T8 tube light by T5 tube light

Particulars		Unit
Total Commercial Consumers	98056	Nos.
Consumers using T8/T12 tube lights	100%	
Target to replace T8/T12 by T5 tube lights	80%	
Number of T8/T12 to be replaced per consumer	2	Nos.
Total number of T8/T12 tube lights to be replaced	156890	Nos.
Indicative cost of installation	784	Lakh

Particulars		Unit
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	4330153	kWh
Cost of electricity savings	217	Lakh
Payback period	3.62	years
Emission reduction	**3507**	**Tonnes**

(ii) Replacement of inefficient fans

Analysis of the sample survey of Coimbatore city reveals 99% consumers use fans during summer. Assuming 15% of the conventional fans in the commercial sector of Coimbatore can be replaced with more energy efficient fans the following techno-commercials have been calculated.

Table 4.72: Replacement of Conventional Fans

Particulars		Unit
Total Commercial Consumers	98056	Nos.
Consumers using Conventional Fans	99%	
Target to replace CF by EE Fans	15%	
Number of Conventional fan to be replaced per consumer	3	Nos.
Total number of Conventional Fans to be replaced	39316	Nos.
Indicative cost of installation	590	Lakh
Energy saved by replacing Conventional Fans by EE Fans	1376044	kWh
Cost of electricity savings	68	Lakh
Payback period	8.57	years
Emission reduction	**1115**	**Tonnes**

(iii) Replacement of conventional air conditioners with EE star rated ones

About 33 % of the commercial units in Coimbatore City use air conditioning units. Assuming the replacement of 10% of the air-conditioning units with star rated air conditioning units the figures related to instalments and energy savings are given below.

Table 4.73: Replacement of Air conditioners with star rated ones

Particulars		Unit
Total Commercial Consumers	98056	Nos.
Consumers using Conventional ACs	33%	
Target to replace Conventional ACs by EE star rated ACs	10%	
Number of Conventional ACs to be replaced per industrial unit	5	Nos.
Total number of Conventional ACs to be replaced	16326	Nos.
Indicative cost of installation	4488	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	6612161	kWh
Cost of electricity savings	331	Lakh
Payback period	13.58	years
Emission reduction	**5356**	**Tonnes**

(iv) Replacement of conventional refrigerators with EE star rated refrigerators

Refrigerators in commercial sector are restricted to the food outlets, restaurants, hotels, guest houses, and ice-cream parlors. General trend reveals that the refrigerators of the range of 200-400 W are found in the commercial sector of Coimbatore City.

Approximately 41% of the consumers own a refrigerator and a target of replacing 25% refrigerators has been taken to show the energy saving potential of replacing conventional refrigerators in commercial sector of Coimbatore city.

Table 4.74: Replacement of Conventional Refrigerators with EE Star Rated Refrigerators

Particulars		Unit
Total Commercial Consumers	98056	Nos.
Consumers using Conventional Refrigerators	41%	
Target to replace Conventional Refrigerators by EE Star Rated Refrigerators	25%	
Number of Conventional Refrigerators to be replaced per consumer	1	Nos.
Total number of Conventional Refrigerators to be replaced	10051	Nos.
Indicative cost of installation	1131	Lakh
Energy saved by replacing Conventional Refrigerators by EE Star Rated Refrigerators	4764051	kWh
Cost of electricity savings	238	Lakh
Payback period	5	years
Emission reduction	**3859**	**Tonnes**

(v) Replacement of conventional water pumps with EE star rated water pumps

About 30% of the commercial units use water pumps. If a target of 25% is made in order to replace the inefficient water pumps with efficient star rated water pumping equipments then the following techno-commercial details ensue which are calculated below.

Table 4.75: Replacement of conventional water pumps with EE star rated water pumps

Particulars		Unit
Total Commercial consumers	98056	Nos.
Household using Water Pumps	30%	
Target to replace Conventional Water Pump by EE Pump	25%	
Number of Conventional Pumps to be replaced per household	1	Nos.
Total number of Conventional Pumps to be replaced	10296	Nos.
Indicative cost of installation	206	Lakh
Energy saved by replacing Conventional Water Pumps by EE Water Pumps	926629	kWh
Cost of electricity savings	32	Lakh
Payback period	6.35	years
Emission reduction	**751**	**Tonnes**

(vi) Summary of EE Strategy in Commercial & Institutional Sector

The estimated energy savings potential from commercial and institutional sector through energy efficiency measures is 58MU in five years, which is about 12% of total target to be achieved. Potential for GHG reduction is 46846 tonnes per year with an investment of Rs. 26717 lakh.

Table 4.76: Summary of EE Strategy in Commercial and Institutional Sector

EE Measures	No. of equipments	Investment (INR)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Replacement of 100 watt incandescent with 15 watt CFL	125512	188	10	8235
Replacement of T8/T12 tube lights with T5 FTL	156890	784	4	3507
Replacement of conventional fans with EE fans	39316	590	1.38	1115
Replacement of conventional AC with EE star rated AC	16326	4488	6.61	5356
Replacement of conventional refrigerators with EE star rated refrigerators	10051	1131	5	3859
Installation of EE water pumps	10296	206	1	751
Total		**7387**	**28.18**	**22822**

4.4.15 EE Strategy for Industrial Sector

Coimbatore has 19779 small-scale industrial units. Majority of these industries are not energy intensive. Energy savings potential lies primarily with lighting and comfort.

(i) Replacement of incandescent with CFLs

As per sample survey only 35% of the industries use incandescent bulbs as lighting appliances which need to be replaced by CFLs. Following table indicates the techno-commercial proposition for this replacement.

Table 4.77: Replacement of incandescent with CFLs in Industrial sector

Particulars		Unit
Total Industrial Consumers	19779	Nos.
Consumers using incandescent bulb	35%	
Target to replace incandescent bulb with CFL	80%	
Number of incandescent bulb to be replaced per consumer	25	Nos.
Total number of incandescent bulb to be replaced	138453	Nos.
Indicative cost of installation	277	Lakh
Energy saved by replacing 100W bulb with 20W CFL	29905848	kWh
Cost of electricity savings	1495	Lakh
Payback period	0.19	Years
Emission reduction	**24224**	**Tonnes**

(ii) Replacement of T8/T12 by T5 tube lights

The T12 and T8 tube lights are also frequently used in the industrial sector in Coimbatore city. Survey results show that almost 90% consumers use these appliances. The energy saving potential by replacement of T12 and T8 with more efficient T5 tube lights is calculated below assuming a replacement of 90% appliances in target industries. . Following table indicates the techno-commercial proposition for this replacement

Table 4.78: Replacement of T8/T12 tube lights

Particulars		Unit
Total Industrial Consumers	19779	Nos.
Consumers using T8/T12 tube lights	90%	
Target to replace T8/T12 by T5 tube lights	90%	
Number of T8/T12 to be replaced per consumer	40	Nos.
Total number of T8/T12 tube lights to be replaced	640840	Nos.
Indicative cost of installation	3204	Lakh
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	22595363	kWh
Cost of electricity savings	1130	Lakh
Payback period	2.84	Years
Emission reduction	**18302**	**Tonnes**

(iii) Replacement of Conventional Fans by EE Star Rated Fans

About 74% of industrial units use conventional fan which should be replaced by star rated energy efficient fans. . Following table indicates the techno-commercial proposition for this replacement.

Table 4.79: Replacement of conventional fans by EE star rated fans

Particulars		Unit
Total Commercial Consumers	19779	Nos.
Consumers using Conventional Fans	74%	
Target to replace CF by EE Fans	25%	
Number of Conventional fan to be replaced per consumer	15	Nos.
Total number of Conventional Fans to be replaced	53972	Nos.
Indicative cost of installation	810	Lakh
Energy saved by replacing Conventional Fans by EE Fans	2590653	kWh
Cost of electricity savings	130	Lakh
Payback period	6	Years
Emission reduction	**2098**	**Tonnes**

(iv) Replacement of conventional air conditioners with EE star rated ones

About 13 % of the industrial units in Coimbatore City use air conditioning units. Assuming the replacement of 50% of the air-conditioning units with star rated air conditioning units the figures related to instalments and energy savings are given below.

Table 4.80: Replacement of Air conditioners with star rated ones

Particulars		Unit
Total Industrial Consumers	19779	Nos.
Consumers using Conventional ACs	13%	
Target to replace Conventional ACs by EE star rated ACs	25%	
Number of Conventional ACs to be replaced per industrial unit	5	Nos.
Total number of Conventional ACs to be replaced	3214	Nos.
Indicative cost of installation	884	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	1301705	kWh
Cost of electricity savings	65	Lakh
Payback period	14	Years
Emission reduction	**1054**	**Tonnes**

(v) Summary of EE Strategy in Industrial Sector

Energy Efficiency measures with mere replacement of incandescent bulbs, tubes and inefficient fans in industrial sector of Coimbatore city can save at least 17.44MU energy per year reducing GHG emission by 14130 tonnes of per year.

Table 4.81: Summary of EE Strategy for Industrial Sector

EE Measures	No. of equipments	Investment (INR)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Replacement of 100 watt incandescent with 15 watt CFL	138453	277	29.91	24224
Replacement of T12/T8 tube lights with T5 tube lights	640840	3204	22.60	18302
Replacement of conventional fans with EE star rated fans	53972	810	2.59	2098
Replacement of conventional AC with EE star rated AC	3214	884	1.30	1054
Total		**5174**	**56.39**	**45679**

Thermal Energy Conservation in Industrial sector

Coimbatore is famous for its textile industries and engineering output. The industrial sector largely comprises of cotton textile manufacturing related enterprises which constitute 75% of the industrial composition in Coimbatore. The main sources of energy in the Industrial sector are electricity, diesel and petrol and with demand for these expected to rise, especially for diesel; the energy conservation measures in the industrial sector can prove to be beneficial from an economic and environmental point of view. Hence, in this section, strategies that can be easily adopted by energy intensive industries in Coimbatore as a means of abating their energy demand by conserving energy in their manufacturing and other processes is proposed.

Waste Heat Recovery (WHR) is considered as one of the most feasible interventions that can be introduced as an energy efficiency initiative. WHR systems render an ease of energy reuse from processes which generate it by re-routed it into another process obviating wasteful release into the ambience causing possible environmental degradation and also saving costs in the process. Some possible systems that can be used through intervening mechanisms after proper feasibility studies are listed hereunder alongside their corresponding expected benefits.

- Waste Heat Recovery – Pressurized Hot Water Generator

D. G. Sets 750 KVA	2 Nos.
Exhaust Temperature	450^{o} C
Heat Recovery	470000 Kcal/hr.
Working Hrs. / Day	8 Hrs.
Annual Savings	INR 44 Lakh

- Waste Heat Recovery – Steam Boiler

D. G. Sets 750 KVA	2 Nos.
Exhaust Temperature	500^{o} C
Heat Recovery	380000 Kcal/hr.

Annual Savings	INR 44 Lakh

- Waste Heat Recovery – Air Pre-heater on Thermo Pack

Capacity	20 Lakh Kcal/hr.
FO. Firing Rate	180 Kg/hr
Exhaust Temperatures	250 Dec.
Heat Recovery	65000 Kcal/hr
Annual Savings	INR 12 Lakh

- Waste Heat Recovery – Steam Boiler on Furnace Exhaust

Equipment	Decarb Furnace
Exhaust Temperatures	280^{o} C
Heat Recovery	22000 Kcal/hr
Annual Savings	INR 9 Lakh

- Waste Heat Recovery – Air Pre-heater on Steam Boiler

Capacity	500 kg/hr at 40 kg / cm^2
Exhaust Temperatures	350^{o} C
Heat Recovery	30000 Kcal/hr
Annual Savings	INR 7.5 Lakh

- Waste Heat Recovery – Hot Water Generator

Equipment	Hot Treatment Furnace
Exhaust Temperatures	400^{o} C
HSD Firing Rate	40 kg / hr
Heat Recovery	100000 Kcal / hr.
Annual Savings	INR 16 Lakh

Source: http://www.energyconservation.co.in/waste-heat-recovery-systems-on-furnace-case-studies.html

4.4.16 Solid Waste Management Interventions

(i) Waste to Energy Potential in Coimbatore

Estimated solid waste generated in Coimbatore city is 650 MT/day. Potential energy recovery from MSW through different treatment methods could be estimated from its calorific value and organic fraction etc. Since relevant details are not available for Coimbatore, widely used estimates for municipal solid waste in India have been used for a preliminary assessment. However, waste to energy potential for the city is considered as an indicative assessment and not included in the strategy to achieve energy savings goal under solar city programme.

(ii) 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 19 MWe and savings per year with 70% PLF is estimated as 116 MU.

Table 4.82: Waste to Energy through thermo-chemical conversion

		Unit
Total waste generated	650	Tonnes
Net Calorific Value (conservative estimate)	2400	kcal/kg
Energy recovery potential (NCV x W x 1000/860)	1813953	kWh
Power generation potential	75581	kW
Conversion efficiency	25%	
Net Power generation potential	18.90	MWe
Plant Load Factor	70%	
Net electrical energy savings potential @70% PLF	115.87	MU
Emission reduction per year	93852	Tonnes
Total Investment	13227	Lakh
MNRE subsidy @ 50% subject to maximum of Rs.300.00 per MW	5669	Lakh
State/City/Private Power Producer	7558	Lakh
Cost savings	5214	Lakh
Payback period	1.45	Years

(iii) Waste to Energy Potential through bio-methanation

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output. It is estimated that a 7 MWe electrical energy generation is possible from this process which could save about 42 MU of energy every year assuming a 70% of PLF.

Table 4.83: Waste to Energy through bio-methanation

		Unit
Total waste generated	650	Tonnes
Total biodegradable volatile solid (VS)	30%	
Typical digestor efficiency	60%	
Typical bio-gas yield (m3 / kg. of VS destroyed)	0.80	CuM/kg
Biogas yield	93600	CuM
alorific Value of bio-gas	5000.00	kcal/CuM
Energy recovery potential	544186.05	kWh
Power generation potential	22674	kW
Conversion efficiency	30%	
Net Power generation potential	6.80	MWe
Plant Load Factor	70%	
Net electrical energy savings potential	41.71	MU
Emission reduction per year	33787	Tonnes
Total Investment	4081	Lakh
MNRE subsidy @ R.200.00 lakh per MW	1360	Lakh
State/City/Private Power Producer	2721	Lakh
Cost savings	1877	Lakh
Payback period	1.45	Years

(iv) Waste to Energy Potential from Sewage Treatment Plant

Liquid waste generated in Coimbatore city is 50 MLD per day. It is estimated that a 1.74 MWe electrical energy generation is possible from Sewage Treatment Plant which could save about 10.7 MU of energy every year assuming a 70% of PLF.

Table 4.84: Liquid Waste to Energy Potential from Sewage Treatment Plant (STP)

		Unit
Total waste water generated	50	MLD
Total biodegradable organic/ Volatile Solid available for Biomethanation	50	Tonnes/day
Typical Digestion Efficiency	60%	
Typical Biogas yield	0.8	cum / kg
Biogas yield	24000	Cum
Electricity (kWh)	139534.88	kWh
Capacity of the plant	5813.95	KW
Conversion Efficiency	30%	
Total Electricity Generated	1.74	MWe
Plant Load Factor	70%	
Net electrical energy savings potential	10.70	MU
Emission reduction per year	8663	Tonnes
Total Investment	1046.51	Lakh
MNRE subsidy @40% subject to maximum of Rs.200.00 lakh/ MW	348.84	Lakh
State/City/Private Power Producer	697.67	Lakh
Cost savings	481.29	Lakh
Payback period	1.45	Years

5. Tiruchirapalli City

5.1 City Profile

Tiruchirapalli, also known as Tiruchi or Trichy is the fourth largest city in the southern State of Tamil Nadu. It is centrally located in the state and is situated on the head of the Kaveri delta on the banks of the River Kaveri. Tiruchirapalli due its location has enjoyed historic importance since the time of early Cholas. Ruled at one point of history or the other by almost all the major south Indian dynasties from Pandyas to Marathas and the Delhi Sultanate, Tiruchirapalli fell into the hands of the British in 1801 after several failed attempts before. During the British control, Trichinopoly, as it was known by the British, emerged as an important city mainly because of its central location in the state at the junction of North-South and East-West major transport routes but also central focal point connecting adjoining districts.

While at one time the population of the city was second only to the then capital Madras, the city currently ranks as the fourth most populous city in Tamil Nadu. Development of an assortment of industries like Heavy Boiler plant, Cotton mills and Structural steel works etc has pushed Trichy's economic prosperity further. Its evolution as an employment and educational hub has increased the urbanization taking place. As a strategic city for the confluence of rail, road and air communication pathways Trichy which is also the district headquarters.

5.1.1 Details of Location, Geography and Climate of Tiruchirapalli

Location

Centrally located perhaps not just within the state but also the south Indian peninsula, the city of Trichy is situated at 10 ° N lat and 78 ° E long and is 88 m above sea-level. The River Kaveri cuts through the district with Trichy located on one side of its bank separated from Srirangam, another important city, on the other side. Within a 60km to 160km vicinity of other important towns of within the district, Trichy is well connected via rail and road.

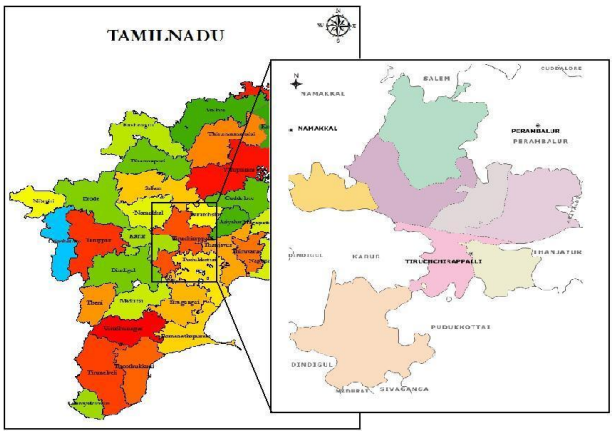


Figure 5.1: Location of Tiruchirapalli

Geography

Trichy is situated on the banks of the River Kaveri such that the city limits extend across the Kaveri delta. Formed of rich alluvial soil washed up by the river, the fertile plains gently slope towards the west. Crystalline rocks like the Rockfort and Golden Rock are liberally sprinkled across the city.

Various tributaries of River Kaveri penetrate the city and sustain the lucrative paddy cultivation all year round. In addition, the fertile land supports Mango and Coconut cultivation too. Trichy is spread over an area of 147 square km.

Climate

Tiruchirapalli has a characteristic hot and dry climate for most of the year. The city experiences high temperature and low humidity especially during the summer months that extend from March to May. The months from September to November are wet and balmy. The typical temperature range of the city is 20° C minimum and 40°C maximum and it receives a rainfall of 70mm to 77mm annually.

The South West Monsoon begins in June and increases the rainfall until August and September. From December to January, the city experiences the coldest months after a windy period that is followed by another burst of South West Monson in May.

Figure 4.2.1: Temperature and Rainfall profile of Tiruchirapalli

Temperature Profile (° C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
MAX	31	33	36	37	38	37	36	36	35	33	30	30
MIN	21	22	23	26	26	26	26	25	25	24	23	21

Rainfall Profile												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
in mm	14	12	24	44	75	48	59	73	122	161	197	92

Source: http://www.worldweatheronline.com/Tiruchchirappalli-weather-averages/Tamil-Nadu/IN.aspx

Administrative profile

Tiruchirapalli city municipality was upgraded to Municipal Corporation level in 1994. The Corporation currently oversees the administration of 4 zones subdivided into a total of 60 wards. The Corporation is headed by the Mayor elected directly by the citizens of the city while its duties are executed by the Commissioner who presides over Senior Officers in charge of different departments of the Corporation like Administration, Engineering, Public Health, Accounts, Planning and Revenue. Following are brief notes on the civic services undertaken by the Corporation.

Water Supply

Water in Tiruchirapalli is supplied through 6 head water works of which 4 are maintained by the Corporation and 2 are contracted to other agencies. In total there are about 58 service reservoirs in the entire district of which 19 are located in the city. About 83 million liters per day (MLD) are supplied to the city which is about 103 liters per capita per day (lpcd). In addition, two state sanctioned projects for water supply were completed in 2010 and three more are currently underway through which 73 rural habitations around the city will be benefitted.

Solid Waste Management and Sewerage

Tiruchirapalli city Corporation has brought about a lot of improvement in its waste management services and is the first city in the country to have obviated open defecation issues in the slums. In addition, the Corporation facilitates door-to-door collection and scientific disposal and waste segregation of about 400 tonnes of solid waste that is generated by the city each year. There are three transit stations at Gandhi market, Central bus stand and Chatram bus stand with its principal landfill site allocated at Ariyamangalam.

Waste water or Sewerage management in Tiruchirapalli and Srirangam are under the administrative control of State Water Board while other sewerage management of other two zones is managed by the Tiruchirapalli Corporation.

Street Lighting

There are about 29,000 street lights maintained by the Tiruchirapalli city Corporation. Of these about 80% are tube lights.

Road and Transport

Well connected by rail and road, Tiruchirapalli city has a road network of 941 km. The national Highways NH 45, NH 45B, NH 67, NH 210 and NH 227 pass through the city. Under the National Roads Schemes, the city Corporations aims to increase the road coverage by 186 km.

Public Health

The public health department that also oversees the solid waste management in the city maintains 13 maternity centers, 5 urban health posts, and 2 urban family welfare centers, 18 dispensaries (14 allopathic and 4 siddha).

Infrastructure and Facilities

The Corporation of Tiruchirapalli maintains and runs 31 elementary schools, 27 middle schools and 2 high schools and one higher secondary school. In addition, the city is serviced by an airport that is the second busiest in the state and two bus stations, one of

which serves the entire South Indian bus network. In addition, the Southern Railways has its five branches in the city connecting it to various locations in South India.

Demographic trends

According to 2001 census findings, the population under Tiruchirapalli corporation limits was 7, 50,066 and the population under urban agglomerate was 8, 66,354. According to 2011 census finding, the Tiruchirapalli population was 1,021,717 registering a decadal growth rate of 17.2%. Following are the population trends from 1961 to 2011. The city recorded a literacy rate of 91.20% higher than Coimbatore and the sex ratio in the city was recorded as 1015. Following tables indicate the current demographics of the region.

Table 5.1: Population growth in Tiruchirapalli*

Year	Population	Decadal Growth %
1961	415759	-
1971	534966	28.7
1981	644558	20.5
1991	755173	17.2
2001	866354	14.7
2011	1021717**	17.9

**Trichy Master Plan and Tiruchirapalli Corporation*
***Census of India 2011(LPA)*

Table 5.2: Population data*

Total Persons	1021717
Males	507180
Females	514537
Sex ratio	1015
Total Persons below 6 years in age	89176
Males below 6 years in age	45321
Females below 6 years in age	43855
Sex ratio(0-6)	968
Total literates	850484
Literate Males	437399
Literate Females	413085
Male Literacy rate	94.70%
Female Literacy rate	87.76%

**Census of India 2011*

Socio-economic profile

On account of its central location, Tiruchirapalli has not just rendered a confluence of the North-South and East-West transport and trade routes, the city is especially important because of the railway locomotive industries and heavy boiler plants in addition to a rice mills and chemical plants located here. Tiruchirapalli is a major engineering hub and has attracted thousands of engineers who graduate mainly from one of the many educational centers and universities in the city, some of these universities are the oldest in the country. In recent years, Tiruchirapalli like almost all south Indian cities has evolved into a software hub with its exports reaching INR 26 lakh annually. Following tables indicate the

stats related to employment (non-exhaustive) and the profile of industrial produce in terms of capacity (units) under operation (non-exhaustive).

Employment statistics*

Sector	Number of Persons
Agriculture, Food based	1862
Textiles industry	1453
Chemical industry(incl. Leather)	3294
Machinery and Transport equipment	2692
Services	8941

**Tiruchirapalli District Collectorate (non exhaustive list)*

Industry profile*

Type of Industry output	Capacity (units)
Food products (incl. other consumables)	62
Garments and other textile based	585
Paper and Wood products	7
Electrical and Transport Machinery	5
Leather, Chemical and Metal	88
Services based	50
Small Scale Industries	802

**Tiruchirapalli District Collectorate (non exhaustive list)*

Ecological and Forest Profile

Tiruchirapalli is rendered fertile by the alluvium carried by the River Kaveri. The city boasts of a rich ecological heritage mainly consisting of coconut trees and Mangroves. The principal crops that are grown here are paddy, banana and sugarcane. The residential and agricultural areas are densely intermingled throughout the city.

The city has several parks and recreational playfields that promote green cover in the city. The forest cover to the North West of the district falls under the Trichy circle which comes under the administrative control of the Tamil Nadu State Forest Department. The table below indicates the land use pattern and green cover in the city from the latest statistics available.

Table 5.3: Land use pattern*

Sector	% of total area
Residential	36
Commercial	2
Industrial	4
Educational	3
Public and Semi Public	7
Agriculture (Wet and Dry)	30
Transportation	6

**Trichy Master Plan 2003*

Table 5.4: Green cover*

Parks	24 No.s
Water bodies	19.17 square km

**Trichy Master Plan 2003*

Energy profile

The main energy consuming industries in Tiruchirapalli are the Chemical and Distillery based and BHEL and railway locomotive workshops. In addition to the domestic energy demand, the Corporation also oversees electricity provision to small scale industrial set ups and rural electrification. In the district, while 31% of electricity demand arises from Agriculture, almost 40% arises from domestic needs.

5.2 Energy Consumption Profile of Tiruchirapalli

Introduction

This section deals with the assessment of the energy consumption patterns in Tiruchirapalli city. The identification of energy sources specific to each sector in the city i.e., Residential, Commercial, Industrial and Municipal is being dealt with as follows.

Total Electricity Consumption in Tiruchirapalli

Tiruchirapalli is relatively less metropolitan than Coimbatore but as a result of its geographical location it has become an important focal point for transport routed that connect the city to important neighbouring cities. The domestic sector is the main consumer of energy and electricity is obviously the main source.

Table 5.5: Sector-wise energy consumption in Tiruchirapalli

Sector	Electricity Consumption (Million kWh)	
	2010-11	2011-12
Domestic	240.52	591.37
Commercial	177.82	504.24
Industrial	34.04	86.49
Municipal Sector	278.09	832.33
Total Electrical Energy supplied	730.47	2014.43

5.2.2 Fuel consumption in Trichirapalli

In absence of clear sector specificity in the data sourced from official and semi-official sources, the information contained in this section is non classified into sectors and hence a relative comparison between different sectors cannot be established. Nevertheless, the data is comprehensive in its compilation and provides an overall snapshot of the fuel consumption in the city over a two year period as monitored by Indian Oil Corporation.

Table 5.6: Petrol consumption in Tiruchirapalli

Fuel	2010-11	2011-12
Petrol (kL)	64346	72931

(Source: ICLEI 2012)

Table 5.7: Diesel consumption in Tiruchirapalli

Fuel	2010-11	2011-12
Diesel (kL)	166752	198526

(Source: ICLEI 2012)

E. Waste

Waste management practices by the Tiruchirapalli Municipal Corporation have effectively rectified the erstwhile issue of poor sanitation in the community sector. Having achieved the first open defecation less sanitation in India, Tiruchirapalli has introduced facilities like door-to-door collection and scientific disposal and waste segregation into its activity portfolio. The city has 38 primary collection points, 11 transfer stations and 60 corporation vehicles being used for the waste management. Waste generated from domestic sector is 85% and 15% commercial waste.

The city has a waste water treatment or sewerage water treatment plant at Panchapur which caters as the sole effluent treatment center in the city and works at an optimum capacity of 56 MLD. Following is the breakdown waste generation in the city.

Table 5.8: Waste generation from city activities

Year	Waste produced
2006-2007	382 MT
2007-2008	432 MT
2008-2009	432 MT
2009-2010	432 MT
2010-2011	405 MT

5.2.3 Energy Consumption in Government sector

A. Energy used in Street Lighting in Tiruchirapalli

The Corporation maintains and operated the street lights within its jurisdiction. Currently, there are about 28, 657 street lights. The breakdown of the equipments used for this purpose is detailed below:

Table 5.9: Equipments used for street lighting in Tiruchirapalli

Equipment	Number
40 watts tube lights	27968
70 watts SV lamps	38
150 watts SV lamps	29
500 watts HL	2
150 watts MHL fittings	4
400 watts MHL fittings	0
4*24 watts CFL	22
1*35 watts CFL	230
2*36 watts CFL	132
65 watts CF lamps	15
2*11 watts CF Lamps	171
High mast (16 m and 30m)	46

B. Energy used in Water Supply

Water from Cauvery is the predominant source of water for city activities. The Corporation expended about 13.11 MU of energy in pumping the water to overhead tanks at different locations in the city in 2009-10. The electricity supply for water facilitation in the city over the last few years is as shown below:

Year	Electricity consumption (MU)
2006-2007	12.19
2007-2008	13.19
2008-2009	12.28
2009-2010	13.11

C. Energy used in lighting in Corporation buildings and facilities

Corporation also incurs energy expenditure due to day-to-day operation of official buildings through general lighting and powering of equipments. Following is the electricity consumption in Corporation buildings over the last few years.

Year	Electricity consumption (MU)
2006-2007	2.91
2007-2008	3.02
2008-2009	2.38
2009-2010	2.46

D. Energy used in Corporation Transport

Use of diesel is more prevalent than use of petrol in Corporation vehicles that aid in execution of activities including transport for personnel mobility, lorries, garbage trucks and pick up vehicles that facilitate in SWM activities in the city. Besides, repair and maintenance of Corporation assets is performed and involves inevitable and extensive travel. Following a breakdown of the fuel usage in the Municipal sector:

Table 5.10: Fuel consumption by Municipal sector in Tiruchirapalli

Fuel	2010-11
Petrol (kL)	8.5
Diesel (kL)	651

5.3 GHG Emissions Inventory of Tiruchirapalli

Based on this inventory, the total emissions from the city that corresponded to the Municipal sector were comparatively lower. A precise comparative analysis is not possible because the data that has been used from different sources corresponded to different years. However, in a particular year, it is clear that the amount of emissions from municipal activities was much lower indicating carbon efficiency of the Corporation activities.

Community level GHG emissions

The total emissions from the Community sector in Tiruchirapalli are 782423.65 tCO_2e of which electricity consumption.

Table 5.11: Community level Carbon Emissions (tCO2e)

Sector	Equiv. CO_2 tonnes	% of total emissions
Residential	451.32	50.0
Commercial	384.83	42.7
Industrial	66.01	7.3
Total Community level Emissions due to Electricity	902.16	100.00
Waste	14,287.00	-
Overall fuel consumption	767234.49	-
Total Emissions	782423.65	-

Residential

The residential sector GHG emission due to electricity usage only was 451.32 tonnes (29 %) to total emissions from community electricity consumption in 2011-12. This however does not include fuel data as it was available without sector wise segregation from the source.

Commercial

The commercial sector GHG emission was 384.83 tonnes (25%) to total emissions from community electricity consumption in 2011-12. This however does not include fuel data as it was available without sector wise segregation from the source.

Industrial

The industrial sector GHG emission was 66.01 tonnes (4%) to total emissions from community electricity consumption in 2011-12. This however does not include fuel data as it was available without sector wise segregation from the source.

Total fuel consumption

The transportation sector included, the overall fuel data was available in bulk indicating an overall GHG emission of 767234.49 tonnes of CO_2e in 2011-12. Following table lists the emissions attributed to overall fuel consumption in the city.

Table 5.12: Overall fuel consumption related Emissions (2011-12)

Fuel	Equiv. CO_2 tonnes	Equiv. CO_2 %
Diesel	586450.54	76.44
Petrol	180783.95	23.56
Overall fuel consumption	**767234.49**	**100**

Waste

Tiruchirapalli has three waste management transit stations at Gandhi market, Central bus stand and Chatram bus stand with its principal landfill site allocated at Ariyamangalam. The Corporation on an average receives 400 MT of waste each day which collected through door-to-door collection services and segregated before being disposed in the managed landfill site. The following emissions calculation is based on the latest data obtained from the Corporation.

Table 5.13: Waste Greenhouse Gas Emissions (2009-10)

Type	Equiv. CO_2 tonnes	Equiv. CO_2 %
Municipal Solid Waste	14,287.00	100
Subtotal Waste	**14,287.00**	**100**

Government Level GHG emissions

As per the framework of the ICLEI protocol, the activities of the Corporation that contribute to GHG emissions are estimated as a separate entity. The total emissions arising from Corporation activities are about tonnes of CO_2. Following table gives details of the activities and their related emission calculations for the latest data that could be availed from the authorities. Note that there may occur overlap based in the manner the data accounting is performed.

Table 5.14: Government level Carbon Emissions (tCO2e)

Sector	tCO_2e	Year
Facilities	20542.47	2010-11
Buildings	1877.21	2010-11
Transport	1743.76	2009-10

Facilities

Facilities like illumination of public precincts through street lights and traffic lights are some of the service that the Corporation is responsible and that generates greenhouse gasses. In Tiruchirapalli, while water supply is under the jurisdictional control of the Corporation, sewerage pumping which is the other activity that causes GHG emissions is controlled by the State water board and hence according to the protocol being followed is not included hereunder. Following table details the activities and the emissions arising from each.

Table 5.15: Facilities Greenhouse Gas Emissions (2010-11)

Activity	Equiv. CO_2 tonnes	Equiv. CO_2 %
Street lighting	8,661.11	42.16
Water supply	10,004.15	48.70
Sewerage pumping	1,877.21	9.14
Subtotal Facilities	20,542.47	100.00

Buildings

Corporation buildings and the equipments therein also become a source of GHG emissions when powered through electricity. The following table details the relevant emissions from this activity.

Table 5.16: Buildings Greenhouse Gas Emissions (2010-11)

Activity	Equiv. CO_2 tonnes	Equiv. CO_2 %
Illumination	1,877.21	100
Subtotal Buildings	1,877.21	100

Transport

In Tiruchirapalli, the emissions due to Corporation owned transport are mostly due to diesel than petrol. Details of the same are provided in the table below. Please note that the latest information available from the Corporation was from 2009-10.

Table 5.17: Transport Greenhouse Gas Emissions (2009-10)

Fuel	Equiv. CO_2 tonnes	Equiv. CO_2 %
Petrol	24.74	1.3
Diesel	1,865.75	98.69
Subtotal Transport	1,890.49	100.00

5.4 Suggested Low Carbon Action Plans

Renewable Energy Resource Assessment

A preliminary assessment has been done for solar, wind and biomass resources and energy recovery potential from municipal solid waste and sewage treatment plant. It should be noted here that biomass data is for entire Trichy district and there is no hydro potential in the city.

Solar Radiation

Trichy (Latitude 10° 48’ N, Longitude 78° 41’ E) receives good amount of solar radiation owing to its southern location in the Indian peninsula.

Table 5.18: Monthly Averaged Insolation Incident on a Horizontal Surface (kWh/M²/Day)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NASA Satellite data	4.74	5.74	6.47	5.9	5.81	5.29	5.02	5.2	5.39	4.58	4.09	4.22	5.21
MNRE Solar Resource	4.70	5.68	6.39	5.85	5.70	5.18	4.92	5.08	5.32	4.53	4.05	4.18	5.21

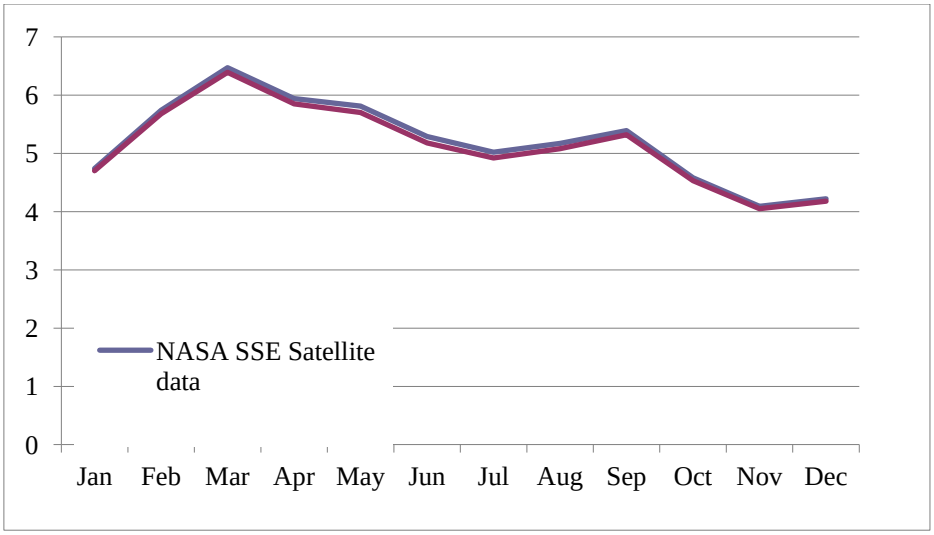


Figure 5.2: Annual Solar Radiation profile in Trichy

Wind Energy

There hasn't been any wind speed measurement undertaken at Trichy as yet and the only wind data available has been satellite referenced by C-WET at 100W/m^2.

Biomass Resource

Biomass resource for Trichy city is not available separately. However, the data is available at district level and presented in the table below. Major agricultural products of the district are Tapioca, Paddy and Maize. The potential of power generation for biomass is estimated to be 102.3 MWe for the entire district[43]. The city had an installed biomass capacity of 18 MW as of 2010. A detailed city-specific assessment needs to be undertaken to establish the biomass potential in the city.

Table 5.19: Biomass Resource

District	Area (kHa)	Crop Production (kT/Yr)	Biomass Generation (kT/Yr)	Biomass Surplus (kT/Yr)	Power Potential (MWe)	Biomass Class
Trichy	65.1	NA	98.5	65	9.1	Forest & wasteland
Trichy	124.8	743.2	1543.0	718.9	93.2	Agro

Small Hydro Power

The Ponnanaiyar project in the district has 20kW capacity. The city itself does not have any potential SHP sites.

Waste generation

Waste generation data for Trichy Municipal area for the last 5 year is presented in the table given below. No segregation was available.

[43] Biomass Atlas India-http://lab.cgpl.iisc.ernet.in/Atlas/

Table 5.20: Solid Waste Generation Data

Year	Solid waste Generation (MT/year)
2006-2007	382 MT
2007-2008	432 MT
2008-2009	432 MT
2009-2010	432 MT
2010-2011	432 MT

Liquid Waste from Sewage Treatment Plant

The city has one STP that treats a capacity of 88.64 MLD.

RE Strategy for Residential sector

The residential sector in Trichy is the largest consumer of electricity. The residential sector roughly consumes 240.52 MU of electricity which is 63.33% of total electricity consumption in Trichy city.

(i) Installation of Solar Water Heating System

The target in 5 years for introduction of SWHs is set at 80% of residential consumers who are already using electric geysers for their daily hot water requirement estimated at 11% of the total population of the city. Introduction of solar water heating system could save up to 35.4MU energy per year. Energy savings and emissions reduction potential is presented in the table below.

Table 5.21: Target for SWHs installation in Trichy City

Particulars		Unit
Total Residential household	261885	Nos.
Total Residential household after being accounted for in apartments	255765	Nos.
Residential household using geysers	11%	
Target to replace electric geyser by SWH in 5 years	80%	
Average size of domestic SWH (2 sqm collector area)	100/125	LPD
Number of SWH to be installed in five years	22507	Nos.
Total collector area in sqm	45015	Sqm
Total energy saved in five years	35.4	MU
Indicative cost of installation	5626.83	Lakh
MNRE subsidy @Rs.3300.00 per sqm	1485.48	Lakh
Cost of energy savings	1240.72	Lakh
Payback period	3	years
Emission reduction in five years	28714	Tonnes

(ii) Use of Solar cookers (Box and dish type)

Both box type 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. It however cannot be used for frying or chapatti making. It is durable and simple to operate. 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. The temperatures attained with this cooker are sufficient for roasting, frying and boiling. Regular 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. Setting a target of 15% residential consumer to adopt solar cooker (75% box type and 25% dish type) in the 5 years period, a total of 0.83 million kg of LPG could be saved, reducing 2878 tonnes of GHG from Trichy city (considering specific emission from LPG as 0.24 kg CO_2 per kWh).

Table 5.22: Target for introducing solar cooker in Trichy City

Particulars		Unit
Total Residential household	261885	Nos.
Household having facility to install a solar cooker	30%	
Target for introducing of solar cooker in 5 years	15%	
Number of Solar Cooker to be installed in 5 years plan	11785	Nos.
Average savings of LPG domestic cylinder per year per solar cooker (14kg)	5	Nos.
Total LPG saved in five years	824938	Kg
Total energy saved in five years	11.99	MU
Indicative cost of installation (75% box type & 25% SK-14)	309.35	Lakh
MNRE subsidy for solar cooker @30%	92.81	Lakh
Cost of energy savings	206.23	Lakh
Payback period	1.05	years
Emission reduction in five years	2878	Tonnes

(iii) Solar lanterns to replace kerosene lamps

Solar lantern has the average capacity of providing three 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 general lighting in poor families in Trichy particularly during load shedding hours and assuming that 8% of population use kerosene lanterns during load shedding to illuminate their houses. Average consumption of kerosene per household is 3 litres per month. Assuming a household uses 3-4 lanterns, consumption of one lantern will be about 3-4 litres per month. Targeting 15% of population to replace at least one kerosene lantern with solar about 0.11 million litres of kerosene could be saved reducing 287 tonnes of GHG per year. Detailed techno commercial is provided in the table below.

Table 5.23: Target for introducing solar lanterns in Trichy City

Particulars		Unit
Total Residential household	261885	Nos.
Residential household use kerosene lamps	8%	
Target to replace kerosene lamp in 5 years	15%	
Number of SL to be installed in 5 years plan	3143	Nos.
Total kerosene lamp replaced	3143	Nos.
Indicative cost of installation	94.28	Lakh
Kerosene saved	113134	Liters
Savings in terms of Electricity	1.14	MU

Cost of kerosene savings	22.63	Lakh
MNRE subsidy @Rs.81.00 per Wp	25.46	Lakh
Payback period	3.0	years
Emission reduction in five years	287	Tonnes

(iv) Use Solar Home Systems (SHS)

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 capacities 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 by 8% population in Trichy 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 3 liters per month per household. Assuming 20% replacement in the planned 5 years period an estimated amount of 659 kiloliters of kerosene could be saved reducing1673 tonnes of GHG emission from the city. The potential of kerosene replacement with Solar Home Systems and financial implication thereon is indicated in the table below.

Table 5.24: Target for introducing solar home system in Trichy City

Particulars		Unit
Total Residential household	261885	Nos.
Residential household use kerosene lamps	8%	
Target to replace kerosene lamp in 5 years	20%	
Number of SHS to be installed in 5 years plan	4190	Nos.
Total kerosene lamp replaced	16761	Nos.
Indicative cost of installation	670.43	Lakh
Kerosene saved	659	kL
Savings in terms of Electricity	7	MU
Cost of kerosene savings	132	Lakh
MNRE Subsidy @Rs.81.00 per Wp	251	Lakh
Payback period	3.2	years
Emission reduction in five years	1673	Tonnes

(v) Using Solar PV for Home Inverters

Use of solar panels to charge Home Inverter system could be an attractive option as standby power supply system during load shedding hours. The power supply situation in Trichy is fairly better than Coimbatore and the city faces power cuts of up to 3-4 hours per day. Assuming that 13% of households who are already using inverters will adopt the 250 W_p solar PV systems to charge their inverter battery, an aggregate of 1277 kWp solar PV systems could be installed in the residential buildings, which will generate 1MU green energy per year and reduce the load demand and emission by 1551 tonnes per year. It is expected that MNRE will provide Rs. 57 per W_p in subsidy for these systems. The potential of energy savings, green house gas emission reduction and budgetary financial implication is indicated in the table below.

Table 5.25: Target for introducing Solar PV for Home Inverters in Trichy City

Particulars		Unit
Capacity of solar PV system for Home Inverter	250	Wp
Indicative cost of incorporating Solar PV to Home Inverter	43750	INR
Total Residential household	261885	Nos.
Residential household that use Inverter during load shedding	13%	
Target to introduce solar charger for inverter in 5 years	15%	
Number of solar inverter to be installed in 5 years plan	5107	Nos.
Total PV capacity installed	1277	kWp
Total Energy generated by PV arrays in five years	2	MU
Cost of energy saved	67	Lakh
Indicative cost of installation	2234	Lakh
MNRE subsidy @Rs.57.00 per Wp	728	Lakh
Payback period	22	years
Emission reduction in five years	1551	Tonnes

(vi) Using Solar PV for replacement of DG/ Kerosene Generator sets

Due to poor power supply situation, assuming that about 6% of resident of Trichy use typically 5-10kW DG/ kerosene 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 W_p solar PV power pack has been considered for an average household in Trichy. 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 246 kilo liters of diesel on an average per year. This would reduce GHG emissions in tune of 3118 tonnes per year.

Table 5.26: Target for replacement of diesel generator sets with PV Power Pack in Trichy City

Particulars		Unit
Capacity of solar PV system	1	kWp
Indicative cost of incorporating Solar power pack	2.60	Lakh
Total Residential household	261885	Nos.
Total Residential household after being accounted for in apartments	255765	Nos.
Residential household use generators during load shedding	6%	
Target to introduce solar power pack in 5 years	10%	
Number of solar power pack to be installed in 5 years plan	1535	Nos.
Total PV capacity installed	1535	kWp
Total Energy generated by PV arrays in five years	2.30	MU
Typical generator set used	5-10	kW
Average fuel consumption per day for 4-6 hours load shedding	4	liters
Amount of diesel saved in five years for entire city	1228	KL
Cost of Diesel saved	491.07	Lakh
Indicative cost of installation	3990	Lakh
MNRE subsidy @Rs.57.00 per kWp	875	Lakh
Payback period	6.34	years
Total Emissions reduction in five year for replacement of diesel	3118	Tonnes

(vii) RE systems for residential Apartments/ housing complexes

The number of apartment buildings and residential complexes are becoming more ubiquitous in Trichy city owing to increase in population from nearby districts and peri-urban regions. The data for number of apartments in the city was unavailable some indicative renewable energy technologies that can be introduced to reduce and limit carbon emissions from residential apartments are SWH systems and Solar PV packs for back up. The scale of implementation remains directly proportional to quantum of investment available from different sources and the number of consumers.

(viii) Summary of RE strategy for Residential Sector

Implementation of renewable energy projects as proposed above will save 59.42MU of energy, which will reduce GHG of 38222 tonnes in five years. It is recommended that promotion of solar water heaters in residential sector should be given higher priority, as energy savings from solar water heaters are typically the highest.

Table 5.27: Summary of RE Strategy for Residential sector in Trichy City

Particulars	Potential Users	Target Capacity	Units of Target	Investment (Lakh)	MNRE subsidy (Lakh)	Beneficiary's contribution (Lakh)	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Solar water Heaters	28807	22507	Nos.	5627	1485	4141	35.45	28714
Solar cookers	78565.5	11785	Nos.	309	93	217	11.99	2878
Solar Lantern	20951	3143	Nos.	94	25	69	1.14	287
Solar Home System	20951	4190	Nos.	670	251	419	6.62	1673
Solar Home inverter	34045	5107	Nos.	2234	728	1506	1.92	1551
PV for replacing DG sets	15713	1535	Nos.	3990	875	3115	2.30	3118
Total				**12925**	**3457**	**9468**	**59.42**	**38222**

5.4.2 RE Strategy for Commercial and Institutional Sector

The commercial sector consumes about 5.21% of total electricity consumed in the city. The city has 42 colleges and institutes (engineering, science and arts), 105 schools, 140 private medical service facilities and 35 hotels. Different strategies are prepared for different categories of consumers based on type and quantum of energy consumed and availability of resource and space to generate renewable energy in their premises. While preparing the strategy, only techno economically viable and commercially available renewable energy options are considered.

RE Strategy for Hotels

There aren't any big hotels in Trichy but only some 3 star hotels, budget hotels and other commercial accommodations facilities. Major energy requirement such as hot water and electricity during load shedding hours could be met by solar energy. Solar thermal system can be used to generate hot water or steam for cooking. Solar PV power plant can be used to reduce or eliminate use of diesel generators which are being used during load shedding hours. Since a clear budget based classification couldn't be obtained, the basic measures of SWH and SPV systems are suggested as indicative measures for hotels in the city.

Introduction of RE system in 50% of the hotels in Trichy city as described in the table below will save 0.84 MU of energy per year and reduce GHG emission by 714.38 tonnes. Introduction of solar water heater system should be given prime importance in the hotels.

Table 5.28: Strategies for hotels

Particulars	Number of Establishment	RE System Proposed			
		Solar Water Heating System (LPD)		Solar PV System (kWp)	PV system
		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity
Budget hotels	35		105000		70
Target in 5 years		50%	52500	50%	35
Energy Savings (MU)			0.79		0.05
Total Emission reduction			669.38		45

Renewable Energy Systems for Restaurants

Trichy has a handful of restaurants and small eateries. The exact number of such establishments was not available. However, indicative renewable energy technologies that find immense carbon reduction potential in restaurants are solar water heaters which can easily be introduced to meet their hot water demand for cooking and utensil cleaning. Typically almost all restaurants use DG sets as standby power supply source during load shedding, PV power plant will be an attractive and profitable option for the restaurants. For smaller establishments like street food stalls and smaller eateries across the city, solar lanterns prove to be a profitable and attractive option in comparison to the typically used kerosene lamps.

Renewable Energy Systems for Hospitals

The Trichy city has 140 private health care facilities, 17 Corporation maintained dispensaries, 5 urban health posts and 4 maternity homes. Since a segregation based on number of beds could not be found, a general summary is being illustrated without case examples to offer an insight on the potential implementation of renewable energy systems for the health sector in Trichy city. Targeting a 50% target to introduce renewable energy systems in hospitals in the city, total energy savings of 7.28 MU and emissions reduction of 6190 tonnes of CO_2 can be achieved.

Table 5.29: Summary of RE systems for Hospitals

Particulars	Number of Establishment	RE System Proposed			
		Solar Water Heating System (LPD)		Solar PV System (kWp)	
Hospitals		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity
Urban health posts	5	2000	10000	10	50
Corporation Dispensaries	17	5000	85000	10	170
Private Hospitals (incl	144	10000	1440000	10	1440

maternity homes)					
Aggregate	161		1525000		1610
Target in 5 years		50%	762500	50%	805
Energy Savings (MU)			11.44		1.21
Total Emission reduction			9722		1026

Renewable Energy Systems for Educational Institutes

Educational institutes are major establishments in the commercial sector of a city. Although they are not major source of energy consumption in the city yet they account for a substantial degree of energy utilization. An informal survey revealed the following figures of educational institutes in Trichy. The city has approximately 104 schools of which 31 are elementary schools, 27 are middle and 1 higher secondary schools. There are a total of 42 colleges including arts, science and engineering. The institutes having hostels can use solar water heater to supply hot water to the bath rooms and the kitchen thereby providing bathing comfort to the students and hot water for cooking.

The two renewable energy options can effectuate a considerable energy saving in educational institutes are the solar water heaters and solar PV systems. The potential for energy savings in different educational institutes in Trichy is tabulated below. The figures give a gross idea about the financial implications and emission reductions rendered by installation of the aforementioned renewable energy systems.

Table 5.30: Summary of RE strategy for educational institutes

Particulars	Number of Establishment	RE System Proposed							
		Solar Cooker/ Steam generating system for Cooking (sqm collector area)		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (Cu M)	
Educational Institutes		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Unit Capacity	Total Capacity
Elementary school/ (incl special needs schools)	32	20	640	0	0	1	32	0	0
Middle Schools	27	0	0	0	0	2	54	0	0
High and Higher Secondary Schools	4	0	0	0	0	2	8	0	0
Colleges (Arts, Science, Engineering)	42	200	8400	10000	420000	10	420	20	840
Aggregate	105		9040		420000		514		840
Target in 5 years		25%	2260	25%	105000	25 %	129	25%	210
Energy Savings (MU)			1.47		1.58		0.19		0.45

Total Emission reduction			1249		1339		164		379

Summary of RE strategy for Commercial and Institutional Sector

The suggested implementations as described above are able to achieve about 0.14% reduction in total energy savings through the RE strategies for commercial and institutional sector. The strategy, once implemented fully will save 17.17 MU of energy per year and reduce 14592.35 tonnes of GHG emissions per year. The primary focus should be given to introduction of solar water heaters for hotels, restaurants, hospitals and other residential institutes, which will save 13.80 MU per year. Solar PV power plant should be introduced for diesel abatement in the establishments that are using diesel sets as standby power supply source. The restaurants and hotels that has considerable amount of food and organic waste, should introduce biogas system. Use of solar cooker for preparing mid-day meal in primary schools will be an attractive option to save LPG for cooking and creation of awareness and demonstration about use of renewable energy devices among school children.

Table 5.31: Summary for RE Strategy for Commercial and Institutional Sector

RE Strategy for Commercial and Institutional sector	Units	Target Capacity	Total Investment (Lakh INR)	MNRE subsidy (Lakh INR)	Sate/ NMC/ Beneficiary's contribution	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Solar Steam Cooker for Cooking in Schools, Hostels, Hotels, Restaurant	sqm	2260	339.00	122.04	216.96	1.47	1248.65
Solar Water Heaters for Hotels, Restaurants, Hospitals	LPD	920000	1840.00	607.20	1232.80	13.80	11730.00
Solar PV Power Plant for Hotels, Restaurants, Hospitals.	kWp	969	1694.88	552.05	1142.83	1.45	1234.84
Biogas for Hotels and Restaurants	CuM	210	31.50	22.05	9.45	0.45	378.86
Total			**3905.38**	**1303.34**	**2602.04**	**17.17**	**14592.35**

5.4.3 RE Strategy for Industrial Sector

The industry sector in Trichy consumes 23.73% of total electricity. In Trichy City there are about 20 small and medium scale industries. The system capacity assumed is average capacity and will vary based on the size of the industry and energy requirement. The data for specific industries in Trichy was unavailable due to their insignificant overall number. However the typical measures based on the scale of industrial establishment-are described below to facilitate implementations in the industrial sector in Trichy city.

Table 5.32: Indicative measures for Industrial sector

Industry Scale	Indicative Industry type	Typical measures
Small scale	Food based cottage industry, Textile and dyeing units	Solar Water Heating, Solar Lanterns etc.
Medium scale	Textile plants, Paper and food processing industry, Metal casting units	Solar Water Heating, Solar PV systems, Solar Cooking/Steaming systems etc.
Large scale	Cement plants, Machinery and beverage industry	Solar Water Heating systems, Solar PV systems, Biomass systems etc.

5.4.4 RE Strategy for Municipal Sector

The municipal sector of Trichy city consumes 7.8% of total electrical energy in the city. The primary consumers in this sector are street lights, outdoor lights in parks, markets, office buildings of the Corporation, advertising hoardings, water supply, sewerage treatment plant etc. Renewable energy devices are suggested to all categories of consumers depending upon the energy demand. The sector has ample opportunity to save energy through introducing renewable energy and energy conservation measures and could show case these initiatives to encourage people to adopt further.

(i) Renewable Energy System for Municipality building and other Office Buildings

The official municipal corporation buildings consume in total about 2.46 MU of electricity per year. The loads consume most of the energy are air conditioners, fans and lighting loads. A 10kWp PV Power plant is recommended for some Corporation buildings to supply power during load shedding hours.

(ii) Renewable Energy System for Markets

There are 11 daily markets in Trichy. Typically electricity is used to power the electrical equipments like bulb, tube lights, fans etc. Taking the note of load shedding for 3-4 hours per day in the city and the increasing of fuel costs for use in generators, some suggestions for RE technologies for the commercial shops are provided, which if implemented will result in substantial reduction in conventional energy and the resultant emissions.

Table 5.33: Summary of RE Strategy for Municipal sector

Particulars	Nos	RE System Proposed				
		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (CuM)
		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Total Capacity
Municipal office buildings	24	0	0	10	240	0
Parks, recreation centres maintained by the corporation	7	0	0	10	70	0
other buildings/sites like staff quarters etc	138	0	0	5	690	0

Particulars	Nos	RE System Proposed				
		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (CuM)
		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Total Capacity
Bus Stands and shelters	134	0	0	5	670	0
Kaliyanamandapam	8	5000	40000	5	40	160
Daily Market	11	0	0	5	55	110
Reading Rooms	24	0	0	1	24	0
Aggregate	629		40000		2451	270
Target in 5 years		20%	8000	20%	490	27
Energy Savings (MU)			0.12		0.74	0.06
Total Emission reduction			102		625	49

5.4.5 EE Strategy for Residential sector

Residential sector consumes largest amount of electricity among all sectors. Important proven and cost effective measures for the sector are described in this section. Based on the survey, it was found that incandescent lights are still being used in the residential sector. Utilizing the survey data the savings due to replacement of incandescent lamps with CFL are calculated and are presented in the table below.

(i) Replace Incandescent Lamps with Fluorescent

Incandescent bulbs are the major and the most common source of high energy consumption in the residential area. Replacement of incandescent lamps has acquired a substantial precedence in all the energy efficiency strategies as the most feasible option. The techno commercial for replacement of incandescent bulbs with CFL is given below. An assumption of 42% households utilizing CFLs has been considered as target group for replacements and 100% replacement is assumed for the calculations below.

Table 5.34: Replacement of incandescent lamps with fluorescent

Particulars		Unit
Total Residential household	261885	Nos.
Household using incandescent bulb	42%	
Target to replace incandescent bulb with CFL	100%	
Number of incandescent bulb to be replaced per household	4	Nos.
Total number of incandescent bulb to be replaced	439967	Nos.
Indicative cost of installation	660	Lakh
Energy saved by replacing 60W bulb with 15W CFL	43358728	kWh
Cost of electricity savings	1518	Lakh
Payback period	0.43	years
Emission reduction per year	35121	Tonnes

(ii) T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast

A conventional tube light (with magnetic ballast consuming 15W) consumes around 55 watts. It can be replaced with T5 tube (28W) with electronic ballast (4W) which will

require around 32W. The calculations have been done for a period of 5 years assuming 80 % replacement of T 12 /T8 tube lights can be possible in 83% of the households using T12/T8 tube lights.

Table 5.35: T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast

Particulars		Unit
Total Residential household	261885	Nos.
Household using T8/T12 tube lights	94%	
Target to replace T8/T12 by T5 tube lights	80%	
Number of T8/T12 to be replaced per household	2	Nos.
Total number of T8/T12 tube lights to be replaced	393875	Nos.
Indicative cost of installation	1969	Lakh
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	13226324	kWh
Cost of electricity savings	463	Lakh
Payback period	4.25	Years
Emission reduction per year	10713	Tonnes

(iii) Efficient ceiling fans to replace conventional ceiling fans

Replacing conventional fans with star rated fans can save substantial amount of electrical energy and money. The financial and technical analysis for replacement of conventional ceiling fans in residential sector of Trichy city assumes that 50% replacement should be possible in almost 91% of the households.

Table 5.36: Efficient Ceiling Fans to Replace Conventional Ceiling Fans

Particulars		Unit
Total Residential household	261885	Nos.
Household using Conventional Fans	91%	
Target to replace CF by EE Fans	50%	
Number of Conventional fan to be replaced per household	3	Nos.
Total number of Conventional Fans to be replaced	357473	Nos.
Indicative cost of installation	5362	Lakh
Energy saved by replacing Conventional Fans by EE Fans	19303543	kWh
Cost of electricity savings	676	Lakh
Payback period	8	years
Emission reduction per year	15636	Tonnes

(iv) Replacement of conventional air-conditioners with EE star rated ACs

In Trichy city it is assumed that approximately 14% of residential households had 1.5 ton air conditioners on average. The energy consumption by a 1.5 ton unit is approximately 7.2 kWh per day. For calculating the energy savings by switching to more energy efficient air conditioners it is assumed that 14% households in Trichy owns an air –conditioner and 10% air conditioners can be assumed as potential target for replacement with energy efficient ACs.

Table 5.37: Replacement of conventional air-conditioners with EE star rated ACs

Particulars		Unit
Total Residential household	261885	Nos.
Household using Conventional AC	14%	
Target to replace Conventional ACs by EE star rated AC	50%	
Number of Conventional ACs to be replaced per household	1	Nos.
Total number of Conventional ACs to be replaced	18332	Nos.
Indicative cost of installation	5040	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	7424440	kWh
Cost of electricity savings	260	Lakh
Payback period	19	years
Emission reduction per year	6014	Tonnes

(v) Replacement of conventional refrigerators with EE star rated refrigerators

One of the most common appliance used in homes are the refrigerators. With increasing affordability refrigerators have become an indispensable item in most Indian households. They come in the capacity range of 200-400 liters. These days many BEE star rated energy efficient refrigerators are available in the Indian market. A conventional refrigerator of 200 watts has been taken to provide the calculations below. An assumption of 59% households with conventional refrigerators is taken to show the energy savings.

Table 5.38: Replacement of Conventional Refrigerators with EE Star Rated Refrigerators

Particulars		Unit
Total Residential household	261885	Nos.
Household using Conventional Refrigerators	59%	
Target to replace Conventional Refrigerators by EE Star Rated Refrigerators	50%	
Number of Conventional Refrigerators to be replaced per household	1	Nos.
Total number of Conventional Refrigerators to be replaced	77256	Nos.
Indicative cost of installation	8691	Lakh
Energy saved by replacing Conventional Refrigerators by EE Star Rated Refrigerators	36619380	kWh
Cost of electricity savings	1282	Lakh
Payback period	6.8	years
Emission reduction per year	29662	Tonnes

(vi) Replacement of conventional water pumps with EE star rated water pumps

Survey in Trichy has shown that residential households use water pumps of 1.5 HP capacities which have an approximate electrical consumption of 2.2 kWh. Assuming 45% households in Trichy use water pumps, 50% replacement of conventional pumps by energy efficient pumps have been targeted for energy savings.

Table 5.39: Replacement of conventional water pumps with EE star rated water pumps

Particulars		Unit
Total Residential household	261885	Nos.
Household using Water Pumps	45%	
Target to replace Conventional Water Pump by EE Pump	50%	
Number of Conventional Pumps to be replaced per household	1	Nos.
Total number of Conventional Pumps to be replaced	82494	Nos.
Indicative cost of installation	1649.87	Lakh
Energy saved by replacing Conventional Water Pumps by EE Water Pumps	9033068	kWh

Cost of electricity savings	316.16	Lakh
Payback period	5.22	years
Emission reduction per year	7317	Tonnes

(vii) Summary of EE Strategy in Residential Sector

The estimated potential of energy savings in the residential sector through energy efficiency measures is 129 MU per year in Trichy City. The reduction of emission through EE measures in residential sector is 104462 tonnes per year. Replacement of incandescent bulbs with CFL, conventional fans, refrigerators and air conditioners with star rated one have the most potential scope for energy savings.

Table 5.40: Summary of EE Strategy in Residential Sector

EE Measures in residential sector	Unit	Target Capacity	Investment (Lacs INR)	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Indicative cost of replacing 60 watt incandescent with 15 watt CFL	Nos.	439967	660	43	35121
Indicative cost of replacing T12/T8 with T5 FTL	Nos.	393875	1969	13	10713
Indicative cost of replacing conventional Fans with EE star rated fans	Nos.	357473	5362	19	15636
Indicative cost of replacing conventional AC with EE star rated AC	Nos.	18332	5040	7	6014
Indicative cost of replacing conventional refrigerator with EE star rated refrigerator	Nos.	77256	8691	37	29662
Indicative cost of installing a EE water pump	Nos.	82494	1650	9	7317
			23372	**129**	**104462**

5.4.6 EE Strategy for Commercial Sector

(i) Replace Incandescent Lamps with Fluorescent

CFL usage has been widespread in the last few years and it is high time that all commercial establishments should voluntarily replace the high energy consuming incandescent lamps with CFLs. It is assumed that 16% of the commercial sector establishments use incandescent bulbs and 100% of establishment use T8/T12 tube lights. A target to replace 80% of the incandescent bulbs and the same amount of T8/T12 tube lights in the commercial sector is assumed so as to give the calculations below.

Table 5.41: Replacement of incandescent lamps with fluorescent

Particulars		Unit
Total Commercial Consumers	74538	Nos.
Consumers using incandescent bulb	16%	
Target to replace incandescent bulb with CFL	80%	
Number of incandescent bulb to be replaced per consumer	10	Nos.
Total number of incandescent bulb to be replaced	95409	Nos.
Indicative cost of installation	143	Lakh
Energy saved by replacing 60W bulb with 15W CFL	7728100	kWh
Cost of electricity savings	386	Lakh
Payback period	0.37	years
Emission reduction per year	6260	Tonnes

Table 5.42: Replace T12/T8 tube light by T5 tube light

Particulars		Unit
Total Commercial Consumers	74538	Nos.
Consumers using T8/T12 tube lights	100%	
Target to replace T8/T12 by T5 tube lights	80%	
Number of T8/T12 to be replaced per consumer	2	Nos.
Total number of T8/T12 tube lights to be replaced	119261	Nos.
Indicative cost of installation	596	Lakh
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	3291598	kWh
Cost of electricity savings	165	Lakh
Payback period	3.62	years
Emission reduction per year	2666	Tonnes

(ii) Replacement of inefficient fans

Analysis of the sample survey of Trichy city reveals that maximum commercial establishments in Trichy city have fans. Conventional fans have an average energy consumption of 1.03kWh per day. Assuming 15% of the conventional fans in the commercial sector of Trichy can be replaced with more energy efficient fans the following techno-commercials have been calculated.

Table 5.43: Replacement of Conventional Fans

Particulars		Unit
Total Commercial Consumers	74538	Nos.
Consumers using Conventional Fans	99%	
Target to replace CF by EE Fans	15%	
Number of Conventional fan to be replaced per consumer	3	Nos.
Total number of Conventional Fans to be replaced	29886	Nos.
Indicative cost of installation	448	Lakh
Energy saved by replacing Conventional Fans by EE Fans	1046010	kWh
Cost of electricity savings	52	Lakh
Payback period	8.57	years
Emission reduction per year	847	Tonnes

(iii) Replacement of conventional air-conditioners with EE star rated ACs

Commercial establishments are usually equipped with air conditioners. In Trichy city like in most other southern cities 1.5 tons air conditioners are more popular in the commercial buildings. Assuming that 33% of the commercial establishments own an air conditioner,

10% target replacement of inefficient air-conditioners with more efficient conditioners are taken into consideration for the below mentioned calculations.

Table 5.44: Replacement of Conventional Air-Conditioners with EE Star Rated ACs

Particulars		Unit
Total Commercial Consumers	74538	Nos.
Consumers using Conventional ACs	33%	
Target to replace Conventional ACs by EE star rated ACs	10%	
Number of Conventional ACs to be replaced per household	5	Nos.
Total number of Conventional ACs to be replaced	12411	Nos.
Indicative cost of installation	3412	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	5026284	kWh
Cost of electricity savings	251	Lakh
Payback period	13.58	years
Emission reduction per year	4071	Tonnes

(iv) Replacement of conventional refrigerators with EE star rated refrigerators

Refrigerators in commercial sector are restricted to the food outlets, restaurants, hotels, guest houses, and ice-cream parlors. General trend reveals that the refrigerators of the range of 200-400 W are found in the commercial sector of Trichy city like most Indian cities. Approximately 41% of the consumers own a refrigerator and a target of replacing 25% refrigerators has been taken to show the energy saving potential of replacing conventional refrigerators in commercial sector of Trichy city.

Table 5.45: Replacement of Conventional Refrigerators with EE Star Rated Refrigerators

Particulars		Unit
Total Commercial Consumers	74538	Nos.
Consumers using Conventional Refrigerators	41%	
Target to replace Conventional Refrigerators by EE Star Rated Refrigerators	25%	
Number of Conventional Refrigerators to be replaced per consumer	1	Nos.
Total number of Conventional Refrigerators to be replaced	7640	Nos.
Indicative cost of installation	860	Lakh
Energy saved by replacing Conventional Refrigerators by EE Star Rated Refrigerators	3621429	kWh
Cost of electricity savings	181	Lakh
Payback period	5	years
Emission reduction per year	2933	Tonnes

(v) Replacement of conventional water pumps with EE star rated water pumps

About 30% of the commercial units use water pumps. If a target of 25% is made in order to replace the inefficient water pumps with efficient star rated water pumping equipments then the following techno-commercial details ensue which are calculated below.

Table 5.46: Replacement of conventional water pumps with EE star rated water pumps

Particulars		Unit
Total Residential household	74538	**Nos.**
Household using Water Pumps	30%	
Target to replace Conventional Water Pump by EE Pump	25%	
Number of Conventional Pumps to be replaced per household	1	**Nos.**
Total number of Conventional Pumps to be replaced	7826	**Nos.**
Indicative cost of installation	157	**Lakh**
Energy saved by replacing Conventional Water Pumps by EE Water Pumps	704384	**kWh**
Cost of electricity savings	25	**Lakh**
Payback period	6.35	**years**
Emission reduction per year	571	**Tonnes**

(vi) Summary of EE Strategy in Commercial & Institutional Sector

The estimated energy savings potential from commercial and institutional sector through energy efficiency measures is 21.41MU per year. Potential for GHG reduction is 17348 tonnes per year.

Table 5.47: Summary of EE Strategy in Commercial & Institutional Sector

EE Measures	Units	Targets	Investment (INR)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Indicative cost of replacing 100 watt incandescent with 15 watt CFL	Nos.	95409	143	7.728	6260
Indicative cost of replacing T8/T12 tube lights with T5 FTL	Nos.	119261	596	3.292	2666
Indicative cost of replacing conventional fans with EE fans	Nos.	29886	448	1.046	847
Indicative cost of replacing conventional AC with EE star rated AC	Nos.	12411	3412	5.026	4071
Indicative cost of replacing conventional refrigerators with EE star rated refrigerators	Nos.	7640	860	3.621	2933
Indicative cost of installing EE water pumps	Nos.	7826	157	0.704	571
			5616	21.418	**17348**

5.4.7 EE Strategy for Industrial Sector

Trichy has around 20 industrial units as per the Corporation assessments. They are also contributing a lot towards the huge energy consumption in Trichy city. Energy efficiency measures are the most financially feasible option in this sector too.

(i) Replacement of incandescent with CFLs

Industrial sector survey in Trichy city reveals that almost 35% use incandescent bulbs as lighting appliances. 80% target for replacing incandescent bulbs with CFLs is taken to provide the energy savings calculations below.

Table 5.48: Replacement of incandescent with CFLs in Industrial sector

Particulars		Unit
Total Industrial Consumers	20	Nos.

Consumers using incandescent bulb	35%	
Target to replace incandescent bulb with CFL	80%	
Number of incandescent bulb to be replaced per consumer	25	Nos.
Total number of incandescent bulb to be replaced	140	Nos.
Indicative cost of installation	0	Lakh
Energy saved by replacing 100W bulb with 20W CFL	30240	kWh
Cost of electricity savings	2	lakh
Payback period	0.19	years
Emission reduction per year	24	Tonnes

(ii) Replacement of T8/T12 by T5 tube lights

The T12 and Tt8 tube lights are also frequently used in the industrial sector in Trichy city. Survey results show that almost 90% consumers use these appliances. The energy saving potential by replacement of T12 and T8 with more efficient T5 tube lights is calculated below assuming a replacement of 90% appliances in target households. The financial and technical details of the replacement in Trichy city industrial units are given below.

Table 5.49: Replacement of T8/T12 tube lights by T5 tube lights

Particulars		Unit
Total Industrial Consumers	20	Nos.
Consumers using T8/T12 tube lights	90%	
Target to replace T8/T12 by T5 tube lights	90%	
Number of T8/T12 to be replaced per consumer	40	Nos.
Total number of T8/T12 tube lights to be replaced	648	Nos.
Indicative cost of installation	3	Lakh
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	22848	kWh
Cost of electricity savings	1	Lakh
Payback period	2.84	years
Emission reduction per year	19	Tonnes

(iii) Replacement of Conventional Fans by EE Star Rated Fans

Conventional fans are other energy guzzlers in industrial units of most cities. They are used for longer hours in this sector hence the replacement of conventional energy efficient fans with more efficient ones would bring about a lot of energy savings. 74% of industrial units have installed a conventional fan which can be targeted for replacement. Assuming a replacement of 25% of the conventional fans with energy efficient fans the economics and technical details of replacement are tabulated below.

Table 5.50: Replacement of conventional fans by EE star rated fans

Particulars		Unit
Total Commercial Consumers	20	Nos.
Consumers using Conventional Fans	74%	
Target to replace CF by EE Fans	25%	
Number of Conventional fan to be replaced per consumer	15	Nos.
Total number of Conventional Fans to be replaced	55	Nos.
Indicative cost of installation	1	Lakh
Energy saved by replacing Conventional Fans by EE Fans	2620	kWh
Cost of electricity savings	0	Lakh
Payback period	6	years
Emission reduction per year	2	Tonnes

(iv) Replacement of Conventional ACs with EE Star Rated ACs

Almost 13 % of the surveyed industrial units in Trichy City had the ownership of air conditioning units in their office premises. Assuming the replacement of 25% of the air-conditioning units with star rated air conditioning units the figures related to instalments and energy savings are given below.

Table 5.51: Replacement of Conventional ACs with EE Star Rated ACs

Particulars		Unit
Total Industrial Consumers	20	Nos.
Consumers using Conventional ACs	13%	
Target to replace Conventional ACs by EE star rated ACs	25%	
Number of Conventional ACs to be replaced per household	5	Nos.
Total number of Conventional ACs to be replaced	3	Nos.
Indicative cost of installation	1	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	1316	kWh
Cost of electricity savings	0.066	Lakh
Payback period	14	years
Emission reduction per year	1	Tonne

(v) Summary of EE Strategy in Industrial Sector

Energy Efficiency measures with mere replacement of incandescent bulbs, inefficient fans, ac and refrigerators in industrial sector of Trichy city can save at least 0.06MU energy per year reducing GHG emission by 46 tonnes per year.

Table 5.52: Summary of EE Strategy for Industrial Sector

EE Measures	Units	Target	Investment (INR)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Indicative cost of replacing 100 watt incandescent with 15 watt CFL	Nos.	140	0	0.03	24
Indicative cost of replacing T12/T8 tube lights with T5 tube lights	Nos.	648	3	0.02	19
Indicative cost of replacing conventional fans with EE star rated fans	Nos.	55	1	0.00	2
Indicative cost of replacing conventional AC with EE star rated AC	Nos.	3	1	0.00	1
	Nos.		**5**	**0.06**	**46**

5.4.8 EE Strategy for Municipal Sector

Street Lighting

Street lighting is one of the major sources of energy consumption in municipal area. In Trichy city, 40 W tube lights, 150 watt and 250 watt HPSV are mostly used as streetlights in different wards of within the jurisdiction of the Corporation.

(i) Replacement of 150 watt HPSV with 100 watt induction lamps

150 watts high pressure sodium vapor lamps are frequently used in street lighting fixture in municipal area. They can be replaced with more energy efficient induction laps available in the Indian market today. A 100% target to replace 3414 number of 150W HPSV lamps with 100 watt induction lamps is taken for Trichy city, to provide the techno-economics of implementing the replacement and bringing about energy savings.

Table 5.53: Replacement of 150 watt HPSV with 100 watt induction lamps

Particulars		Unit
Total number of 150 watt HPSV	29	Nos.
Target to replace 150 watt HPSV with 100 watt induction lamp	100%	
Total number of 100 watt induction lamp needed	29	Nos.
Indicative cost of installation	6	Lakh
Energy saved by replacing 150 & 125 HPSV with 100 watt induction lamp	6351	kWh
Cost of electricity savings	31755	INR
Payback period	19.2	years
Emission reduction per year	5	Tonnes

(ii) Replacement of 40 watt tube lights with 25 W LED lamps

There are 12231 number of 40 watts tube lights currently under use within different wards of the Trichy Corporation area. A replacement target of 100% is proposed with 25 W LED lamps to improve the efficiency of the street lighting systems. Following table indicates the techno-economic analysis and energy saving such a replacement accompanies.

Table 5.54: Replacement of 40 watt tube lights with 25 watt LED lamps

Particulars		Unit
Total number of 40 W tube lights	27968	Nos.
Target to replace 40 W tube lights by 25 W LED lamps	100%	
Total number of 25 watt LED lamp needed	27968	Nos.
Indicative cost of installation	5924	Lakh
Energy saved	6124992	kWh
Cost of electricity savings	306	Lakh
Payback period	19.35	years
Emission reduction per year	1102.50	Tonnes

(iii) Sensors for automatic on/off of street lights

Automatic street lights ensure that energy is not wasted by lights turned on during day time. Many streetlights in India face this predicament due to faulty manually controlled street lights. Manual control involves labour costs, energy wastes and poor efficiency; hence Municipal street lights should hasten the process of installing automatic sensors. Solar sensors are the new and upcoming products in the market today and should be applied by municipalities for higher efficiency in the operation and maintenance of municipal street lights. The following scheme of power saver application has been recommended for street lights in Trichy city that aren't undergoing any replacement as suggested in the previous sections:

Table 5.55: Application of 20KVA power saver packs HPSV, MHL and CFL lighting systems

Particulars	HPSV			MHL	CFL			
	400 W (High mast SVL)	500W	70 W	150 W	2*11 W	65W	4*25 W	1*35 W
Total no of street lights	46	2	38	4	171	15	22	230
Wattage (kW)	400	500	70	250	72	36	96	120
Load (KW)	18.4	1	2.66	1	12.312	0.54	2.112	27.6
Electricity Consumption (kWh)	73876	4015	10679.9	4015	49432.68	2168.1	8479.68	110814
No of 25 KVA power Saver Required	0.92	0.05	0.133	0.05	0.6156	0.027	0.1056	1.38
Cost of each 20 KVA power saver is INR 85000	78200	4250	11305	4250	52326	2295	8976	117300
Energy Saved	22162.8	1204.5	3203.97	1204.5	14829.804	650.43	2543.904	33244.2
Cost of Energy Saved (INR)	77569.8	4215.75	11213.895	4215.75	51904.314	2276.505	8903.664	116354.7
Payback Period	1.01	1.01	1.01	1.0081243	1.0081243	1.0081243	1.008124296	1.008124
Emissions Saved (in tonnes)	17.95	0.98	2.60	0.975645	12.0121412	0.5268483	2.06056224	26.9278

(iv) 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 state in its Manual for Development of Municipal Energy Efficiency Projects states that 25% energy savings can be obtained from initiatives in water systems alone. In Karnataka Municipal energy efficiency Improvement initiatives, water pumping has been addressed. This has been further taken up as a Municipal Energy efficiency CDM project. The effort can be replicated throughput other municipalities sin India. This would bring about a lot of energy savings in water pumping utilities.

Proper pump-system design (efficient Pump, pumps heads with system heads)

Proper water pumping design can bring about lots of 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 and the height it needs to be raised to. 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 5.56: Proper pump-system design (efficient Pump, pumps heads with system heads)

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	13.11
Annual Energy Cost in Rs. (lacs)	458.85
Saving %	20%
Total Annual Saving in MU	2.622
Annual Saving in Rs. (lacs)	91.77
eCO_2 (Tonne) Reduction	2123.82

Installation of variable speed drivers

Dimension and adjustment losses are two of the major energy loss sources in pumping processes. Adjusting pump speed or using Variable Speed Driver to adjust speed is one way to decreasing both the aforementioned losses in pumping processes. An assumption of 5% savings is taken to provide the financial and technical details of installing variable speed drivers in municipal water pumping systems in Trichy City.

Table 5.57: Variable Speed Drivers

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	13.11
Annual Energy Cost in Rs. (lacs)	458.85
Saving %	5%
Total Annual Saving in MU	0.6555
Annual Saving in Rs. (lacs)	22.9425
eCO2 (Tonne) Reduction	530.955

Power saver installation in pump house

An assumption of 15% savings is taken as the energy saving potential for installing power saver in municipal pump houses. The following techno-economics is based on this assumption.

Table 5.58: Power saver installation in pump house

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	13.11
Annual Energy Cost in Rs. (lacs)	458.85
Saving %	15%
Total Annual Saving in MU	1.9665
Annual Saving in Rs. (lacs)	68.8275
eCO_2 (Tonne) Reduction	1592.865

(v) Sewage Treatment Plant (STP)

Pumping systems are utilized in water treatment plants of the municipal corporations whose energy efficiency can also be determined through efficient system design. A considerable amount of energy can be saved taking suitable measures in STP. TMC should initiate energy audit in all its utility services and installations to take a stalk of the energy consumption and potential savings.

Proper pump-system design (efficient pump, pumps heads with system heads)

The same principle of speed adjustment to reduce adjustment and dimension energy losses in water pumping process applies in water treatment plants. An assumption of 5% saving is taken into consideration for giving the techno-economics of installing variable

Table 5.59: Proper pump-system design (efficient pump, pumps heads with system heads)

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	2.46
Annual Energy Cost in Rs. (lacs)	86.1
Saving %	20%
Total Annual Saving in MU	0.492
Annual Saving in Rs. (lacs)	350

eCO_2 (Tonne) Reduction	399

Installation of variable speed drivers

Installation of variable speed drivers for municipal pumps could save at least 5% energy resulting total savings of 0.20MU per year reducing 165 tonnes of GHG emission.

Table 5.60: Variable Speed Drivers

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	2.46
Annual Energy Cost in Rs. (lakhs)	86.1
Saving %	5%
Total Annual Saving in MU	0.12
Annual Saving in Rs. (lakhs)	4.31
eCO_2 (Tonne) Reduction	100

Power saver installation in pump house

An assumption of 15% savings has been taken to calculate the energy saving potential and financial implications of installing power saver in pump houses.

Table 5.61: Power saver installation in pump house

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	2.46
Annual Energy Cost in Rs. (lakhs)	86.1
Saving %	15%
Total Annual Saving in MU	0.369
Annual Saving in Rs. (lakhs)	12.92
eCO2 (Tonne) Reduction	299

Summary of EE Strategy for Municipal Sector

The energy savings potential through energy efficiency measures in municipal sector is 12.44MU per year causing emissions to reduce to about 6216.35 tonnes.

Table 5.62: Summary of EE Strategy for municipal sector

EE Measures	Investment (Lakh)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Indicative cost of replacing 150 watt HPSV with 100 watt induction lamps	6	0.01	5
Indicative cost of replacing 40W tube lights with 25 W LED lamps	5924	6.12	1102
Proper pump system design, installation of variable speed drivers and power savers in existing water supply facility		5.24	4247.64
Proper pump system design, installation of variable speed drivers and power savers in existing sewage system facility		0.98	797
Use of power saver in street lighting	3	0.08	64
		12.44	**6216.35**

5.4.9 Solid Waste Management Interventions

Waste to Energy Potential in Trichy

Estimated solid waste generated in Trichy city is over 400 MT/day. Potential energy recovery from MSW through different treatment methods could be estimated from its calorific value and organic fraction etc. Since relevant details are not available for Trichy, widely used estimates for municipal solid waste in India have been used for a preliminary assessment. However, waste to energy potential for the city is considered as an indicative assessment and not included in the strategy to achieve energy savings goal under solar city programme.

(i) 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 12.56 MWe and savings per year with 70% PLF is estimated as 77 MU.

Table 5.63: Waste to Energy through thermo-chemical conversion

Particulars		Unit
Total waste generated	432	Tonnes
Net Calorific Value (conservative estimate)	2400	kcal/kg
Energy recovery potential (NCV x W x 1000/860)	1205581	kWh
Power generation potential	50233	kW
Conversion efficiency	25%	
Net Power generation potential	12.56	MWe
Plant Load Factor	70%	
Net electrical energy savings potential @70% PLF	77.01	MU
Emission reduction per year	62375	Tonnes
Total Investment	8791	Lakh
MNRE subsidy @ 50% subject to maximum of Rs.300.00 per MW	3767	Lakh
State/City/Private Power Producer	5023	Lakh
Cost savings	3465	Lakh
Payback period	1.45	Years

(ii) Waste to Energy Potential through bio-methanation

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output. It is estimated that a 4.52 MWe electrical energy generation is possible from this process which could save about 27.72 MU of energy every year assuming a 70% of PLF.

Table 5.64: Waste to Energy through bio-methanation

Particulars		Unit
Total waste generated	432	Tonnes
Total biodegradable volatile solid (VS)	30%	
Typical digestor efficiency	60%	
Typical bio-gas yield (m3 / kg. of VS destroyed)	0.80	CuM/kg
Biogas yield	62208	CuM
Calorific Value of bio-gas	5000.00	kcal/CuM
Energy recovery potential	361674.42	kWh

Particulars		Unit
Power generation potential	15070	kW
Conversion efficiency	30%	
Net Power generation potential	4.52	MWe
Plant Load Factor	70%	
Net electrical energy savings potential	27.72	MU
Emission reduction per year	22455	Tonnes
Total Investment	2713	Lakh
MNRE subsidy @ R.200.00 lakh per MW	904	Lakh
State/City/Private Power Producer	1808	Lakh
Cost savings	1248	Lakh
Payback period	1.45	Years

(iii) Waste to Energy Potential from Sewage Treatment Plant

Liquid waste generated in Trichy city is 88.64 MLD per day. It is estimated that a 3.09 MWe electrical energy generation is possible from Sewage Treatment Plant which could save about 18.96 MU of energy every year assuming a 70% of PLF.

Table 5.65: Liquid Waste to Energy Potential from Sewage Treatment Plant (STP)

Particulars		Unit
Total waste water generated	88.64	MLD
Total biodegradable organic/ Volatile Solid available for Biomethanation	88.64	Tonnes/day
Typical Digestion Efficiency	60%	
Typical Biogas yield	0.8	cum / kg
Biogas yield	42547.2	cum
Electricity (kWh)	247367.44	kWh
Capacity of the plant	10306.98	KW
Conversion Efficiency	30%	
Total Electricity Generated	3.09	MWe
Plant Load Factor	70%	
Net electrical energy savings potential	18.96	MU
Emission reduction per year	15358	Tonnes
Total Investment	1855.26	Lakh
MNRE subsidy @40% subject to maximum of Rs.200.00 lakh per MW	618.42	Lakh
State/City/Private Power Producer	1236.84	Lakh
Cost savings	853.23	Lakh
Payback period	1.45	Years

6. Tirunelveli City

6.1 City Profile

Historically associated with Lord Shiva, Nellai as it is also called Tirunelveli is one of the oldest cities in India. Located in the penultimate districts of Tamil Nadu, Tirunelveli has been regarded as the microcosm of the state due the rich variety of physical and geographical features it presents like the lofty mountains and low plains, rivers and cascades, seacoast and thick inland forest, sandy soils and fertile alluvium, a variety of flora, fauna, and protected wild life**.** Situated on the western banks of the Perennial River Thamirabarani and fed by it, the city is famous for its paddy fields also called *Nell* in Tamil from which the city earns its name.

Ruled over by many dynasties until it was annexed by the British in 1801, the district was reorganized after the Indian independence on 20th October 1986. The city of Tirunelveli has been one of the oldest serving Lok Sabha constituencies composed of 6 assembly sections electing representatives directly to the country's lower house.

6.1.1 Details of Location, Geography and Climate of Tirunelveli

Location

Located at the southern end of the Deccan plateau and in the penultimate district of the state of Tamil Nadu, Tirunelveli lies 47 m above sea-level and is situated at 8.7 ° N lat and 77 ° E long. The city lies amidst important towns like Tuticorin, Palayamkottai, and Gangaikondan etc. The district itself is surrounded by Virudhunagar district on the North, Western Ghats on the West, Kanniyakumari district on the south, Tuticorin district on the East.

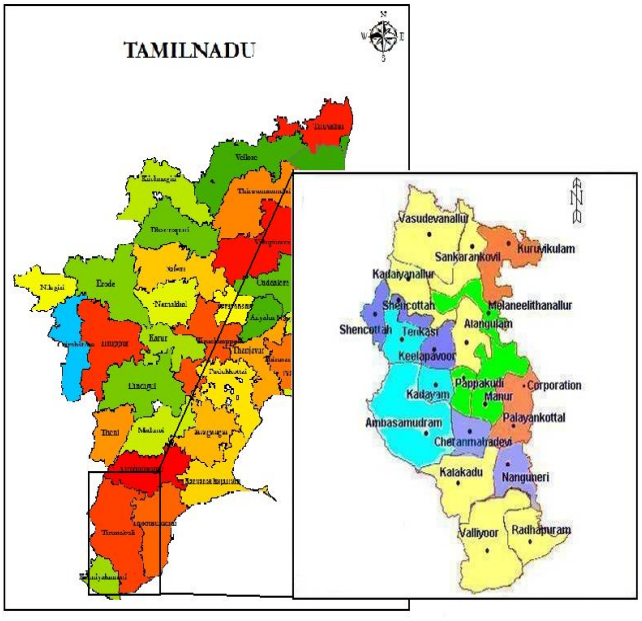


Figure 6.1: Location of Tirunelveli

Geography

Tirunelveli is located on the southernmost tip of the Deccan plateau. The River Thamirabarani cuts across the city and causes heavy alluvial soil deposition making the land in the city rich and conducive for intensive rice farming activity. Spread over an area of 108.65 square km., the city has a number of water bodies likes Nainar Lake and Udayarpetti Lake and several ponds.

Climate

Tirunelveli city experiences hot and humid climate for most time of the year and the city has an average minimum temperature of 18 ° C and an average maximum temperature of 41° C. The city receives an annual rainfall of 95.6 mm. The city receives most rainfall during the autumn months of September and October.

Table 6.1: Temperature and Rainfall profile

Temperature Profile (° C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Max.	27	24	21	19	24	14	18	21	21	29	22	25
Min.	23	17	15	18	19	23	18	14	20	26	19	20

Rainfall Profile												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
in mm	0	0	6	0	0	0	15	9	15	78	3	15

Source: http://www.worldweatheronline.com/Tirunelveli-weather/Tamil-Nadu/IN.aspx

Administrative profile

Tirunelveli city municipality was upgraded to Municipal Corporation level in 1994. The Corporation currently oversees the administration of 4 zones subdivided into a total of 55 wards. The Corporation now oversees the administration of three Municipal towns and several villages that lie within its jurisdiction. The Corporation is headed by a Mayor elected directly by the citizens of the city while its duties are executed by the Commissioner who presides over Senior Officers in charge of different departments of the Corporation like Administration, Engineering, Public Health, Accounts, Planning and Revenue. Following are brief notes on the civic services undertaken by the Corporation.

Water Supply

The River Thamirabarani is the only major source of water for the denizens of Tirunelveli. While the water is adequate, the supply falls short of expectation despite the extensions undertaken by the Corporation. The short-fall in supply is sharply experienced in Thatchanallur and Melapalayam administrative zones amounting to about 100 lpcd. The current consumption of water from this source stands at around 35 MLD.

Solid Waste Management and Sewerage

The Tirunelveli Corporation has undertaken extensions of the Underground Drainage (UGD) services. Several schemes for increasing the road length of UGD were

implemented but have had limited impact as the capacity hasn't been fully realized. The slum areas have been installed with community toilets and more such installations have been planned already. In 2007, the Corporation had maintained a SWM efficiency of 72% despite shortfalls in the necessary infrastructure and a daily garbage collection of 120 tons.

The Corporation has extended tenders in September last year for creation of 130 M.T. capacity STP at Ramayanpatti which is spread over an area of 65 acres.

Street Lighting

The Corporation undertakes the maintenance and repair of the street lights in the Local Planning Area. In 2006 and 2007, the Corporation made investments towards replacement of mercury lamps, tube lights with sodium vapor lamps costing more than INR 6 lakh. In addition, new street lights were installed and the Corporation currently maintains more than 17000 street lights.

Road and Transport

The city of Tirunelveli is ideally placed on the path of the NH7 which passes from Kashmir to Kanniyakumari. The city has a well established road network and provides easy accessibility via road to pivotal neighboring cities of Madurai and Tuticorin. The Corporation added a total length of 18km from 2005-2007.

Public Health

The Corporation maintains and runs 6 dispensaries (2 allopathic and 2 siddha), 8 maternity centers, 8 urban health posts and three government hospitals. In addition, the city has 15 private hospitals, 90 private dispensaries and 15 diagnostic centers.

Infrastructure and Facilities

Although, the nearest airport is located 22 km to the East of the city at Tuticorin; Tirunelveli is well connected via other means of transport like bus and rail. The Puthiya Perunthu Nilayam bus stand which was operationalised in 2003 serves as an all-destination center for south India. In addition, the Southern railway network maintains the Tirunelveli junction which is one of the oldest and most popular stations in southern India. The nearest port is Thoothukudi port which is 50km away.

The Corporation also maintains recreational areas and parks besides 33 schools, of which 22 are primary, six are middle and five are higher secondary. The Palayamkottai zone area is famously known as Oxford of the South owing to a large number of educational and vocational centers focused on enriching the local skills of the population.

Demographic trends

According to 2001 census, the population of Tirunelveli city was 411,831 which registered a decadal growth of 17.94%. According to 2001 census finding, the city's population was 474,838 registering a decadal growth of 21.16%. The literacy rate of Tirunelveli according

to 2011 census data was 90.86% and the sex ratio was 1023. Following tables indicate the growth rate and current demographic profile of the city.

Table 6.2: Population profile of Tirunelveli*

Year	Population	Decadal Growth %
1971	241013	-
1981	291104	20.8
1991	321454	10.43
2001	411831	17.94
2011	498984**	21.16

**City Master Plan Tirunelveli*
*** Census of India 2011*

Table 6.3: Population data*

Total Persons	498984
Males	264710
Females	252274
Sex ratio	1023
Total Persons below 6 years in age	46335
Males below 6 years in age	23677
Females below 6 years in age	22658
Sex ratio(0-6)	957
Total literates	411281
Literate Males	211727
Literate Females	199554
Male Literacy rate	94.93
Female Literacy rate	86.91

**Census of India 2011*

Socio-economic profile

In relation to the other two cities, the economy of Tirunelveli is not as prolific. Although the city has a matured workforce most concentrated in the service or tertiary sector, agriculture still remains prominent along with secondary following in at second place in terms of workforce. The city has cement factories, steel mills and cotton textile industries. There a large clout of small scale industries in and around the city within the Local Planning Area.

Owing to its opportune geographical location, the city has a large concentration of wind power multi-national companies like Suzlon, Gamesa and Vestas. The city is also a growing hub of software companies with several software firms located here. Given below are the employment stats and profile of industrial produce.

Table 6.4: Employment statistics*

Sector	% of working population	% of total population
Primary	4.20	2.21
Secondary	35.60	17.98
Tertiary	60.20	30.40
Total Workers	100	50.50

**City Master Plan Tirunelveli 2001 statistics*

Table 6.5: Industry profile*

Type of Industry output	% of total industrial units
Garments and other textile based	76.47
Paper and Print	5.88
Sugar	5.88
Roller Flour mill	5.88
Cement	5.88

**Tirunelveli District Collectorate*

Ecological and Forest Profile

Saturated by the perennial River Thamirabarani, Tirunelveli has fertile soils that sustain its paddy rich agricultural activities all year round enabled by the good network of irrigation systems. There are red and black soils present in abundance which are basically river drawn as it flows from the heights of the Agasthiyar Periya pothigai hills which lie to the west of the city. Besides being located in the shadow region of the Western Ghats, the lower valley region of Tirunelveli is one of the most densely populated spots in southern India.

In the district, there are more than 100 rivers and their tributaries that inundate the region making it one of the most habitable and most populous.

The total area under Forest reserves and protected ranges extends to about 1220.5 square km of which 817 square km is set apart for Tiger reserve of Mundanthurai and Kalakadu. Featuring a wide variety of flora and fauna, the forests in the district represent the biodiversity of the region spread across the foothills of Western Ghats. The table below indicates the land use pattern in the city and the green cover from latest available data sources.

Table 6.6: Land use pattern*

Sector	% of total area
Residential	11.06
Commercial	0.85
Industrial	1.99
Educational	2.20
Public and Semi Public	2.68
Transportation	6.09
Hills	2.63
Other (underdeveloped etc)	72.5

**Tirunelveli Master Plan 2005*

According to 2005 data 36 out of 55 wards had slums totalling to 68 in total and sustaining a fourth of the population at the time.

Table 6.7: Green cover*

Parks, Gardens and Open spaces	29 No.s
Water bodies	34.43 square km

6.2 Energy Profile

From the energy perspective, the district of Tirunelveli is crucial because of the energy plants located here. The Kudankulam Atomic Power Project that generates about 2000 MW of power is located here besides several wind projects which are 3622 in number and generate about 1600 MW. In addition, the abundance of rivers and water bodies enable Hydro Power Projects that have an installed capacity of 233 MW.

Nevertheless, the district also has some energy intensive industries like cement manufacturing plants, sugar cane industries and a large number of textile mills. The energy make-up of the district is hence rendered more or less equated in terms of energy production and consumption.

6.2.1 Energy Consumption Profile of Tirunelveli

Introduction

This section deals with the assessment of the energy consumption patterns in Tirunelveli city. The identification of energy sources specific to each sector in Tirunelveli i.e., Residential, Commercial, Industrial and Municipal is being dealt with as follows.

Total Electricity Consumption in Tirunelveli

The main source of energy consumption in Tirunelveli is electricity, albeit the usage is substantially below average city standards owing to the lower sprawl and population of the city. The data collection was a considerable issue due to fewer data points where information could be sourced from and information pertaining to liquid fuel types has been lumped in domestic and transport sector due to absence of sector-wise segregation. Following table gives the details of the data collected.

Table 6.8: Sector-wise electricity consumption in Tirunelveli

Sectorl	Electricity Consumption (Million kWh)
	2010-11
Domestic	133.96
Commercial	27.17
Industrial	100.52
Municipal Sector	29.31
Total Electricity consumed	**290.96**

6.2.2 Sector-Wise energy consumption in Community sector

A. Domestic Sector

Liquid fuels like Kerosene and LPG are extensively use in the domestic sector for cooking, general lighting and heating. Following tables provides the details of consumption.

Table 4.3.9: Fuel consumption domestic sector in Tirunelveli

Fuel	2010-11
Kerosene (kL)	17033
LPG (tonnes)	43472.1

B. Commercial Sector

Information lumped under Residential sector.

C. Industrial Sector

Information lumped under Transport sector.

D. Transport Sector

Community level transport usage in Tirunelveli contributes to a considerable level of emissions of which contributions due to usage of diesel are predominant. Following table provides the details of consumption.

Table 6.9: Fuel consumption transport sector in Tirunelveli

Fuel	2010-11
Petrol (kL)	40144.16
Diesel (kL)	179477.86

E. Waste

The Corporation of Tirunelveli has recently released a tender inviting interest of contractors for construction of a dumping/landfill facility. Currently, there are no waste management centres or treatment plants in the city. According to recent estimates, the city generated 39,434 MT of waste in 2010-11 at the rate of about 110 tonnes per day. Following is the data available with the Corporation provided to ICLEI.

Table 6.10: Waste generated in Tirunelveli

Type	2007-08	2008-09	2009-10	2010-11
Solid Waste (MT/year)	24428	26184	38732	39434

6.2.3 Energy Consumption in Government sector

A. Energy used in Street Lighting

With increasing growth rate, the Corporation has increasingly invested in infrastructure as indicated by the increase in number of street lights. In 1999, when the Corporation had maintained just over 15000 street lights, the entire maintenance and operation was privatized through bidding process and has remained privatized even since. Following are the latest details of electricity consumption by street lights in Tirunelveli.

Table 6.11: Energy consumed by Street Lights in Tirunelveli

	2006-2007		2007-2008		2008-2009		2009-2010	
	Quantity (MWh)	Rate (in lacs)	Quantity (MWh)	Rate (in lacs)	Quantity (MWh)	Rate (in lacs)	Quantity (MWh)	Rate (in lacs)
Street Lights	9.24	280.00	9.41	285.00	9.80	297.00	9.97	302.00

Table 6.12: Equipments used for street lighting

Equipment	Number
40 watts tube lights	12231
70 watts SV lamps	833
250 watts SV lamps	2824
250 watts MHL fittings	71
400 watts MHL fittings	418
150 watts SV lamps	3414
250 watts CF lamps	616
High mast (400 watts SVL fittings)	23

B. Energy used on Water Supply and Sewerage pumping

Water supply from the perennial River Thamirabarani is the main source of water for Tirunelveli city residents and industries. The water is conveyed through pumping stations which fill overhead tanks and are then used by the citizens. Although there is enough water, the current level of infrastructure does not allow satiation of the growing demand for water in the city. Following are the details describing the electricity expended on water supply to the city and sewerage pumping from the city.

Table 6.13: Energy used in Water Supply and Sewerage pumping in Tirunelveli

Particulars	2006-2007	2007-2008	2008-2009	2009-2010
	Quantity (MU)	Quantity (MU)	Quantity (MU)	Quantity (MU)
Water supply	12.100	12.22	12.27	12.32
Sewerage Pump stations	3.9	3.97	4.02	4.07

(Source: ICLEI 2012)

C. Energy used in Corporation buildings and facilities

Corporation of Tirunelveli administers its responsibility from its headquarters located at Swami Nellaiapper High Road. The main use of electricity in the building and facilities is for power the lighting and air conditioning equipment and various other office equipments. Besides these uses, the Corporation powers public places like parks and precincts, government schools and hospitals etc. The following table indicates the electricity usage for these activities and the related rates of usage.

Table 6.14: Energy used in Corporation buildings and facilities

Particulars	2006-2007	2007-2008	2008-2009	2009-2010
	Quantity (MU)	Quantity (MU)	Quantity (MU)	Quantity (MU)
Bldg and Facilities	2.17	2.52	2.87	2.95

(Source: ICLEI 2012)

D. Energy used in Corporation Transport

Corporation maintains vehicles in order to execute its duties like field visits, repair and maintenance etc. Tirunelveli Corporation has 4 cars that run on petrol and 56 other vehicles including 8 cars, 7 light-duty vehicles and 41 heavy-duty vehicles that run on diesel. There are an additional 21 vehicles like Lorries, container vehicles, tractors etc that assist the Corporation public health workers in waste management services around the city. Following table lists the estimates of fuel costs.

Table 6.15: Corporation vehicle characteristics

	No. of vehicles	2006-2007	2007-2008	2008-2009	2009-2010
		Rate (Rs in lacs)	Rate (Rs in lacs)	Rate (Rs in lacs)	Rate (Rs in lacs)
Petrol	4	3.74	3.85	4.12	4.58
Diesel	77	125.13	147.23	194.32	115.42

(Source: ICLEI 2012)

Based on the rate of fuel in 2010, the amount of fuel used in kilo Liters can be found. This calculation is indicated in the following table.

Table 6.16: Fuel usage by Corporation vehicles

Fuel type	Total cost (Rs in Lacs)	Cost of fuel per liter (Rs/Liter)	Fuel Usage (kL)
Petrol	4.58	51.59	8.8
Diesel	115.42	37.78	305.5

*

6.3 GHG Emissions Inventory of Tirunelveli

Based on this inventory, the total emissions from the city for the year 2009-2010 were 794147.37 tonnes of carbon dioxide equivalents (CO_2e). In instances where data is unavailable from the same year, comparative analysis between sectors may not possible. However, from the data presented here it can be clearly seen that the amount of emissions

from municipal activities was much lower indicating carbon efficiency of the Corporation activities.

Community level GHG emissions

The total emissions from the Community sector in Tirunelveli is 794147.37 tCO_2e

Table 6.17: Community level Carbon Emissions (tCO2e)

Sector	Equiv. CO_2 tonnes
Residential	174089
Commercial	20.70
Industrial	76.71
Transport	602027
Waste	17933.08
Total Community level Emissions	794147.37

Residential

The residential sector GHG emissions were 174089 tonnes with LPG fuel type contributing the most to the overall value. The details of residential emissions are given below. Please note that this includes fuel usage (LPG and Kerosene) from commercial sector as well.

Table 6.18: Residential Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Electricity	102.24	0.06
LPG	129,942.00	74.64
Kerosene	44,045.61	25.30
Subtotal Residential	174,089.84	100.00

Commercial

Due to unavailability of fuel data based on sector-wise usage data collection and inventory has been altered in order that the amount of LPG and Kerosene used in the city is lumped under the Residential sector. Hence, emission source types besides Electricity are not included in this sector for the sake of clarity in calculations:

Table 6.19: Commercial Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes
Electricity	20.70
Subtotal Commercial	**20.70**

Industrial

Due to unavailability of fuel data based on sector-wise usage data collection and inventory has been altered in order that the amount of Petrol and Diesel used in the city is lumped under the Transport sector. Hence, emission source types besides Electricity are not included in this sector for the sake of clarity in calculations:

Table 6.20: Industrial Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes
Electricity	76.71
Subtotal Industrial	**76.71**

Transport

The transportation sector GHG emission was 602027 tonnes. Following table lists the emissions attributed to this sector. Please note that this includes fuel usage (Petrol and Diesel) from industrial sector as well.

Table 6.21: Transport Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes
Diesel	99556.65
Petrol	502470.39
Subtotal Transport	**602027.04**

Waste

Tirunelveli Corporation has a proposal for installation of a disposal center as part of its waste management activities. The Corporation has extended tenders in September last year for creation of 130 M.T. capacities STP at Ramayanpatti which is spread over an area of 65 acres. (More to be added) The following emissions calculation is based on the latest data obtained from the Corporation.

Table 6.22: Waste Greenhouse Gas Emissions (2010-11)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Municipal Solid Waste	1,126.69	100
Subtotal Waste	1,126.69	100

Government Level GHG emissions

The total emissions arising from Corporation activities are about 900 tonnes of CO_2 with a large part on account of fossil fuel use in Corporation owned transport. Following table gives details of the activities and their related emission calculations for the latest data that could be availed from the authorities.

Table 6.23: Government level Carbon Emissions (tCO_2e)

Sector	Equiv. CO_2 tonnes	% of total emissions
Facilities	20.12	2.24
Buildings	2.25	0.25
Transport	877.11	97.51
Total Government level Emissions	**899.47**	**100**

Facilities

Facilities like illumination of public precincts through street lights and traffic lights are some of the service that the Corporation is responsible and that generates greenhouse gasses. Water supply and sewerage pumping are other activities that cause emissions. Following table details the activities and the emissions arising from each.

Table 6.24: Facilities Greenhouse Gas Emissions (2008-09)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Street lighting	7.61	37.82
Water supply	9.40	46.74
Sewerage pump stations	3.11	15.44
Subtotal Facilities	**20.12**	**100.00**

Buildings

Corporation buildings and the equipments therein also become a source of GHG emissions when powered through electricity. The following table details the relevant emissions from this activity.

Table 6.25: Buildings Greenhouse Gas Emissions (2009-10)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Illumination	2.25	100
Subtotal Buildings	**2.25**	**100**

Transport

In Tirunelveli, the emissions due to Corporation owned transport are mostly due to diesel than petrol. Details of this are provided in the table below.

Table 6.26: Transport Greenhouse Gas Emissions (2008-09)

	Equiv. CO_2 tonnes	Equiv. CO_2 %
Petrol	21.82	2.49
Diesel	855.28	97.51
Subtotal Transport	**877.11**	**100.00**

6.4 Suggested Low Carbon action plans

6.4.1 Renewable Energy Resource Assessment

A preliminary assessment has been done for solar, wind and biomass resources and energy recovery potential from municipal solid waste and sewage treatment plant. While biomass data is for entire Tirunelveli district, there is no hydro potential in the city.

6.4.2 Solar Radiation

Tirunelveli (Latitude 8.43 N, Longitude 77.42 E) receives good amount of solar radiation owing to its southern location in the Indian peninsula.

Table 6.27: Monthly Averaged Insolation Incident on a Horizontal Surface (kWh/M²/Day)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NASA SSE Satellite	4.84	5.58	6.14	5.51	5.31	4.46	4.53	4.87	5.13	4.42	3.97	4.43
MNRE Solar Resource	5.52	6.14	6.24	5.59	5.57	4.82	4.70	5.07	5.04	4.02	3.71	4.60

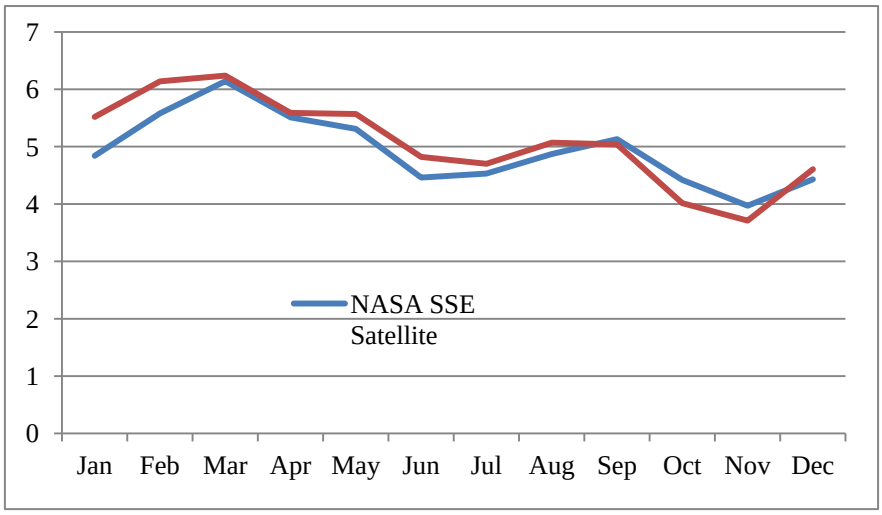


Figure 6.2: Annual Solar Radiation profile in Tirunelveli

6.4.3 Wind Energy

Wind energy data for Tirunelveli is presented in the table below. Generally, average TMCual wind speeds of at least 4.0-4.5 m/s are needed for a wind turbine to produce enough electricity to be cost-effective. From the wind data available, there seems to be enough potential for wind energy in Tirunelveli. Detailed Study is required for assessment of energy generation potential from wind resource

Table 6.28: Designated wind sites near Tirunelveli city

Site Name	Latitude		Longitude		Elevation in meters	Mean annual wind speed at 20m/25m in m/sec	WPD at 20m/ 25m	WPD at 50m in W/sqm
	Deg	Min	Deg	Min				
Panakudi	8	19	77	33	20	6.36	366	469
Mangalapuram	9	3	77	22	20	6.19	312	423
Achankuttam	8	57	77	29	20	5.17	270	397
Kalunir Kulam	8	55	77	27	50	6.60	390	390
Sankaneri	8	12	77	40	25	6.28	258	388
Kumarapuram	8	16	77	34	25	6.11	288	385
Kannankulam	8	9	77	35	25	5.92	238	375
Gangaikondan	8	51	77	46	25	5.11	246	338
Ovari	8	17	77	52	20	5.08	160	221

Source: www.windpowerindia.com/

6.4.4 Biomass Resource

Biomass resource for Tirunelveli city is not available separately. However, the data is available at district level and presented in the table. Major agricultural products of the district are Paddy, Maize, Coconut and Urad grains. Though the potential of power

generation for biomass is estimated to be 74.6 MWe for the entire district, apparently there is no potential of power generation from biomass within the Tirunelveli city.

Table 6.29: Biomass Resource

District	Area (kHa)	Crop Production (kT/Yr)	Biomass Generation (kT/Yr)	Biomass Surplus (kT/Yr)	Power Potential (MWe)	Biomass Class
Tirunelveli	100.2	734.6	1095.3	426.5	55.1	Agro
Tirunelveli	162.8	NA	211.2	139.4	19.5	Forest & wasteland

6.4.5 Small Hydro Power

As per MNRE, there are 14 sites for small hydro power projects up to 25 MW already commissioned and more than 100 under proposal for future development within Tamil Nadu state. The table gives the details of two major sites.

Table 6.30: Small Hydro Power Projects

Name of Project	River	Capacity (kW)
Servalar SHP	Servalar	20000
Vaigai SHP	Vaigai	6000

6.4.6 Waste generation

Waste generation data for Tirunelveli Municipal area for the last 5 year is presented in the table given below. No segregation was available.

Table 6.31: Solid Waste Generation Data

Year	Solid waste Generation (MT/year)
2006-2007	23352 M.T
2007-2008	24428M.T
2008-2009	26184 M.T
2009-2010	38732 M.T
2010-2011	39434 M.T

6.4.7 RE Strategy for Residential sector

The residential sector in Tirunelveli is the largest consumer of electricity. The residential sector roughly consumes 46% of total electricity consumption of 290.91 MU in Tirunelveli city. However, in comparison to the consumption and subsequent emissions from use of LPG and Kerosene in residential sector, electricity contributed only a mere fraction towards emissions. The total emissions share of this sector was about 22% to overall emissions value. LPG is the major fraction 76.64% of energy consumed by the residential sector. Use of renewable system to cater a part of energy demand in residential sector can substantially reduce fossil fuel consumption and green house gas emissions. Different renewable energy options have been proposed based on technology available and economic feasibility. Only those renewable energy devices are recommended which are technically proven, commercially available and attractive in terms of financial benefit from energy savings.

(i) Installation of Solar Water Heating System

The target in 5 years for introduction of SWHs is set at 80% of residential consumers who are already using electric geysers for their daily hot water requirement. Introduction of solar water heating system could save up to 16.5MU energy per year. Cost implication and energy savings potential is presented in the table below.

Table 6.32: Target for SWHs installation in Tirunelveli City

Particulars		Unit
Total Residential household	125378	Nos.
Total Residential household after being accounted for in apartments	119258	No.s
Residential household using geysers	11%	
Target to replace electric geyser by SWH in 5 years	80%	
Average size of domestic SWH (2 sqm collector area)	100/125	LPD
Number of SWH to be installed in five years	10495	Nos.
Total collector area in sqm	20989	Sqm
Total energy saved in five years	16.5	MU
Indicative cost of installation	2623.68	Lakh
MNRE subsidy @Rs.3300.00 per sqm	692.65	Lakh
Cost of energy savings	578.52	Lakh
Payback period	3	years
Emission reduction per year	13389	Tonnes

(ii) Use of Solar cookers (Box and dish type)

Both box type 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. It however cannot be used for frying or chapatti making. It is durable and simple to operate. 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. The temperatures attained with this cooker are sufficient for roasting, frying and boiling. Regular 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. Setting a target of 15% residential consumer to adopt solar cooker (75% box type and 25% dish type) in the 5 years period, a total of 0.40 million kg of LPG could be saved by reducing 1378 tonnes of GHG from Tirunelveli City (considering specific emission from LPG as 0.24 kg CO2 per kWh).

Table 6.33: Target for introducing solar cooker in Tirunelveli City

Particulars		Unit
Total Residential household	125378	Nos.
Household having facility to install a solar cooker	30%	
Target for introducing of solar cooker in 5 years	15%	
Number of Solar Cooker to be installed in 5 years plan	5642	Nos.
Average savings of LPG domestic cylinder per year per solar cooker (14kg)	5	Nos.
Total LPG saved in five years	394941	kg
Total energy saved in five years	5.74	MU
Indicative cost of installation (75% box type & 25% SK-14)	148.10	Lakh
MNRE subsidy for solar cooker @30%	44.43	Lakh
Cost of energy savings	98.74	Lakh

Particulars		Unit
Payback period	1.05	years
Emission reduction in five years	1378	Tonnes

(iii) Solar lanterns to replace kerosene lamps

Solar lantern has the average capacity of providing three 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 in Tirunelveli particularly during load shedding hours and assuming that 8% of population use kerosene lanterns during load shedding to illuminate their houses. Average consumption of kerosene per household is 3 liters per month. Assuming a household uses 3-4 lanterns, consumption of one lantern will be about 3-4 liters per month. Targeting 15% of population to replace at least one kerosene lantern with solar about 0.05 million liters of kerosene could be saved reducing 138 tonnes of GHG per year. Detailed techno-commercial is provided in the table below.

Table 6.34: Target for introducing solar lanterns in Tirunelveli City

Particulars		Unit
Total Residential household	125378	Nos.
Residential household use kerosene lamps	8%	
Target to replace kerosene lamp in 5 years	15%	
Number of SL to be installed in 5 years plan	1505	Nos.
Total kerosene lamp replaced	1505	Nos.
Indicative cost of installation	45.14	Lakh
Kerosene saved	54163	Liters
Savings in terms of Electricity	0.54	MU
Cost of kerosene savings	10.83	Lakh
MNRE subsidy @Rs.81.00 per Wp	12.19	Lakh
Payback period	3.0	years
Emission reduction per year	138	Tonnes

(iv) Use Solar Home Systems (SHS)

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 capacities 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 by 8% population in Tirunelveli 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 3 liters per month per household. Assuming 20% replacement in the planned 5 years period an estimated amount of 315 kiloliters of kerosene could be saved reducing 801 tonnes of GHG emission from the city. The potential of kerosene replacement with Solar Home Systems and financial implication thereon is indicated in the table below.

Table 6.35: Target for introducing solar home system in Tirunelveli City

Particulars		Unit
Capacity of residential Solar Home System	74	Wp
Number lights per Solar Home System	4	Nos.
Number of Kerosene lamp replaced by SHS	4	Nos.
Consumption of kerosene per household/month	13	Liters
Cost of kerosene per liter in the market	20	INR
Cost of kerosene per year per household	3144	INR
Indicative cost of installing a SHS	16000	INR
MNRE subsidy @Rs.81.00 per Wp	5994	INR
Payback period when replacing the kerosene lamps	3.2	years

Particulars		Unit
Total Residential household	125378	Nos.
Residential household use kerosene lamps	8%	
Target to replace kerosene lamp in 5 years	20%	
Number of SHS to be installed in 5 years plan	2006	Nos.
Total kerosene lamp replaced	8024	Nos.
Indicative cost of installation	320.97	Lakh
Kerosene saved	315	KL
Savings in terms of Electricity	3	MU
Cost of kerosene savings	63	Lakh
MNRE Subsidy @Rs.81.00 per Wp	120	Lakh
Payback period	3.2	years
Emission reduction in five years	801	Tonnes

(v) Using Solar PV for Home Inverters

Use of solar panels to charge Home Inverter system could be an attractive option as standby power supply system during load shedding hours. The power supply situation in Tirunelveli is very poor. About 6-7 hours load shedding occurs per day in most of the places of Tirunelveli city. About 52% of residential consumer use inverters during load shedding hours. Assuming that 13% of households who are already using inverters will adopt the 250 Wp solar PV systems to charge their inverter battery, an aggregate of 611 kWp solar PV systems could be installed in the residential buildings, which will generate 1 MU green energy per year and reduce the load demand and emission by 743 tonnes per year. It is assumed that MNRE will provide Rs. 57 per Wp in 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 6.36: Target for introducing Solar PV for Home Inverters in Tirunelveli City

Particulars		Unit
Capacity of solar PV system for Home Inverter	250	Wp
Indicative cost of incorporating Solar PV to Home Inverter	43750	INR
Total Residential household	125378	Nos.
Residential household use Inverter during load shedding	13%	
Target to introduce solar charger for inverter in 5 years	15%	
Number of solar inverter to be installed in 5 years plan	2445	Nos.
Total PV capacity installed	611	kWp
Total Energy generated by PV arrays in five years	1	MU

Particulars		Unit
Cost of energy saved	32	Lakh
Indicative cost of installation	1070	Lakh
MNRE subsidy @Rs.57.00 per Wp	348	Lakh
Payback period	22	years
Emission reduction in five years	743	Tonnes

(vi) Using Solar PV for replacement of DG/ Kerosene Generator sets

Due to poor power supply situation, assuming that about 6% of resident of Tirunelveli use typically 5-10kW DG/ kerosene 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 Tirunelveli. 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 572 kilo liters of diesel per year reduce GHG in the tune of 1454 tonnes per year.

Table 6.37: Target for replacement of diesel generator sets with PV Power Pack in Tirunelveli City

Particulars		Unit
Capacity of solar PV system	1	kWp
Indicative cost of incorporating Solar power pack	2.60	Lakh
Total Residential household	125378	Nos.
Total Residential household after being accounted for in apartments	119258	Nos.
Residential household use generators during load shedding	6%	
Target to introduce solar power pack in 5 years	10%	
Number of solar power pack to be installed in 5 years plan	716	Nos.
Total PV capacity installed	716	kWp
Total Energy generated by PV arrays in five years	1.07	MU
Typical generator set used	5-10	kW
Average fuel consumption per day for 4-6 hours load shedding	4	liters
Amount of diesel saved in five years for entire city	572	KL
Cost of Diesel saved	228.98	Lakh
Indicative cost of installation	1860	Lakh
MNRE subsidy @Rs.57.00 per kWp	408	Lakh
Payback period	6.34	years
Total Emissions reduction in five year for replacement of diesel	1454	Tonnes

(vii) RE systems for residential Apartments/ housing complexes

The number of apartment buildings and residential complexes in Tirunelveli are much less compared to Coimbatore and Trichy. Also, since the data for number of apartments in the city was unavailable some indicative renewable energy technologies that can be introduced to reduce and limit carbon emissions from residential apartments are SWH systems and Solar PV packs for back up. The scale of implementation remains directly proportional to quantum of investment available from different sources and the number of consumers.

(viii) Summary of RE strategy for Residential Sector

Implementation of renewable energy projects as proposed above will save 27.98MU energy per year, which will reduce GHG of 17902 tonnes per year. When the target is, residential sector strategy will meet 5.8% of total target for energy savings for the city as

per mandate of development of solar city. The entire target could be achieved with a total investment of about Rs.6068 lakh in the 5 years period where contribution from MNRE will be about Rs.1626 lakh with existing schemes and balance fund could be met from users, state or other funding agencies. It is recommended that promotion of solar water heaters in residential sector should be given higher priority, as energy savings from solar water heaters is the highest.

Table 6.38: Summary of RE Strategy for Residential sector in Tirunelveli City

RE Strategy for residential sector	Potential Users	Target Capacity	Units of Target	Investment (Lakh)	MNRE subsidy (Lakh)	Beneficiary's contribution (Lakh)	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)	% contribution to target
Solar water Heaters	13792	10495	Nos.	2624	693	1931	16.53	13389	3.43%
Solar cookers	37613.4	5642	Nos.	148	44	104	5.74	1378	1.19%
Solar Lantern	10030	1505	Nos.	45	12	33	0.54	138	0.11%
Solar Home System	10030	2006	Nos.	321	120	201	3.17	801	0.66%
Solar Home inverter	16299	2445	Nos.	1070	348	721	0.92	743	0.19%
PV for replacing DG sets	7523	716	Nos.	1860	408	1453	1.07	1454	0.22%
SWHS for Residential Apartment	0	0	LPD	0	0	0	0.00	0	0.00%
PV for Residential Apartment	0	0	kWp	0	0	0	0.00	0	0.00%
				6068	**1626**	**4442**	**27.98**	**17902**	**5.80%**

6.4.8 RE Strategy for Commercial and Institutional Sector

The commercial sector has a lower contribution to the total energy consumption in Tirunelveli city. The sector consumes about 9.3% of total electricity consumed in the city with its 18 colleges and institutes, 32 schools, 43 private medical service facilities, 40 hotels. Different strategies are prepared for different categories of consumers based on type and quantum of energy consumed and availability of resource and space to generate renewable energy in their premises. While preparing the strategy, only techno economically viable and commercially available renewable energy options are considered.

RE Strategy for Hotels

There aren't any big hotels in Tirunelveli as most commercial accommodation facilities are smaller in size with only a handful being 2 or 3 star hotels or budget establishments. Major energy requirement such as hot water and electricity during load shedding hours

could be met by solar energy. Solar thermal systems can be used to generate hot water or steam for cooking. Solar PV power systems can be used to reduce or eliminate use of diesel generators which are being used during load shedding hours. Since a clear budget based classification couldn't be obtained, techno-commercial calculations for hotels haven't been performed. Nevertheless, similar calculations in Coimbatore and Trichy action plans should suffice to undertake projects in the hotel industry in Tirunelveli city.

Renewable Energy Systems for Restaurants

Tirunelveli has only a few restaurants and eateries that mostly comprise of street corner establishments and small restaurants called Dhaba or Mess catering to the lower middle class and middle class of the city. Solar water heaters can easily be introduced in these small restaurants to meet their hot water demand for cooking and utensil cleaning. Cart food is very popular in Tirunelveli. There are hundreds of food cart which use kerosene or gas operated lights for illumination. Solar Lanterns will be a profitable and attractive option for these food cart operators.

Renewable Energy Systems for Hospitals

The Tirunelveli city has 5 Corporation maintained dispensaries, 8 urban health posts and 3 maternity homes and some private hospitals as well whose number could not be ascertained. Since a segregation based on number of beds also could not be found, a general summary is being illustrated without case examples to offer an insight on the potential implementation of renewable energy systems for the health sector in Tirunelveli city. Targeting a 50% target to introduce renewable energy systems in hospitals in the city, total energy savings of 0.59MU and emissions reduction of 505 tonnes of CO_2 can be achieved.

Table 6.39: Summary of RE systems for Hospitals

Hospitals	Number of Establishment	RE System Proposed			
		Solar Water Heating System (LPD)		Solar PV System (kWp)	
		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity
Urban Health Posts	8	2000	16000	2	16
Maternity Homes	3	10000	30000	5	15
Corporation Dispensaries	5	5000	25000	10	50
Aggregate	16		71000		81
Target in 5 years		50%	35500	50%	41
Energy Savings (MU)			0.53		0.06
Total Emission reduction			453		52

Renewable Energy Systems for Educational Institutes

Educational institutes are major establishments in the commercial sector of a city. Although they are not major source of energy consumption in the city yet they account for a substantial degree of energy utilization. An informal survey revealed the following

figures of educational institutes in Tirunelveli. The city has 32 schools of which 22 are elementary schools, 5 are middle and 5 higher secondary schools. There are a total of 150 colleges including arts, science and engineering. The institutes having hostels can use solar water heater to supply hot water to the bath rooms and the kitchen thereby providing bathing comfort to the students and hot water for cooking.

The two renewable energy options can effectuate a considerable energy saving in educational institutes are the solar water heaters and solar PV systems. The potential for energy savings in different educational institutes in Tirunelveli is tabulated below. The figures give a gross idea about the financial implications and emission reductions rendered by installation of the aforementioned renewable energy systems.

Table 6.40: Summary of RE strategy for educational institutes

Educational Institutes	Number of Establishment	RE System Proposed							
		Solar Cooker/ Steam generating system for Cooking (sqm collector area)		Solar Water Heating System (LPD)		Solar PV System (kWp)		Biogas System (CuM)	
		Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Unit Capacity	Total Capacity	Unit Capacity	Total Capacity
Elementary schools	22	20	440	0	0	1	22	0	0
Middle Schools	5	0	0	0	0	2	10	0	0
Higher Secondary Schools	5	0	0	0	0	2	10	0	0
Colleges (Arts, Science, Engineering)	150	200	30000	10000	1500000	10	1500	20	3000
Aggregate	182		30440		1500000		1542		3000
Target in 5 years		25%	7610	25%	375000	25 %	386	25%	750
Energy Savings (MU)			4.95		5.63		0.58		1.59
Total Emission reduction			4205		4781		492		1353
Investment (Lakh INR)		15000	1142	200	750	1.75	675	15000	113

(i) Summary of RE strategy for Commercial and Institutional Sector

The suggested implementations as described above are able to achieve about 3% reduction in total energy savings through the RE strategies for commercial and institutional sector. The strategy, once implemented fully will save 13.33 MU of energy per year and reduce 11334.63 tonnes of GHG emissions per year. The primary focus should be given to introduction of solar water heaters which will save 6.16MU per year. Solar PV power plant should be introduced for diesel abatement in the establishments that are using diesel sets as standby power supply source.

Table 6.41: RE Strategy for Commercial and Institutional Sector

RE Strategy for Commercial and Institutional sector	Units	Target Capacity	Total Investment (Lakh INR)	MNRE subsidy (Lakh INR)	Sate/ NMC/ Beneficiary's contribution	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Solar Steam Cooker for Cooking in Schools, Hostels	sqm	7610	1141.50	410.94	730.56	4.95	4204.53
Solar Water Heaters for Hospitals	LPD	410500	821.00	270.93	550.07	6.16	5233.88
Solar PV Power Plant for Hotels, Hospitals.	kWp	426	745.50	242.82	502.68	0.64	543.15
Biogas for Hotels	CuM	750	112.50	78.75	33.75	1.59	1353.08
Total			**2820.50**	**1003.44**	**1817.06**	**13.33**	**11334.63**

6.4.9 RE Strategy for Industrial Sector

The industry sector in Tirunelveli consumes 36% of total electricity. Most industries are small or medium scale. As data regarding the exact number and classification of industries was not verifiable, typical measures based on the scale of industrial establishment-are described below to facilitate implementations in the industrial sector in Tirunelveli city.

Table 6.42: Indicative measures for industrial sector

Industry Scale	Indicative Industry type	Typical measures
Small scale	Food based cottage industry, Textile and dyeing units	Solar Water Heating, Solar Lanterns etc.
Medium scale	Textile plants, Paper and food processing industry, Metal casting units	Solar Water Heating, Solar PV systems, Solar Cooking/Steaming systems etc.
Large scale	Cement plants, Machinery and beverage industry	Solar Water Heating systems, Solar PV systems, Biomass systems etc.

6.4.10 RE Strategy for Municipal Sector

The municipal sector of Tirunelveli city consumes 26% of total electrical energy in the city. The primary consumers in this sector are street lights, outdoor lights in parks, markets, office buildings of the Municipal Corporation, advertising hoardings, water supply, sewerage treatment plant etc. Renewable energy devices are suggested to all categories of consumers depending upon the energy demand. The sector has ample opportunity to save energy through introducing renewable energy and energy conservation measures and could show case these initiatives to encourage people to adopt further.

(i) Renewable Energy System for Municipality building and other Office Buildings

The official municipal corporation buildings consume in total about 2.95 MU of electricity per year. The loads consume most of the energy are air conditioners, fans and lighting loads. A 10kWp PV Power plant is recommended for each of the five official buildings to supply power during load shedding hours.

(ii) Renewable Energy System for Markets

There are 4 main markets in Tirunelveli which included 3 weekly and one daily market. Primarily the shop owners use electricity to power the electrical equipments like bulb, tube lights, fans, Acc etc. Taking the note of load shedding in the city and the increasing bill of diesel fuel for generators, some suggestions for RE technologies for the commercial shops are provided, which if implemented will result in substantial reduction in conventional energy and the resultant emissions.

(iii) RE System for Outdoors lighting (Streets, Traffic, Road safety etc.)

The city has about 12231 outdoor lights, which have been fixed for illumination of streets, wards, etc. The objective is to introduce one solar PV outdoor light in every three conventional lights so that minimum illumination level is maintained during load shedding hours. The tables below indicate targets, investment thereon and energy savings potential etc.

Table 6.43: Summary of RE Strategy for Municipal sector

Particulars	Numbers	RE System Proposed		
		Solar Water Heating System (LPD)	Solar PV System (kWp)	Biogas System (Cu m)
		Total Capacity	Total Capacity	Total Capacity
Municipal office buildings	5	0	50	0
Parks, recreation centres maintained by the corporation	142	0	1420	0
Hospitals, clinics maintained by the corporation	18	36000	90	0
Schools maintained by the corporation	32	0	160	0
other buildings/sites	66	0	330	0
Bus Stands and shelters	72	0	360	0
Kaliyanamandapam	3	15000	15	60
Commercial Complexes	5	0	50	0
Daily Market	1	0	5	10
Weekly Market	3	0	6	30
Pay and use toilets	213	0	426	1065
Reading Rooms	29	0	29	0
Aggregate	560	51000	2941	1165
Target in 5 years		10200	588	117
Energy Savings (MU)		0.15	0.88	0.25

Total Emission reduction		130	750	210

6.4.11 EE Strategy for Residential sector

Residential sector consumes largest amount of energy. Important proven and cost effective measures for the sector are described in this section. Based on the survey, it was found that incandescent lights are still used a lot in the residential sector. Utilizing the survey data the savings due to replacement of incandescent lamps with CFL are calculated and are presented in the table below.

(i) Replace Incandescent Lamps with Fluorescent

Incandescent bulbs are the major and the most common source of high energy consumption in the residential area. Replacement of incandescent lamps has acquired a substantial precedence in all the energy efficiency strategies as the most feasible option. The techno commercial for replacement of incandescent bulbs with CFL is given below. An assumption of 42% households utilizing CFLs has been considered as target group for replacements and 100% replacement is assumed for the calculations below.

Table 6.44: Replacement of incandescent lamps with fluorescent

Particulars		Unit
Total Residential household	125378	Nos.
Household using incandescent bulb	42%	
Target to replace incandescent bulb with CFL	100%	
Number of incandescent bulb to be replaced per household	4	Nos.
Total number of incandescent bulb to be replaced	208850	Nos.
Indicative cost of installation	313	Lakh
Energy saved by replacing 60W bulb with 15W CFL	20582134	kWh
Cost of electricity savings	720	Lakh
Payback period	0.43	years
Emission reduction per year	16672	Tonnes

(ii) T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast

A conventional tube light (with magnetic ballast consuming 15W) consumes around 55 watts. It can be replaced with T5 tube (28W) with electronic ballast (4W) which will require around 32W. The calculations have been done for a period of 5 years assuming 80 % replacement of T 12 /T8 tube lights can be possible in 83% of the households using T12/T8 tube lights.

Table 6.45: T5 tube light + Electronic Ballast to replace T12/T8 tube light+ Magnetic Ballast

Particulars		Unit
Total Residential household	125378	Nos.
Household using T8/T12 tube lights	94%	
Target to replace T8/T12 by T5 tube lights	80%	
Number of T8/T12 to be replaced per household	2	Nos.
Total number of T8/T12 tube lights to be replaced	188402	Nos.
Indicative cost of installation	942	Lakh
Energy saved by replacing T8/T12(with magnetic ballast)	6326539	kWh

Particulars		Unit
with T5 (with electronic ballast)		
Cost of electricity savings	221	Lakh
Payback period	4.25	years
Emission reduction per year	5124	Tonnes

(iii) Efficient ceiling fans to replace conventional ceiling fans

Replacing conventional fans with star rated fans can save substantial amount of electrical energy and money. The financial and technical analysis for replacement of conventional ceiling fans in residential sector of Tirunelveli city assumes that 50% replacement should be possible in almost 91% of the households.

Table 6.46: Efficient Ceiling Fans to Replace Conventional Ceiling Fans

Particulars		Unit
Total Residential household	125378	Nos.
Household using Conventional Fans	91%	
Target to replace Conventional fans by EE Fans	50%	
Number of Conventional fan to be replaced per household	3	Nos.
Total number of Conventional Fans to be replaced	171976	Nos.
Indicative cost of installation	2580	Lakh
Energy saved by replacing Conventional Fans by EE Fans	9286703	kWh
Cost of electricity savings	325	Lakh
Payback period	8	Years
Emission reduction per year	7522	Tonnes

(iv) Replacement of conventional air-conditioners with EE star rated ACs

In Tirunelveli city it is assumed that approximately 14% of residential households had 1.5 ton air conditioners on average. The energy consumption by a 1.5 ton unit is approximately 7.2 kWh per day. For calculating the energy savings by switching to more energy efficient air conditioners it is assumed that 14% households in Tirunelveli owns an air –conditioner and 10% air conditioners can be assumed as potential target for replacement with energy efficient ACs.

Table 6.47: Replacement of conventional air-conditioners with EE star rated ACs

Particulars		Unit
Total Residential household	125378	Nos.
Household using Conventional AC	14%	
Target to replace Conventional ACs by EE star rated AC	10%	
Number of Conventional ACs to be replaced per household	1	Nos.
Total number of Conventional ACs to be replaced	1701	Nos.
Indicative cost of installation	468	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	689059	kWh
Cost of electricity savings	24	Lakh
Payback period	19	Years
Emission reduction per year	558	Tonnes

(v) Replacement of conventional refrigerators with EE star rated refrigerators

One of the most common appliance used in homes are the refrigerators. With increasing affordability refrigerators have become an indispensable item in most Indian households. They come in the capacity range of 200-400 liters. These days many BEE star rated energy efficient refrigerators are available in the Indian market. A conventional refrigerator of 200 watts has been taken to provide the calculations below. An assumption of 59% households with conventional refrigerators is taken to show the energy savings.

Table 6.48: Replacement of Conventional Refrigerators with EE Star Rated Refrigerators

Particulars		Unit
Total Residential household	125378	Nos.
Household using Conventional Refrigerators	59%	
Target to replace Conventional Refrigerators by EE Star Rated Refrigerators	10%	
Number of Conventional Refrigerators to be replaced per household	1	Nos.
Total number of Conventional Refrigerators to be replaced	7392	Nos.
Indicative cost of installation	832	Lakh
Energy saved by replacing Conventional Refrigerators by EE Star Rated Refrigerators	3503766	kWh
Cost of electricity savings	123	Lakh
Payback period	6.8	Years
Emission reduction per year	2838	Tonnes

(vi) Replacement of conventional water pumps with EE star rated water pumps

Survey in Tirunelveli has shown that residential households use water pumps of 1.5 HP capacity which has an approximate electrical consumption of 2.2 kWh. Assuming 45% households in Tirunelveli use water pumps, 20% replacement of conventional pumps by energy efficient pumps have been targeted for energy savings.

Table 6.49: Replacement of conventional water pumps with EE star rated water pumps

Particulars		Unit
Total Residential household	125378	Nos.
Household using Water Pumps	45%	
Target to replace Conventional Water Pump by EE Pump	20%	
Number of Conventional Pumps to be replaced per household	1	Nos.
Total number of Conventional Pumps to be replaced	15723	Nos.
Indicative cost of installation	314.45003	Lakh
Energy saved by replacing Conventional Water Pumps by EE Water Pumps	1721614	kWh
Cost of electricity savings	60.26	Lakh
Payback period	5.22	Years
Emission reduction per year	1395	Tonnes

(vii) Summary of EE Strategy in Residential Sector

The estimated potential of energy savings in the residential sector through energy efficiency measures is 42 MU per year. The reduction of emission through EE measures in

residential sector is 34109 tonnes per year. Replacement of incandescent bulbs with CFL, conventional fans, refrigerators and air conditioners with star rated one have the most potential scope for energy savings.

Table 1 : Summary of EE Strategy in Residential Sector

EE Measures in residential sector	Unit	Target Capacity	Investment (Lacs INR)	Amount of Energy Saved (MU)	Emissions Reductions (Tonnes)
Indicative cost of replacing 60 watt incandescent with 15 watt CFL	Nos.	208850	313	21	16672
Indicative cost of replacing T12/T8 with T5 FTL	Nos.	188402	942	6	5124
Indicative cost of replacing conventional Fans with EE star rated fans	Nos.	171976	2580	9	7522
Indicative cost of replacing conventional AC with EE star rated AC	Nos.	1701	468	1	558
Indicative cost of replacing conventional refrigerator with EE star rated refrigerator	Nos.	7392	832	4	2838
Indicative cost of installing a EE water pump	Nos.	15723	314	2	1395
Total			**5449**	**42**	**34109**

6.4.12 EE Strategy for Commercial Sector

The commercial sector comprises primarily of offices, shopping malls, markets, hotels and restaurants and comprises of a mix of air conditioned and non air-conditioned buildings. The prime load centers in the sector are air-conditioning, lighting and pumps/equipment. The major share of electricity consumption is attributed to by air-conditioning in a full conditioned building followed by lighting, whereas the prime energy consumption in a non-air conditioned building is lighting followed by space conditioning (coolers, fans, etc.).

The energy conservation and efficiency measures targeted for commercial sector thus should be aimed at enhancing efficiency levels and deploying conservation options for lighting and air conditioning. Thus efficiency and conservation have to be addressed in existing and new buildings to affect overall demand and consumption reduction.

(i) Replace Incandescent Lamps with Fluorescent

CFL usage has been widespread in the last few years and it is high time that all commercial establishments should voluntarily replace the high energy consuming incandescent lamps with CFLs. It is assumed that 16% of the commercial sector establishments use incandescent bulbs and 100% of establishment use T8/T12 tube lights. A target to replace 80% of the incandescent bulbs and the same amount of T8/T12 tube lights in the commercial sector is assumed so as to give the calculations below.

Table 6.50: Replacement of incandescent lamps with fluorescent

Particulars		Unit
Total Commercial Consumers	8861	Nos.
Consumers using incandescent bulb	16%	
Target to replace incandescent bulb with CFL	80%	
Number of incandescent bulb to be replaced per consumer	10	Nos.
Total number of incandescent bulb to be replaced	11342	Nos.
Indicative cost of installation	17	Lakh
Energy saved by replacing 60W bulb with 15W CFL	918708	kWh
Cost of electricity savings	46	Lakh
Payback period	0.37	Years
Emission reduction per year	744	Tonnes

Table 6.51: Replace T12/T8 tube light by T5 tube light

Particulars		Unit
Total Commercial Consumers	8861	Nos.
Consumers using T8/T12 tube lights	100%	
Target to replace T8/T12 by T5 tube lights	80%	
Number of T8/T12 to be replaced per consumer	2	Nos.
Total number of T8/T12 tube lights to be replaced	14178	Nos.
Indicative cost of installation	71	Lakh
Energy saved by replacing T8/T12(with magnetic ballast) with T5 (with electronic ballast)	391302	kWh
Cost of electricity savings	20	Lakh
Payback period	3.62	Years
Emission reduction per year	317	Tonnes

(ii) Replacement of inefficient fans

Analysis of the sample survey of Tirunelveli city reveals that maximum commercial establishments in Tirunelveli city have fans. Conventional fans have an average energy consumption of 1.03kWh per day. Assuming 15% of the conventional fans in the commercial sector of Tirunelveli can be replaced with more energy efficient fans the following techno-commercials have been calculated.

Table 6.52: Replacement of Conventional Fans

Particulars		Unit
Total Commercial Consumers	8861	Nos.
Consumers using Conventional Fans	99%	
Target to replace CF by EE Fans	15%	
Number of Conventional fan to be replaced per consumer	3	Nos.
Total number of Conventional Fans to be replaced	3553	Nos.
Indicative cost of installation	53	Lakh
Energy saved by replacing Conventional Fans by EE Fans	124349	kWh
Cost of electricity savings	6	Lakh
Payback period	8.57	years
Emission reduction per year	101	Tonnes

(iii) Replacement of conventional air-conditioners with EE star rated ACs

Commercial establishments are usually equipped with air conditioners. In Tirunelveli city like in most other southern cities 1.5 tons air conditioners are more popular in the commercial buildings. Assuming that 33% of the commercial establishments own an air

conditioner, 10% target replacement of inefficient air-conditioners with more efficient conditioners are taken into consideration for the below mentioned calculations.

Table 6.53: Replacement of Conventional Air-Conditioners with EE Star Rated ACs

Particulars		Unit
Total Commercial Consumers	8861	Nos.
Consumers using Conventional ACs	33%	
Target to replace Conventional ACs by EE star rated ACs	10%	
Number of Conventional ACs to be replaced per household	5	Nos.
Total number of Conventional ACs to be replaced	1475	Nos.
Indicative cost of installation	406	Lakh
Energy saved by replacing Conventional ACs by EE Star Rated ACs	597519	kWh
Cost of electricity savings	30	Lakh
Payback period	13.58	years
Emission reduction per year	484	Tonnes

(iv) Replacement of conventional refrigerators with EE star rated refrigerators

Refrigerators in commercial sector are restricted to the food outlets, restaurants, hotels, guest houses, and ice-cream parlors. General trend reveals that the refrigerators of the range of 200-400 W are found in the commercial sector of Tirunelveli City like most Indian cities. Approximately 41% of the consumers own a refrigerator and a target of replacing 10% refrigerators has been taken to show the energy saving potential of replacing conventional refrigerators in commercial sector of Tirunelveli city.

Table 6.54: Replacement of Conventional Refrigerators with EE Star Rated Refrigerators

Particulars		Unit
Total Commercial Consumers	8861	Nos.
Consumers using Conventional Refrigerators	41%	
Target to replace Conventional Refrigerators by EE Star Rated Refrigerators	10%	
Number of Conventional Refrigerators to be replaced per consumer	1	Nos.
Total number of Conventional Refrigerators to be replaced	363	Nos.
Indicative cost of installation	41	Lakh
Energy saved by replacing Conventional Refrigerators by EE Star Rated Refrigerators	172205	kWh
Cost of electricity savings	9	Lakh
Payback period	5	years
Emission reduction per year	139	Tonnes

(v) Replacement of conventional water pumps with EE star rated water pumps

About 30% of the commercial units use water pumps. If a target of 25% is made in order to replace the inefficient water pumps with efficient star rated water pumping equipments then the following techno-commercial details ensue which are calculated below.

Table 6.55: Replacement of conventional water pumps with EE star rated water pumps

Particulars		Unit

Particulars		Unit
Total Residential household	8861	Nos.
Household using Water Pumps	30%	
Target to replace Conventional Water Pump by EE Pump	25%	
Number of Conventional Pumps to be replaced per household	1	Nos.
Total number of Conventional Pumps to be replaced	930	Nos.
Indicative cost of installation	19	Lakh
Energy saved by replacing Conventional Water Pumps by EE Water Pumps	83736	kWh
Cost of electricity savings	3	Lakh
Payback period	6.35	years
Emission reduction per year	68	Tonnes

(vi) Summary of EE Strategy in Commercial & Institutional Sector

The estimated energy savings potential from commercial and institutional sector through energy efficiency measures is 2.29MU per year. Potential for GHG reduction is 1853 tonnes per year.

Table 6.56: Summary of EE Strategy in Commercial & Institutional Sector

EE Measures	Units	Targets	Investment (INR)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Indicative cost of replacing 100 watt incandescent with 15 watt CFL	Nos.	11342	17	0.919	744
Indicative cost of replacing T8/T12 tube lights with T5 FTL	Nos.	14178	71	0.391	317
Indicative cost of replacing conventional fans with EE fans	Nos.	3553	53	0.124	101
Indicative cost of replacing conventional AC with EE star rated AC	Nos.	1475	406	0.598	484
Indicative cost of replacing conventional refrigerators with EE star rated refrigerators	Nos.	363	41	0.172	139
Indicative cost of installing EE water pumps	Nos.	930	19	0.084	68
Total			**606**	**2.288**	**1853**

6.4.13 EE Strategy for Industrial Sector

Following is a list of indicative measures that can be implemented in the industrial sector as a means of achieving energy efficiency. Due to lack of verifiable data, some of the typical measures have been listed below without specific techno-commercial calculations. Similar calculations performed for the industrial sector in Trichy and Coimbatore provides the impetus for undertaking energy efficiency measures in the industrial sector in Tirunelveli city.

- Replacement of incandescent lamps with CFL
- Replacement of T8/T12 tube lights with T5 tube lights
- Replacement of conventional ceiling fans with star rated ceiling fans
- Replacement of conventional ACs with star rated ACs

Introduction of these measures depends on the actual number of conventional equipments in use and the initial targets for replacement with energy efficient equipments.

6.4.14 EE Strategy for Municipal Sector

Municipal services annually incur huge expenditures on electricity consumption to cater to the local public services. Hence energy efficiency has become crucial for municipal organizations in India, owing to the growing city needs. The Bureau of Energy Efficiency in India has already come out with the Manual for development of Municipal Energy Efficiency Projects. Energy conservation drives in the municipal corporations and councils will become an exemplary initiative for similar activities in eth city. As a high visibility and administration centre Municipal bodies across India should go ahead in implementing the strategies and replicating the success stories.

EE measures in Street Lighting

Street lighting is one of the major sources of energy consumption in municipal area. In Tirunelveli city, 40 W tube lights, 150 watt and 250 watt HPSV are mostly used as streetlights in different wards of within the jurisdiction of the Corporation.

(i) Replacement of 150 watt HPSV with 100 watt induction lamps

150 watts high pressure sodium vapor lamps are frequently used in street lighting fixture in municipal area. They can be replaced with more energy efficient induction laps available in the Indian market today. A 100% target to replace 3414 number of 150W HPSV lamps with 100 watt induction lamps is taken for Tirunelveli city, to provide the techno-economics of implementing the replacement and bringing about energy savings.

Table 6.57: Replacement of 150 watt HPSV with 100 watt induction lamps

Particulars		Unit
Total number of 150 watt HPSV	3414	Nos.
Target to replace 150 watt HPSV with 100 watt induction lamp	100%	
Total number of 100 watt induction lamp needed	3414	Nos.
Indicative cost of installation	717	Lakh
Energy saved by replacing 150 watt HPSV with 100 watt induction lamp	747666	kWh
Cost of electricity savings	37	Lakh
Payback period	19.18	years
Emission reduction per year	606	Tonnes

(ii) Replacement of 250 watt HPSV with 200 watt induction lamps

There are about 2824 number of 250 watt HPSV lamps lights used for street illumination in Tirunelveli. A replacement target of 100% is proposed with 200 watt induction lamps to improve the efficiency of the street lighting systems. Following table indicates the techno-economic analysis and energy saving such a replacement accompanies.

Table 6.58: Replacement of 250 watt HPSV with 200 watt induction lamps

Particulars		Unit
Total number of 250 watt HPSV	2824	Nos.
Target to replace HPSV lamp with Induction Lamp	100%	
Total number of 200 watt Induction Lamp needed	2824	Nos.

Particulars		Unit
Indicative cost of installation	716	Lakh
Energy saved by replacing 250 watt HPSV with 200 watt Induction Lamp	618456	kWh
Cost of electricity savings	31	Lakh
Payback period	23.15	years
Emission reduction per year	501	Tonnes

(iii) Replacement of 40 watt tube lights with 25 W LED lamps

There are 12231 number of 40 watts tube lights currently under use within different wards of the Tirunelveli Corporation area. A replacement target of 100% is proposed with 25 W LED lamps to improve the efficiency of the street lighting systems. Following table indicates the techno-economic analysis and energy saving such a replacement accompanies.

Table 6.59: Replacement of 40 watt tube lights with 25 watt LED lamps

Particulars		Unit
Total number of 40 W tube lights	12231	Nos.
Target to replace 40 W tube lights by 25 W LED lamps	1	
Total number of 25 watt LED lamp needed	22925	Nos.
Indicative cost of installation	4856	Lakh
Cost savings in lower replacement costs in 25 W LED	282	Lakh
Energy saved	1380658	kWh
Cost of electricity savings	48	Lakh
Total cost savings	330	Lakh
Payback period	14.70	years
Emission reduction per year	45.94	Tonnes

(iv) Sensors for automatic on/off of street lights

Automatic street lights ensure that energy is not wasted by lights turned on during day time. Many streetlights in India face this predicament due to faulty manually controlled street lights. Manual control involves labor costs, energy wastes and poor efficiency; hence Municipal street lights should hasten the process of installing automatic sensors. Solar sensors are the new and upcoming products in the market today and should be applied by municipalities for higher efficiency in the operation and maintenance of municipal street lights. The following scheme of power saver application has been recommended for street lights in Tirunelveli city that aren't undergoing any replacement as suggested in the previous sections:

Table 6.60: Application of 20KVA power saver packs 400W HPSV, 400W and 250W MHL and 250W CFLs

Particulars	HPSV Lamps		MHL Fittings		CFLs
Wattage	400 W (High mast SVL)	70 W	400 W	250 W	250 W
Total no. of street lights	23	883	418	71	616
Wattage (kW)	400	70	400	250	250
Load (KW)	9	62	167	18	154
Electricity Consumption (kWh)	36938	248167	671308	71266	618310
No of 25 KVA power	0.46	3.09	8.36	0.89	7.70

Particulars	HPSV Lamps		MHL Fittings		CFLs
Wattage	**400 W (High mast SVL)**	**70 W**	**400 W**	**250 W**	**250 W**
Saver Required					
Cost of each 20 KVA power saver is INR 85000	39100	262692.5	710600	75437.5	654500
Energy Saved	11081.4	74450.2	201392.4	21379.9	185493
Cost of Energy Saved (INR)	38784.9	260575.5	704873.4	74829.56	649225.5
Payback Period	1.01	1.01	1.01	1.01	1.01
Emissions Saved (in tonnes)	**8.98**	**60.30**	**163.13**	**17.32**	**150.25**

(v) Energy Efficiency Measures in Water Pumping

Proper pump-system design (efficient Pump, pumps heads with system heads)
Proper water pumping design can bring about lots of 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 and the height it needs to be raised to. 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 6.61: Proper pump-system design (efficient Pump, pumps heads with system heads)

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	12.32
Annual Energy Cost in Rs. (lacs)	431.2
Saving %	20%
Total Annual Saving in MU	2.464
Annual Saving in Rs. (lacs)	86.24
eCO_2 (Tonne) Reduction	1995.84

Installation of variable speed drivers
Dimension and adjustment losses are two of the major energy loss sources in pumping processes. Adjusting pump speed or using Variable Speed Driver to adjust speed is one way to decreasing both the aforementioned losses in pumping processes. An assumption of 5% savings is taken to provide the financial and technical details of installing variable speed drivers in municipal water pumping systems in Tirunelveli City.

Table 6.62: Variable Speed Drivers

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	12.32
Annual Energy Cost in Rs. (lacs)	431.2
Saving %	5%
Total Annual Saving in MU	0.616
Annual Saving in Rs. (lacs)	21.56
eCO_2 (Tonne) Reduction	498.96

Power saver installation in pump house

An assumption of 15% savings is taken as the energy saving potential for installing power saver in municipal pump houses. The following techno-economics is based on this assumption.

Table 6.63: Power saver installation in pump house

	Value
Annual Energy Consumption in MU	12.32
Annual Energy Cost in Rs. (lacs)	431.2
Saving %	15%
Total Annual Saving in MU	1.848
Annual Saving in Rs. (lacs)	64.68
eCO2 (Tonne) Reduction	1496.88

(vi) Energy Efficiency Measures in STP

Pumping systems are utilized in water treatment plants of the municipal corporations whose energy efficiency can also be determined through efficient system design. A considerable amount of energy can be saved taking suitable measures in STP. TMC should initiate energy audit in all its utility services and installations to take a stalk of the energy consumption and potential savings.

Proper pump-system design (efficient pump, pumps heads with system heads)

The same principle of speed adjustment to reduce adjustment and dimension energy losses in water pumping process applies in water treatment plants. An assumption of 5% saving is taken into consideration for giving the techno-economics of installing variable

Table 6.64: Proper pump-system design (efficient pump, pumps heads with system heads)

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	4.07
Annual Energy Cost in Rs. (lacs)	142.45
Saving %	5%
Total Annual Saving in MU	0.20
Annual Saving in Rs. (lacs)	7.12
eCO2 (Tonne) Reduction	165

Installation of variable speed drivers

Installation of variable speed drivers for municipal pumps could save at least 5% energy resulting total savings of 0.20MU per year reducing 165 tonnes of GHG emission.

Table 6.65: Variable Speed Drivers

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	4.07
Annual Energy Cost in Rs. (lacs)	142.45
Saving %	5%
Total Annual Saving in MU	0.20
Annual Saving in Rs. (lacs)	7.12
eCO2 (Tonne) Reduction	165

Power saver installation in pump house

An assumption of 15% savings has been taken to calculate the energy saving potential and financial implications of installing power saver in pump houses.

Table 6.66: Power saver installation in pump house

Standard/Recommended Condition	Value
Annual Energy Consumption in MU	4.07
Annual Energy Cost in Rs. (lacs)	142.45
Saving %	15%
Total Annual Saving in MU	0.6105
Annual Saving in Rs. (lacs)	21.37
eCO2 (Tonne) Reduction	495

Summary of EE Strategy for Municipal Sector

The energy savings potential through energy efficiency measures in municipal sector is 9.8 MU per year. The corresponding reduction in emissions is about 6863 tonnes.

Table 6.67: Summary of EE Strategy for municipal sector

EE Measures	Investment (Lakh)	Electricity Saved (MU)	Emissions Saved (Tonnes)
Indicative cost of replacing 250 watt HPSV with 200 watt induction lamps	716	0.62	501
Indicative cost of replacing 150/125 watt HPSV with 100 watt induction lamps	717	0.75	606
Indicative cost of replacing 40W tube lights with 25 W LED lamps	4856	1.38	46
Proper pump system design, installation of variable speed drivers and power savers in existing water supply facility		4.93	3991.68
Proper pump system design, installation of variable speed drivers and power savers in existing sewage system facility		1.63	1319
Use of power saver in street lighting	17.42	0.49	400
Total		**9.80**	**6862.84**

6.4.15 Solid Waste Management Interventions

Waste to Energy Potential in Tirunelveli

Estimated solid waste generated in Tirunelveli city is 120 MT/day. Potential energy recovery from MSW through different treatment methods could be estimated from its calorific value and organic fraction etc. Since relevant details are not available for Tirunelveli, widely used estimates for municipal solid waste in India have been used for a preliminary assessment. However, waste to energy potential for the city is considered as an indicative assessment and not included in the strategy to achieve energy savings goal under solar city programme.

(i) 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 3.5 MWe and savings per year with 70% PLF is estimated as 21.39 MU.

Table 6.68: Waste to Energy through thermo-chemical conversion

Particulars		Unit
Total waste generated	120	Tonnes
Net Calorific Value (conservative estimate)	2400	kcal/kg
Energy recovery potential (NCV x W x 1000/860)	334884	kWh
Power generation potential	13953	kW
Conversion efficiency	25%	
Net Power generation potential	3.49	MWe
Plant Load Factor	70%	
Net electrical energy savings potential @70% PLF	21.39	MU
Emission reduction per year	17326	Tonnes
Total Investment	2442	Lakh
MNRE subsidy @ 50% subject to maximum of Rs.300.00 per MW	1047	Lakh
State/City/Private Power Producer	1395	Lakh
Cost savings	963	Lakh
Payback period	1.45	Years

(ii) Waste to Energy Potential through bio-methanation

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output. It is estimated that a 1.26 MWe electrical energy generation is possible from this process which could save about 7.7 MU of energy every year assuming a 70% of PLF.

Table 6.69: Waste to Energy through bio-methanation

Particulars		Unit
Total waste generated	120	Tonnes
Total biodegradable volatile solid (VS)	30%	
Typical digestor efficiency	60%	
Typical bio-gas yield (m3 / kg. of VS destroyed)	0.80	Cu M/kg
Biogas yield	17280	Cu M
Calorific Value of bio-gas	5000.00	kcal/Cu M
Energy recovery potential	100465.12	kWh
Power generation potential	4186	kW
Conversion efficiency	30%	
Net Power generation potential	1.26	MWe
Plant Load Factor	70%	
Net electrical energy savings potential	7.70	MU
Emission reduction per year	6238	Tonnes
Total Investment	753	Lakh
MNRE subsidy @ R.200.00 lakh per MW	251	Lakh
State/City/Private Power Producer	502	Lakh
Cost savings	347	Lakh
Payback period	1.45	Years

(iii) Waste to Energy Potential from Sewage Treatment Plant

Tirunelveli city currently has no STP and the possibility of waste to energy generation is therefore curtailed. The city has a vast waste to energy potential and it is suggested that an

STP is established to tap into this. For this purpose, following box item is presented as a case study indicating the salient features of the STP that was established in Surat.

Energy generation from Liquid Waste in Surat

- Total project cost for 4 STP units: Rs. 212.4 million
- MNRE financial support: Rs. 69.2 million
- Energy generated since commencement of operation until May 2009: 16.45 million units
- Amount saved since commencement of operation until May 2009: Rs 71.80 million
- Reduction in Carbon emissions since: 9990 MT/year

Thermal energy conservation strategies and measures will help regulate energy use and reuse eventually providing energy conservation especially in energy intensive activities and processes. While the below mentioned measures can be generally applied to any industry type, more specific measure can be developed after specific study of industry processes and equipment usage.

Table 6.70: Thermal Energy Conservation strategies

Measures	Description	Expected impact
General	• Exercise regular energy audits • Pre-heat oil for proper combustion. Make sure that there are no leaks and filter oil • Use low pressure burners	• Plugging of leaks saves almost 2000 liters of oil per year • Proper combustion of oil improves combustion efficiency • Low pressure burners save 15% of oil in furnaces
Furnace	• Control excess air in the furnace • Undertake proper design of lids and insulation of the furnace • Avoid escape of heat through openings or holes in the furnace body	• Excess air control in the furnace helps reduce fuel consumption that amounts to a saving of Rs. 3 Lakh/year • Heat loss reduction through insulation improves fuel efficiency • Plugging of furnace holes and gaps results in 10%-15% reduction in losses respectively
Boiler	• Removal of soot deposits • Recover heat from steam condensate • Administer proper boiler control • Use treated water in boilers • Avoid escape of steam/heat	• Soot deposits removal can avoid 2.5% increase in fuel consumption that occurs without such removal • Heat from steam condensate helps save 1% of fuel per 6°C rise in boiler temperature • Treated water forms less or no scales on the boiler interior which usually causes reduction of 5%-8% in fuel consumption • Steam loss causes huge losses annually which can be avoided by plugging holes in the boiler system

Measures	Description	Expected impact
DG sets	• Regularly service injection pump, nozzle, filters • Monitor fuel consumption per kWh of electricity	• Faulty injection pump, nozzle and blocked filters can cause reduction is fuel usage efficiency by 2gm/kWh and can be saved by regular checks • A rising trend of fuel consumption against per kWh of electricity indicates poor system performance which needs above mentioned system checks
Compressed air	• This is a highly energy intensive process and should only be sued for justifiable processes • Ensure low inlet air temperature and low discharge pressure • Ensure no leaks in the pipe system leading to or from the compressor • Monitor compressor output against per kWh of electricity	• Avoid use of compressed air for cleaning • Control of inlet air temperature and discharge pressure saved fuel by up to 1% and 5% respectively. • Leaks in pipes causes pressure loss and hence system inefficiency • System inefficiency tends to fail overtime and monitoring helps take corrective action
Refrigeration and Air Conditioning	• External measures like air curtains, automatic door closures, double glazed windows, polyester sun films etc. • Maintain condensers for proper hear exchange • Proper utilization of air conditioned/refrigerated space • Use of waste heat from steam and flue gasses to replace gas compression system by absorption chilling system • Monitor specific power consumption of compressors	• External measures reduce air conditioning/refrigeration load of buildings • Evaporated temperature heat loss causes rise of specific power consumption in condensers by 15% • Regulation in cooling load within the cooling space improves efficiency of refrigeration • Use of continuous duty compressor during active duty and use of others on standby improves life and reduced energy consumption
Pumps	• Select pump based on expected water flow • Preferably use variable valves • Avoid belt lag that connect the pump and its drives • Use synthetic flat belts instead of conventional V belts	• Pumps operate at 85% efficiency at rated flow and 65% at half that flow • Connector belt lag causes 10%-15% loss in transmission efficiency • Synthetic belts improve 5%-10% of energy

Source: http://www.energyconservation.co.in/energy-conservation-tips.html

7. Conclusion

About 70% of the world's population is predicted to reside in cities and urban centres by 2030. With the annual growth rate of Indian population at 1.43%, consistency of economic development and the achievement of climate change resilience at city levels have become two major areas of concern that demand increasing attention from policy makers in the country. The idea of a low carbon development economy is gaining momentum in a number of cities across the world. In India, dealing with climate change vulnerability requires an understanding of the city level socio-economic idiosyncrasies besides energy and resource consumption patterns. This report hopes to underscore these aspects of three south Indian cities; Coimbatore, Tiruchirapalli and Tirunelveli while taking into account their specific energy and emissions profiles and streamlining proposed action plans and related targets to achieve low carbon development.

The three project cities in this report correspond to different levels of economic development and each of these cities face climate related vulnerabilities. With individual social, economic and cultural identities, the project cities have been showcased through city profiles that describe these identities and energy and emission profiles that quantify the activities within these cities to address carbon emissions abatement through action plans that fit with the city profiles.

With solutions ranging from retrofitting lighting in government buildings to process heat conservation and use of solar home based systems, the techno-economic analysis combines leveraging national and sub-national subsidies and customized targets to identify measures that can be sustainably applied by the local governments. The measures presented for each project city are evaluated for its carbon abatement potential and implementation feasibility through consultative meeting with city officials. Wherever possible, indicative and generic measures provide the general framework for achievement of low carbon development in the project cities.

British
High Commission
New Delhi

British High Commission

The British High Commission in India supports projects combating climate change across the country through various funding streams including the Prosperity Fund to promote Low Carbon High Growth initiatives. The Fund will focus on promoting sustainable global growth, consistent with the UK's development objectives of promoting sustainable development and improving welfare.

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ICLEI - Local Governments for Sustainability - South Asia

ICLEI - Local Governments for Sustainability - South Asia is a non-profit making organisation operating from New Delhi, India. It began its activities in April 2005 and is presently supporting over 40 South Asian cities. ICLEI South Asia supports environmental and other sustainability initiatives at the local level by working with city governments as well as with state, national and international governmental bodies to build appropriate local environment initiatives and policies.

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