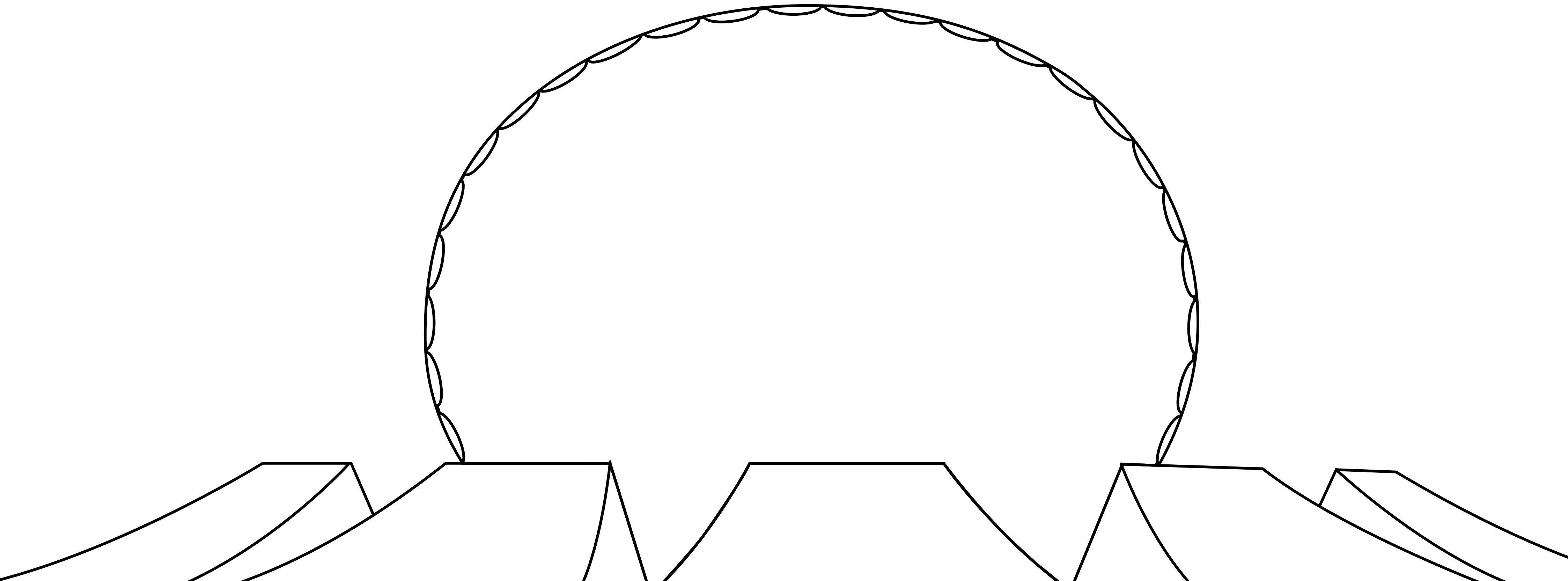
2015

# AUROVILLE
# ENERGY AND WATER
# EFFICIENCY MASTER PLAN



**Project Holder**

Auroville Town Development Council

**Project Execution**

Auroville Consulting

*With Support by:*

Ministry of New and Renewable Energy

Varuna Auroville

# DISCLAIMER

The Energy and Water Efficiency Master Plan is an attempt to establish a better understanding of Auroville's water and energy consumption for the base year 2014. As water meters are not installed at all sites and buildings in Auroville, the water baseline needed to be established with extrapolation of existing data. Data on transportation (ownership rate and consumption) is currently available in insufficient form only and the energy baseline for the transportation sector needed to be established on a set of assumptions. Assumptions and system boundaries for any calculations in establishing baselines or in forecasting are made transparent and accessible in the annexure of this document. A more coherent recording of water and energy consumption and smart data management practices are recommended in order to increase the efficiency of future planning exercises.

# ACKNOWLEDGMENT

The Energy and Water Master Plan was prepared by Auroville Consulting over a period of eight months from August 2014 to March 2015. It has been made possible with the support of Ministry of New and Renewable Energy, Government of India and Varuna Auroville.

We would like to acknowledge the support of many Aurovilians who permitted us to conduct water and energy audits at their homes and workplaces. Special thanks to team members of the Auroville Town Development Council in supporting the preparation of this Master Plan through regular working sessions. Special thanks also to Dr. A.K. Tripathi, Director, Ministry of New and Renewable Energy, Hemant Lamba, from Aurore, to proceed with this Energy and Water Master Plan.

The following team members were involved in its preparation: Clementine Browne, Guru Vignesh, Janani Ravindran, Kerstin Graebner, Martin Scherfler, Nithin Cherian, Nitish Pal, Segar, and Vikram Devatha.

# FOREWORD

The Auroville Energy and Water efficiency master plan 2014 indicates areas where substantial and cost effective savings for both water and energy can be achieved for the Auroville Township. It shows, that though excellent work is being done at Auroville in areas such as rainwater harvesting and renewable energy deployment, there is still a significant scope for the water and energy demand side management, conservation and efficiency initiatives. With these initiatives Auroville's carbon and water footprint can be further reduced and new benchmarks can be set for the future development of the township. The focus of this program is on the demand side management by highlighting the responsibilities of each resident, the relevant service providers and the planning bodies. Indicating low-.-hanging fruits for interventions, the plan provides a roadmap and sets clear targets that Auroville is committed to achieve by 2020. The Auroville Town Development Council is determined to achieve the proposed goals and will set up a resource management cell for implementation.

Sauro Mezzetti
Coordinator, Auroville Town Development Council
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**LIST OF ABBREVIATIONS**

| | |
|---|---|
| AM | Auromodel |
| AV | Auroville |
| AWS | Auroville Water Service |
| BAU | Business as Usual |
| BEE | Bureau of Energy Efficiency |
| CFL | Compact Fluorescent Lamp |
| $CO_2E$ | Carbon-dioxide Emission |
| COP | Coefficient of Performance |
| CRT | Cathode Ray Tube |
| ECBC | Energy Conservation Building Code |
| EE | Energy Efficiency |
| EER | Energy Efficiency Ratio |
| EPI | Energy Performance Index |
| GHG | Green House Gas |
| GRIHA | Green Buildings Rating System India |
| HVAC | Heating, Ventilation, Air-Conditioning |
| LCD | Liquid Crystal Display |
| LCOE | Levelised Cost of Energy at the Point of Production |
| LCOP | Levelised Cost of Energy at the Point of Consumption |
| LED | Light Emitting Diodes |
| LPG | Liquefied Petroleum Gas |
| MNRE | Ministry for New and Renewable Energy |
| MSW | Municipal Solid Waste |
| NBC | National Building Code |
| RES | Reference Energy System |
| RET | Renewable Energy Technology |
| SPV | Solar Photo Voltaic |
| TDC | Town Planning Development Council |
| TEDA | Tamil Nadu Energy Development Agency |
| TNEB | Tamil Nadu Electricity Board |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UPS | Uninterrupted Power Supply |

**LIST OF UNITS**

| | |
|---|---|
| A | Ampere |
| Ah | Ampere Hours |
| BTU | British Thermal Unit |
| cu.m | Cubic Meter |
| CUF | Capacity Utilization Factor |
| GWh | Giga Watt Hours |
| ha | Hectare |
| INR | Indian Rupee |
| J | Joule |
| kCal | Kilo Calories |
| kg | Kilogram |
| kJ | Kilo Joule |
| kL | Kilo Litre |
| KL | Kilo Litre (equal to meter cube) |
| km | Kilometer |
| kW | Kilo Watt |
| kWh | Kilo Watt Hours |
| L | Litre |
| LPD | Litres Per Day |
| m | Meter |
| m/s | Metres per Second |
| MJ | Mega Joule |
| MMBTU | Million British Thermal Units |
| MU | Million Units |
| MWh | Mega Watt Hours |
| Rs. | Rupees |
| sq.km | Square Kilometres |
| sq.m | Square Meters |
| T | Metric Tonne |
| V | Voltage |
| W | Watt |
| yr. | Year |

# EXECUTIVE SUMMARY

This report attempts to establish an Energy and Water Efficiency Master Plan for Auroville, International Township, located 130 km south of Chennai in Tamil Nadu. Extensive time and effort went into the collection and preparation of existing data required for this exercise. We hope that this effort will result in an increased energy and water efficiency for Auroville and that it simultaneously creates an impetus to review existing data management practices and to develop a strategy for implementing a coherent, transparent and IT based data management tool which will serve all stakeholders working on water and energy management in Auroville.

The report is divided into eight chapters. Chapter 1 briefly presents the scope of the Energy and Water Master Plan study. Chapter 2 gives a short introduction to Auroville, its governance and its current water and energy infrastructure. Chapter 3 establishes a water consumption baseline for Auroville and its sectors, and informs about water saving opportunities as they were identified through water audits conducted for this study. Chapter 4 focuses on the energy baseline overall and by sectors, and names the identified electricity saving potential by sector and for each type of fixture/application. Simple payback has been used to highlight the most cost efficient interventions and to support an informed decision-making. Chapter 5 attempts a water demand forecasting from 2014 to 2020. Chapter 6 includes the energy demand forecasting of Auroville until the year 2020. Chapter 7 assesses various renewable energy technologies and their potential and feasibility for Auroville today. Chapter 8 sets annual targets for water saving, energy efficiency and renewable energy capacity addition in order to achieve the goal of a 25% $CO_2$ emission reduction until the year 2020.

## WATER

Auroville's total pumped water has been estimated at 1,502,029 KL for the base year 2014. The average per capita/day consumption (including Agriculture and all other sectors) amounts to 1,779 litres per day (including distribution losses). The total household per capita/day consumption is 620 litres including the distribution losses and a 433 litres per capita/day excluding the distribution losses (see Table 1). This is comparatively high, and an extensive water efficiency program is highly recommended. Table 2 indicates high-level figures for water consumption, water saving potential and investment requirement per type of intervention. A water saving potential of 34% has been identified by replacing current less efficient water fixtures with efficient ones.

*Table 1 Per Capita/Day Water Consumption, Auroville 2014*

| | |
|---|---|
| Total Population | 2,314 |
| Total Water Pumped | 1, 502,029 KL |
| Total Water Pumped for Residential Sector | 522,748 KL |
| Per Capita/Day Consumption of Total | 1,779 litres |
| Per Capita/Day Consumption Residential | 620 litres |

*Table 2 Water Baseline and Savings by Fixtures, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings In KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 1,73,754 | 6.59% | 72,230 | 136 | 98,22,709 | 1,965 | 8 |
| Garden Pipe | 81,604 | 5.38% | 58,956 | 8 | 4,99,830 | 769 | 0.5 |
| Kitchen Sink Tap | 1,62,653 | 6.08% | 66,646 | 83 | 55,30,622 | 2,212 | 5 |
| Micro Irrigation | 2,29,699 | 3.35% | 36,752 | 40 | 14,74,000 | 59 | 2 |
| Shower | 2,09,355 | 7.64% | 83,742 | 49 | 40,69,925 | 1,770 | 3 |
| Tap | 38,791 | 2.12% | 23,275 | 129 | 30,11,733 | 3,012 | 7 |
| Urinals | 11,517 | 0.51% | 5,560 | 605 | 33,63,565 | 673 | 34 |
| Wash Basin Tap | 62,680 | 2.51% | 27,495 | 286 | 78,70,409 | 3,279 | 16 |
| Matrimandir | 60,225 | - | - | - | - | - | - |
| Others | 65,980 | - | - | - | - | - | - |
| **Total** | **10,96,258** | **34.18%** | **3,74,656** | | **35,64,2793** | | **5** |

## ENERGY

Auroville's total energy demand is estimated at 9,299 MWh in 2014. Considering the different sources and their respective share of the total energy consumption, the $CO_2$ footprint for the same year is 4,812 $TCO_2$. The largest share (43%) of Auroville's energy demand is sourced from the state utility grid. Thermal energy sources such as LPG and firewood are the second largest source of energy with 25% of the total. Renewable energy sources account for 14% of Auroville's energy baseline of 2014 (see Table 3). Auroville's per capita/year energy consumption is 4,019 kWh and the electricity consumption per capita/year is 2,023 kWh. For households, the electricity consumption per capita/year amounts to 990 kWh (see Table 35).

*Table 3 Overview of Energy Data, Auroville 2014*

| Sources | Consumption in MWh/yr. | % of Total | $CO_2$ Emissions in $TCO_2E$/yr. | % of Total |
|---|---|---|---|---|
| TNEB | 3,965 | 43% | 3,767 | 78% |
| Renewables | 1,260 | 14% | - | 0% |
| Diesel & Petrol * | 1,753 | 19% | 373 | 8% |
| Thermal ** | 2,322 | 25% | 672 | 14% |
| **Total** | **9,299** | **100%** | **4,812** | **100%** |

* *Diesel & Petrol contains fuel for diesel generators and motorized transport.*
** *Thermal contains LPG and fire wood.*

*Table 4 Summary Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 4,88,770 | 10.44% | 19,13,110 | 3.19% | 1,49,378 | 9,26,747 | 47,43,082 | 5.12 |
| Fan | 3,93,357 | 8.40% | 26,10,605 | 4.67% | 2,18,799 | 15,14,022 | 109,39,602 | 7.23 |
| Light | 7,75,553 | 16.57% | 45,19,244 | 7.72% | 3,61,391 | 23,09,880 | 78,22,359 | 3.39 |
| Others | 21,35,721 | 45.63% | 101,37,543 | 0.31% | 14,301 | 84,859 | 3,25,663 | 3.84 |
| Pump | 1,74,236 | 3.72% | 3,21,994 | - | - | - | - | - |
| Refrigerator | 3,54,523 | 7.57% | 47,41,311 | 4.45% | 2,08,391 | 14,51,618 | 66,20,960 | 4.56 |
| Washing Machine | 33,737 | 0.72% | 6,79,301 | 1.62% | 75,750 | 4,44,934 | 30,72,238 | 6.90 |
| Water Efficiency | 43,622 | 0.93% | 2,81,636 | 0.15% | 6,980 | 45,062 | 7,37,000 | 16.36 |
| Municipal Pumps | 2,81,074 | 6.01% | 18,14,697 | 4.80% | 2,24,606 | 14,50,123 | 2,85,000 | 0.20 |
| **Total** | **46,80,596** | **100%** | **270,19,442** | **26.91%** | **12,59,594** | **82,27,244** | **345,45,908** | **4.20** |

Table 5 gives an overview of the targets for water and energy savings as well as for renewable (solar PV) capacity addition which have been set in order to achieve a 25% $CO_2$ emission reduction of the baseline by the year 2020.

*Table 5 Summary of Water and Energy Targets and Targets for Solar PV Capacity Addition*

| Baseline | Units | in % of Baseline | $CO_2E$ Reduction in % | $CO_2E$ Reduction in tonnes |
|---|---|---|---|---|
| Water Savings | 1,75,650 KL | 16% | 0 | - |
| Electricity Savings | 10,28,096 kWh | 21% | 18% | 861.34 |
| Solar PV (245 kWp) | 3,59,856 kWh | - | 7% | 341.86 |

# 1. INTRODUCTION

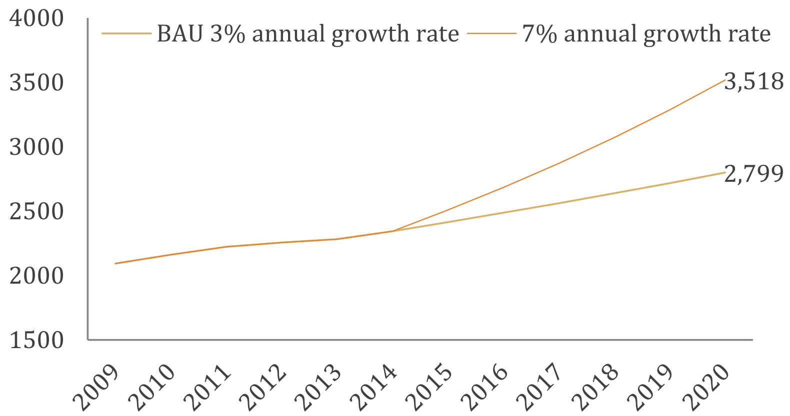
## 1.1 SCOPE OF STUDY

This study presents an Energy and Water Efficiency Master Plan for the International Township Auroville as per the Ministry for New and Renewable Energy Green Campus guidelines with the following scope:

- Establish the energy and water baseline for the entire township
- Assess the current carbon footprint of Auroville
- Conduct water and energy audits to study consumption patterns
- Identify water and energy efficiency interventions to estimate saving potential and cost of interventions
- Assess renewable energy technologies
- Set water and energy efficiency goals and propose a five year road map
- Set renewable energy goal and propose a five year road map
- Estimate greenhouse gas emission reduction

The water and energy forecast was based on a projected average annual population increase of 7% from the year 2014 to 2020. Figure 1 indicates the projected population increase in numbers.

*FIGURE 1 POPULATION FORECAST FOR AUROVILLE UNTIL 2020 - TWO SCENARIOS*




To establish the energy and water baseline, the Auroville Town Development Council requested to work with a categorisation in sectors that allows a more in-depth analysis and reflects the diversity and ground reality of Auroville. Instead of the typical segmentation into residential, municipal, industrial and commercial, twelve distinct sectors have been used for this exercise (see Table 6).

*TABLE 6 LISTING OF SECTORS BY TOTAL NUMBER OF SITES, NUMBER OF ELECTRIC ENERGY METERS INSTALLED AND THE NUMBER OF WATER AND ENERGY AUDITS CONDUCTED PER SECTOR*

| Sectors | Sites | TNEB Meters | Energy Audits | Water Audits |
|---|---|---|---|---|
| Administration | 7 | 9 | 3 | 3 |
| Agriculture | 9 | 12 | 0 | 3 |
| Commercial | 32 | 33 | 2 | 2 |
| Community & Culture | 22 | 25 | 4 | 4 |
| Municipal Pumps | 30 | 32 | 4 | 0 |
| Education | 37 | 50 | 3 | 3 |
| Food Processing | 15 | 15 | 4 | 4 |
| Guest Houses | 22 | 25 | 4 | 4 |
| Health Services | 2 | 4 | 1 | 1 |
| Manufacturing & Handicraft | 46 | 47 | 3 | 3 |
| Public Service | 16 | 16 | 2 | 2 |
| Residential | unknown | 799 | 12 | 12 |

A short definition of the sectors is given below. For a detailed listing of units/departments by sector, refer to Annexure 1.

**ADMINISTRATION:** public services with a focus on the administrative activities of Auroville, such as financial services, town planning, education (SAIIER) etc.
**AGRICULTURE:** all farms
**COMMERCIAL:** all commercial offices (design studios, consulting offices) and various boutiques in Auroville

**COMMUNITY & CULTURE:** services and centres with the primary function to enable community gathering and hosting of cultural events (venues for cultural events, sport facilities, art galleries etc.)
**MUNICIPAL PUMPS:** multiple decentralized pumps which supply water to one or more Auroville communities (settlements)
**EDUCATION:** educational institutions for child and adult learning
**FOOD PROCESSING:** restaurants and food processing units
**GUEST HOUSES:** registered Auroville guest houses, not including home stay places
**HEALTH SERVICES:** health and dental services for Auroville and the neighbouring villages
**MANUFACTURING & HANDICRAFT:** diverse manufacturing and handicraft units, such as engineering and metal work units, textile units, contractors, mechanics, carpenters, ceramic studios and potters etc.
**PUBLIC SERVICE:** services such as the Auroville water service, Auroville electrical service, library, telephone service, gas service etc.
**RESIDENTIAL:** all types of residential living, including home stays

# 2. BACKGROUND

## 2.1 CHARTER OF AUROVILLE

1. Auroville belongs to nobody in particular. Auroville belongs to humanity as a whole. But to live in Auroville, one must be a willing servitor of the Divine Consciousness.
2. Auroville will be the place of an unending education, of constant progress, and a youth that never ages.
3. Auroville wants to be the bridge between the past and the future. Taking advantage of all discoveries from without and from within, Auroville will boldly spring towards future realizations.
4. Auroville will be a site of material and spiritual researches for a living embodiment of an actual Human Unity.

## 2.2 HISTORY & GOVERNANCE

The universal township of Auroville was founded on February 28th, 1968, in a ceremony where youth of 124 nations and the states of India deposited the soil of their countries in a foundation urn to symbolise the coming together of the nations of the world. At the occasion, the Charter of Auroville was read, stating that Auroville belongs to humanity as a whole. Auroville aims at international understanding, human unity, and peace. It strives to be a learning society and a place of an all-round material and spiritual development for a harmonious individual and collective growth. Auroville draws inspiration from the work of Sri Aurobindo and The Mother.

The Government of India recognised the importance of the project of Auroville, and passed the Auroville Foundation Act in 1988, whereby it created the Auroville Foundation. This is an autonomous statutory body with the specific purpose of making long-term arrangements for the better management and further development of Auroville in accordance with its original Charter. The nodal Ministry of the Auroville Foundation is the Ministry of Human Resource Development.

The General Assembly of UNESCO, recognizing that the project of Auroville contributes to the advancement of UNESCO's objectives, adopted resolutions in 1966, 1968, 1970 and 1983 to provide support to this project. UNESCO also celebrated Auroville's 25th, 30th and 40th anniversaries with functions at UNESCO's head office in Paris. The Executive Board of UNESCO passed a resolution in 2009 inviting UNESCO's Member States to participate in the development of Auroville as an international Cultural Township in pursuance of UNESCO's core mandate by building a pavilion of their country in Auroville's International Zone.

## 2.3 LOCATION & CLIMATE

Auroville is located at a distance of 160 km south of Chennai on the East Coast of India, just 6 km north of Puducherry. Most of the township area lies in Villupuram district and comprises the panchayats of Irumbai and Bommapalayam. Small areas of this land are also in Kottakuppam. The geographical centre of the city is 54 metres above mean sea level. The climate is tropical, hot and humid with two monsoons a year: the south-west monsoon from June to August and the north-east monsoon from October to December. The average number of rainy days/year varies from 50-70 days, with an average temperature range of 18° C to 42° C. The relative humidity varies from 50-80%, with average wind speeds of 3-5 m/sec. The area is prone to cyclonic storms with wind speeds of up to 55-60 m/sec. The predominant wind directions are the sea breeze from the east in the afternoon and evenings, and the land breeze from the west from midnight to midday.

## 2.4 SOIL & WATER

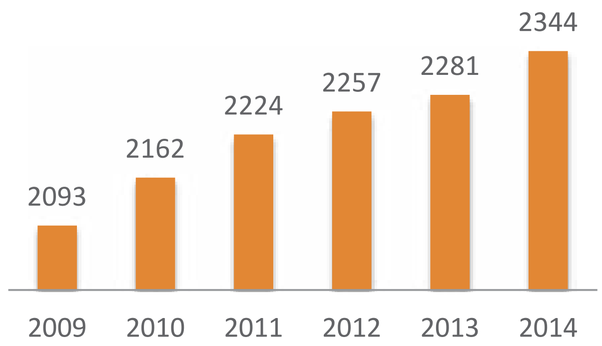
The soil varies between the coastal watershed, which has ferralitic soil with high percolation capacity, and the inland watershed with clayey soils. All water requirements in this area are either met by groundwater (wells ranging from 20–300 m in depth) or surface water collection ponds for washing, cattle and irrigation. In Auroville, the population depends entirely on groundwater for all its potable and non-potable needs. There are five villages within or in the proximity of the township area with an estimated total population of 50,000.

## 2.5 POPULATION & DIVERSITY

In April 2014, Auroville counted 2,344 permanent residents from more than 45 different nations. About 40 percent of the permanent residents are Indian nationals. From 2009 to 2014, Auroville's population grew, on average, by about 3% per year. Figure 2 depicts the total number of permanent residents in Auroville for the years 2009 to 2014.

Besides permanent residents, Auroville hosts a significant, but varying number of researchers and students who come for short durations to volunteer or intern. At any given point, this number may range between 200 to 300 students, researchers and volunteers. Workers and employees from neighbouring villages working in Auroville's economic activities and services are estimated to be about 5,000 in number. On average 3,000 short-term, including casual, visitors come to experience Auroville's work in diverse fields per day.

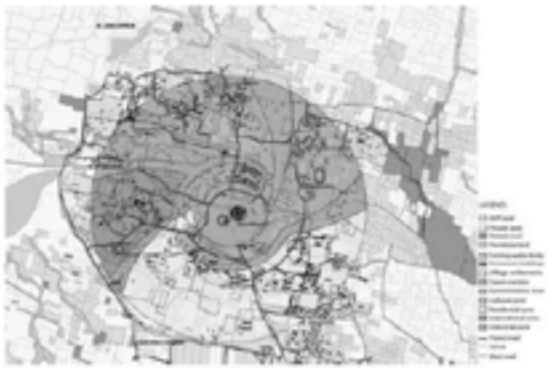
*Figure 2 Auroville Population Growth 2009 - 2014*



## 2.6 PLANNING & DEVELOPMENT

Within the city area of 516 hectares, the township is planned to have various zones, namely the Residential, the Industrial, the Cultural, the International and the Peace zone, in which specific activities are to be focused. The township consists of two distinct parts: the city area of 5 sq.km and the greenbelt of 15 sq.km, which encircles the former. About 172 ha of the land is allocated to the Residential zone, 137 ha to the Industrial zone, 103 ha to the Cultural zone, 76 ha to the International zone and 28 ha to the Peace zone. Special economic activities will be concentrated in the Industrial zone, which has a share of 26.6% of the land in the city area. Figure 3 depicts the layout of these planned areas. The city is planned for a resident population of 50,000. However, as previously stated, at present the number of permanent residents is about 2,300. Due to the early compulsions for the regeneration of the barren land and making it fit for habitation, the small community settlements were established in a dispersed manner both within the proposed township boundary as well as just outside it. The distribution of existing settlements and activity areas as they exist today may also be seen in Figure 3.

*Figure 3 Auroville Map and Zoning*



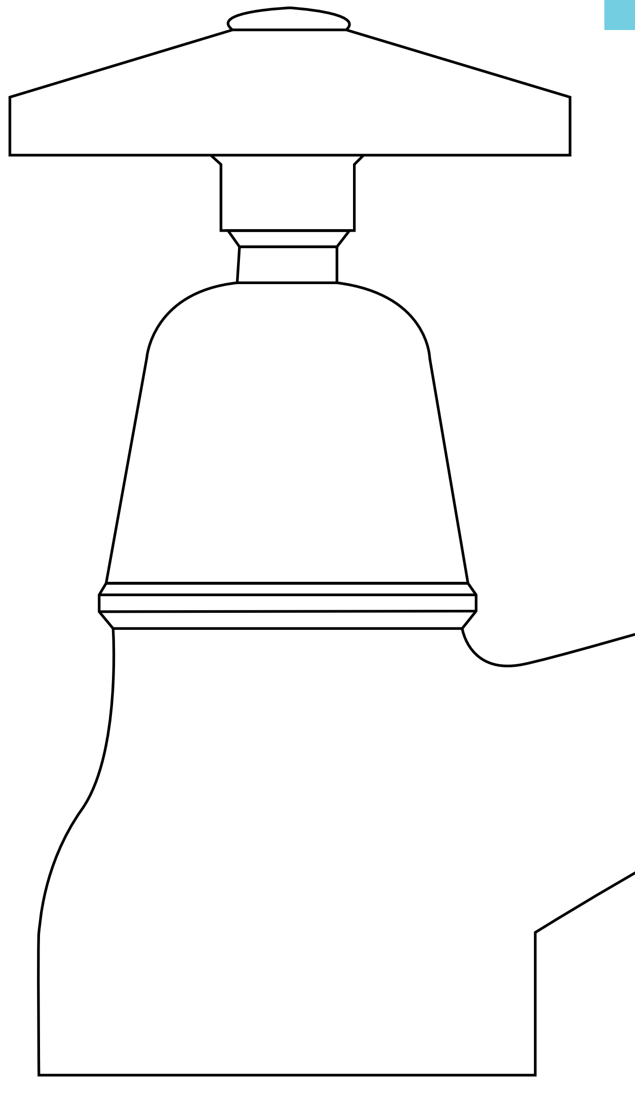
*Source: Auroville Township Development Council*

## 2.7 ELECTRICITY INFRASTRUCTURE

Auroville draws its main supply of electrical energy from the Tamil Nadu Electricity Board (TNEB) through the 110/22 kV sub-stations located at Irrumbai village. Several load-centre sub-stations are located around the township to step down the voltage from 22 kV to 415 V and supply 3-phase electricity through low-tension distribution lines to the end users. As of 2014, there are a total of 28 transformers in 15 sub-stations, with a cumulative capacity of 3,282 VA. Two standard sizes of transformers are used, either 63 kVA or 100 kVA. A few Auroville communities and establishments are also connected to the transformers supplying electricity to the neighbouring villages.

## 2.8 WATER INFRASTRUCTURE

Auroville's current water infrastructure is highly decentralized with an estimated number of 150 bore wells supplying the water requirements for the residential and other sectors of Auroville. Water pricing differs from location to location, as well as water metering systems, quality of operation and maintenance. Wastewater treatment at Auroville is either done at the settlement or the building level using technologies such as decentralized wastewater treatment systems or simple septic tanks.



# 1. WATER BASELINE & SAVING OPPORTUNITIES

# 3. WATER BASELINE & SAVING OPPORTUNITIES

## 3.1 OVERALL FINDINGS

### METHODOLOGY

Different methodologies were used to establish the water baseline for Auroville. Many sites do not have water meters in place, and sites with installed water meters do not maintain adequate data recordings. For the Residential sector, the recordings from two water providers with adequate historical data were used and then extrapolated for the total Residential sector. For the Agriculture sector, three out of 17 farms had at least one year of recorded water consumption. This data was used to establish the baseline for the Agriculture sector. For all other sectors, data records on water consumption were not available.

For these sectors the baseline was established using the data collected in the water audits which were conducted for this study. Table 7 lists the total number of people per sector and the number of water audits completed per sector. For the analysis, the following types of fixtures/applications have been considered: cisterns, garden pipes, kitchen sink taps, micro irrigation, shower heads, taps (taps not covered under wash basin taps, kitchen sink taps), urinals, wash basin taps (in bathrooms), and others (such as swimming pools, mopping floors, washing car, cleaning tables etc.).

*Table 7 Listing of Sectors by Total Number of People and Audits Conducted per Sector*

| Sector | No. | Water Audits |
|---|---|---|
| Administration | 202 | 3 |
| Agriculture | 147* | 3 |
| Commercial | 616 | 2 |
| Community & Culture | 547 | 4 |
| Education | 722 | 3 |
| Food Processing | 519 | 4 |
| Guest Houses | 733 | 4 |
| Health Services | 317 | 1 |
| Manufacturing & Handicraft | 2,616 | 2 |
| Public Service | 236 | 2 |
| Residential | 2,314 | 12 |

** acres cultivated*

*Sources: Auroville Resident Service, Auroville Guest Service and Farm Group*
*No. is calculated using the ratio of number of Non-Aurovilians to Aurovilians. Thus this number contains the sum of total number of people working, both Non-Aurovilians and Aurovilians.*

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*Table 8 Fixture Types, Pricing and Saving Potential per Fixture/Application as Used for Estimating Water Savings, Auroville 2014*

| Fixture Type | Price in INR | Water Saving in % |
|---|---|---|
| Cistern | 5,000 | 60% |
| Garden Pipe | 650 | 80% |
| Kitchen Sink Tap | 2,500 | 45% |
| Micro Irrigation | 25,000* | 40% |
| Shower | 2,300 | 40% |
| Tap | 1,000 | 60% |
| Urinals | 5,000 | 50% |
| Wash Basin Tap | 2,400 | 45% |

* *per acre*

*Sources: Cistern: Jaquar Catalogue, 2014. Garden Pipe: Connectors Shopclues, 2015.*
*Wash Basin Taps: Ikea catalog products, 2015. Shower Tubstiles: Water-saving-device, 2015.*
*Kitchen Sink: Aliexpress Touch-water-saving-valve-faucet-aerator, 2015.*
*Taps: Therodingroup, 2015. Urinals: green-buildings-water-saving-urinals-green-building-and-leed, 2015.*

Table 8 lists the average price of water fixtures which were audited to establish the water baseline and to estimate the water savings. A short description of the fixture types is given below:

## FIXTURE DESCRIPTION

**CISTERN:** tank for storing water, or flushing tank of toilets
**GARDEN PIPE:** garden hose
**KITCHEN SINK TAP:** water tap especially designed for kitchen uses
**MICRO IRRIGATION:** application of water at low volume and frequent interval under low pressure to plant root zone, without water losses in evaporation etc. The two most common methods of micro irrigation are drip-irrigation and sprinkle-irrigation.
**SHOWER:** water fixture used for taking bath
**TAP:** water faucet other than kitchen sink tap and bathroom wash basin tap
**URINALS:** bowl or other receptacle, typically attached to a wall in a public toilet, into which men may urinate
**WASH BASIN TAP:** basin, typically fixed to a wall or on a pedestal, used for washing one's hands and face

## BASELINE

Auroville's annual water consumption for the year 2014 was estimated at 10, 96,258 KL of revenue water, that is, water accounted for at the point of delivery. The total water extraction is estimated to be 15, 02,029 KL for the same time period. Non-revenue water due to losses in the distribution network is estimated to be 4, 44,014 KL or 30% of the total extracted water (see Figure 4). The percentage value for water losses is assumed to apply equally to all sectors of Auroville. (see Table 9 and Figure 5).

*Table 9 Water Baseline by Sector, Auroville 2014*

| Sectors | Total Revenue Water in KL | Revenue Water in % of Total | Total Non-Revenue Water in KL | Total Water Pumped in KL |
|---|---|---|---|---|
| Residential | 3,65,924 | 33.4% | 1,56,824 | 5,22,748 |
| Agriculture | 2,29,699 | 21.0% | 98,442 | 3,28,141 |
| Manufacturing & Handicraft | 2,18,445 | 19.9% | 93,619 | 3,12,064 |
| Matrimandir | 60,225 | 5.5% | 25,811 | 86,036 |
| Community & Culture | 57,731 | 5.3% | 24,742 | 82,472 |
| Guest Houses | 56,397 | 5.1% | 24,170 | 80,567 |
| Food Processing | 46,070 | 4.2% | 19,744 | 65,815 |
| Commercial | 27,038 | 2.5% | 11,588 | 38,626 |
| Administration | 13,147 | 1.2% | 5,635 | 18,782 |
| Education | 12,762 | 1.2% | 5,469 | 18,231 |
| Health Services | 6,054 | 0.6% | 2,595 | 8,649 |
| Public Service | 2,766 | 0.3% | 1,185 | 3,952 |
| **Total Baseline for AV** | **10,96,258** | **100%** | **4,69,825** | **15,66,082** |

*FIGURE 4 NON-REVENUE AND REVENUE WATER IN % OF OVERALL WATER PUMPED, AUROVILLE 2014*

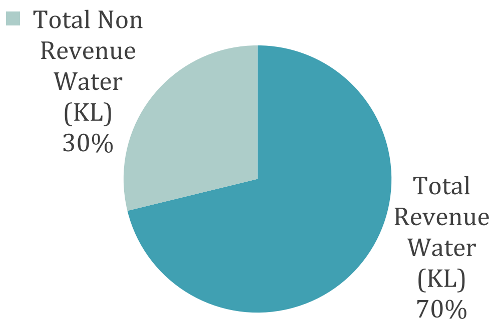
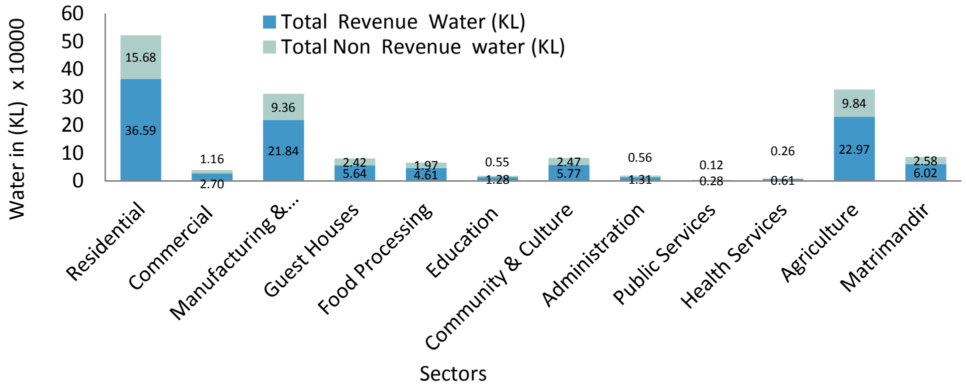



*FIGURE 5 TOTAL REVENUE TO NON-REVENUE WATER PER SECTOR, AUROVILLE 2014*



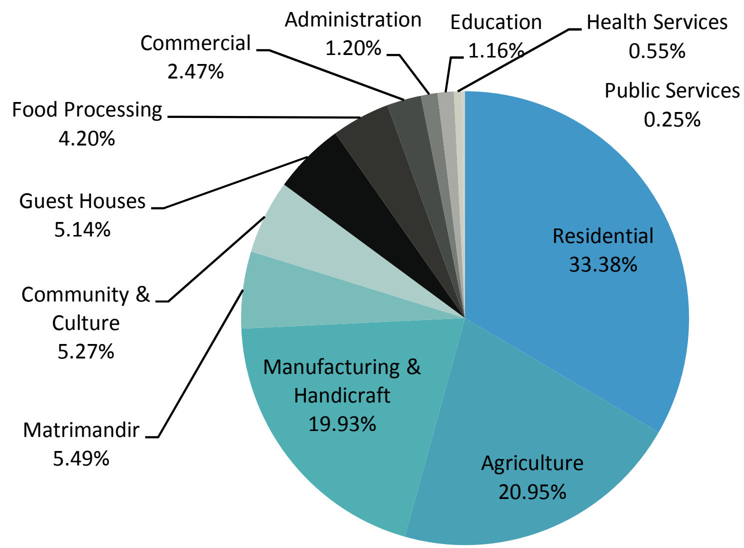

The per capita/day water consumption including the distribution losses for Auroville is estimated to be 1,778 litres, and 619 litres for the Residential sector (see Table 10). The per capita/day consumption for the Residential sector exclusive distribution losses is estimated at 433 litres per capita/day. This is very high compared to the standards by the Indian Bureau of Statistics which states a per capita/day consumption of 150 to 200 litres. Domestic water consumption for Delhi is estimated at 220 litres per capita/day. For London and Paris, the consumption in the same sector is estimated to be 70 litres and 150 litres, respectively (Down to Earth 2014, ICC 2014 and Hindustan Times 2015).

*TABLE 10 PER CAPITA/DAY WATER CONSUMPTION, AUROVILLE 2014*

| | |
|---|---|
| Total Population | 2,314 |
| Total Water Pumped | 1,502,029 KL |
| Total Water Pumped for Residential Sector | 522,748 KL |
| Per Capita /Day Consumption of Total | 1,779 litres |
| Per Capita/Day Consumption Residential | 620 litres |

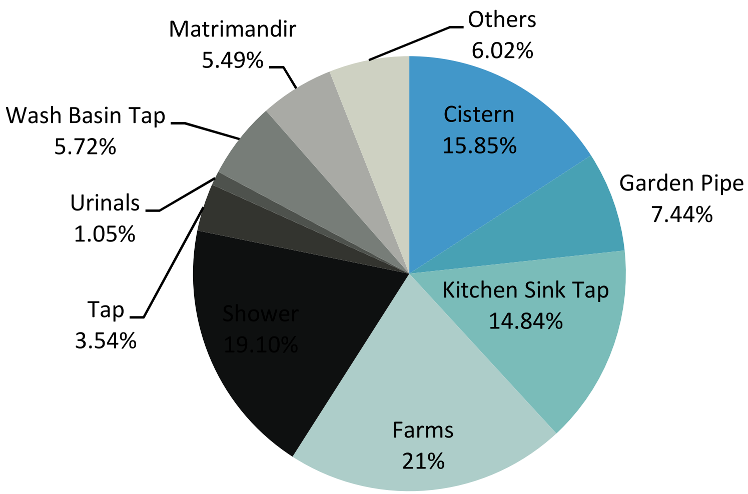
Figure 6 indicates the water consumption of the various sectors on the total Auroville water consumption 2014. The main water consuming sectors are the Residential sector (33%), followed by Agriculture (21%) and Manufacturing & Handicraft (20%). It may be noted that the water consumption of Matrimandir and its surrounding gardens is estimated to make up approximately 6% of the overall water consumption, or 60 KL per day.

*FIGURE 6 WATER CONSUMPTION IN % BY SECTOR, AUROVILLE 2014*



The findings of the water audit reports were used to estimate the total water consumption by type of fixture/usage. The highest water consumption in percentage of the total water consumption in Auroville was identified for irrigation in agriculture, followed by the water consumption for showers, cisterns, kitchen sink taps, garden pipes and Matrimandir irrigation (see Figure 7). These water intensive areas may be especially attractive for water conservation interventions.

*Figure 7 Water Baseline per Type of Fixture/Usage in % of Overall, Auroville 2014*




## SAVING POTENTIAL

Auroville has an overall water saving potential of 34.18%, which equals 33, 74,656 KL of revenue water and 5, 35,222 KL of pumped water. The highest water saving potential was identified for the Residential sector with about 14%, followed by the Manufacturing & Handicraft, Agriculture and the Guest Houses sector (see Figure 8). In terms of per type of fixture/application saving potential, Figure 9 indicates that the highest water savings can be achieved by replacing existing inefficient shower heads with more efficient ones. This can result in savings of 7.64% or 83,742 KL of the total Auroville water consumption of 2014. The interventions for cisterns generate a water saving potential of 6.59%, 6.08% for kitchen sink taps and 5.38% for installing water efficient garden pipes. Figure 9 shows the cost effectiveness for each intervention by type of fixture/application in terms of capital investment required per KL of water saving. The most cost effective water efficiency intervention is for garden pipes with an investment requirement of INR 8 per KL of water saving. This is followed by micro irrigation (INR 40) for the Agriculture sector and by interventions for shower heads (INR 48).

*Figure 8 Overall Water Saving Potential per Sector in %, Auroville 2014*

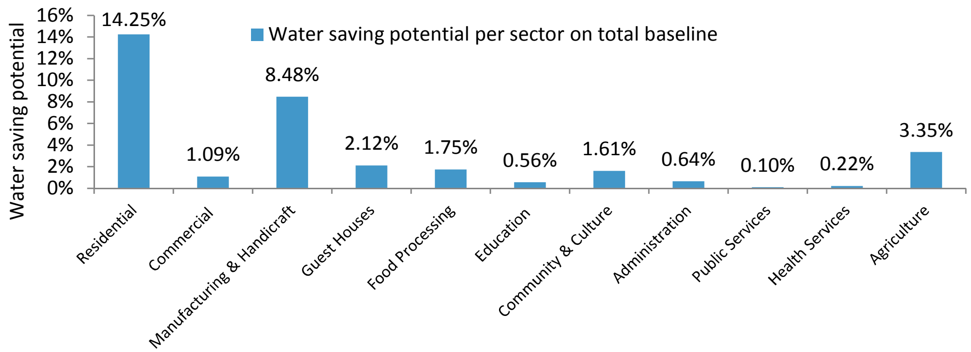



*Figure 9 Overall Water Saving Potential by Type of Fixture/Application in %, Auroville 2014*

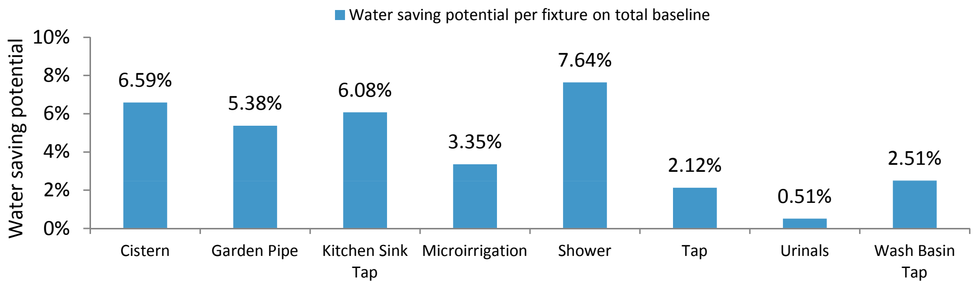


*Figure 10 Overall Capital Investment in INR Required per KL of Water Saving by Type of Fixture/Application, Auroville 2014*

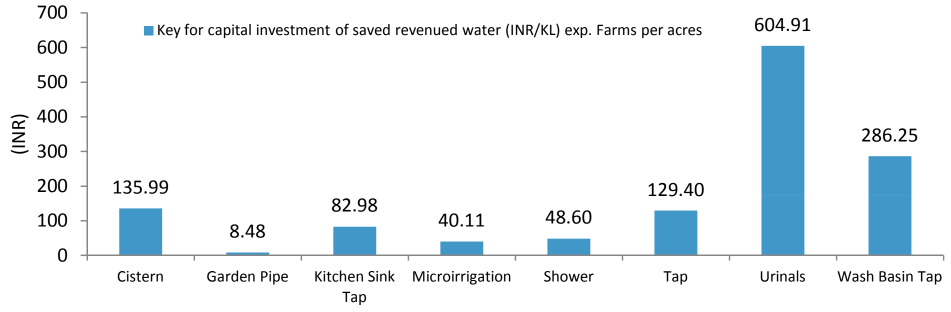



Table 11 summarizes the overall findings for all sectors listing the water saving potential, investment requirement, number of fixtures required to achieve the water savings and also indicating the payback period for each water efficiency intervention. The three most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 11 Water Baseline and Savings by Fixtures, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 1,73,754 | 6.59% | 72,230 | 136 | 98,22,709 | 1,965 | 8 |
| Garden Pipe | 81,604 | 5.38% | 58,956 | 8 | 4,99,830 | 769 | 0.5 |
| Kitchen Sink Tap | 1,62,653 | 6.08% | 66,646 | 83 | 55,30,622 | 2,212 | 5 |
| Micro Irrigation | 2,29,699 | 3.35% | 36,752 | 40 | 14,74,000 | 59 | 2 |
| Shower | 2,09,355 | 7.64% | 83,742 | 49 | 40,69,925 | 1,770 | 3 |
| Tap | 38,791 | 2.12% | 23,275 | 129 | 30,11,733 | 3,012 | 7 |
| Urinals | 11,517 | 0.51% | 5,560 | 605 | 33,63,565 | 673 | 34 |
| Wash Basin Tap | 62,680 | 2.51% | 27,495 | 286 | 78,70,409 | 3,279 | 16 |
| Matrimandir | 60,225 | - | - | - | - | - | - |
| Others | 65,980 | - | - | - | - | - | - |
| **Total** | **10,96,258** | **34.18%** | **3,74,656** | | **356,42,793** | | **5** |

## 3.2 RESIDENTIAL

### METHODOLOGY

The total baseline for the Residential sector was established by using exiting water metering data of two water service providers with an accumulated 537 residents to extrapolate on the total. The two sets of existing data provided a representative mix of housing types, including family houses and apartments. This methodology was required, as no additional meter readings for residential communities were available.

### BASELINE

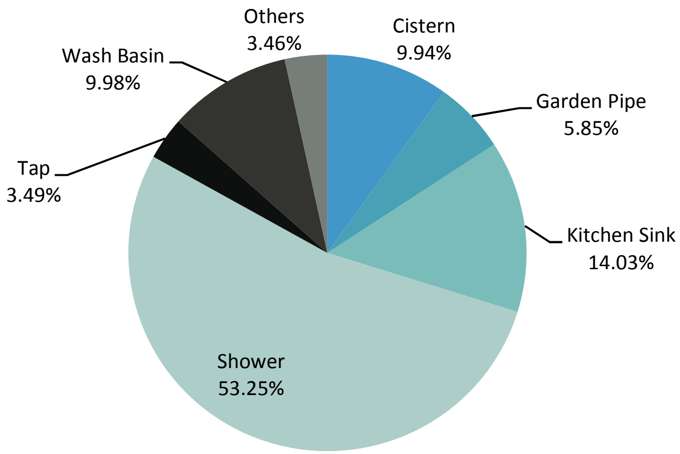
The total residential water consumption is estimated to be 3,65,924 KL of revenue water for 2014 (or 33% of the total Auroville water consumption). The average per capita/day residential water consumption is 433 L; this includes indoor and outdoor (landscaping etc.) water usage.

*Table 12 Residential Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 433 L |
| Total Population, Nov 2014 | 2,314 |
| Revenue Water | 365,924 KL |
| Non-Revenue Water | 156,824 KL |

According to the water audit findings, the majority of the residential water consumption is accounted for by showers (53%), followed by the kitchen sink tap (14%), the cistern and wash basin tap (10% each) as well as the garden pipe (6%). For a detailed break-up of the water consumption in percent by type of fixture/application, refer to Figure 11.

*Figure 11 Residential Sector Water Baseline per Fixture/Application in % of Water Baseline, Auroville 2014*




## SAVING POTENTIAL

The highest water saving potential was identified for showers by replacing existing inefficient shower heads with more water efficient ones. This could result in savings of up to 7% (or 77,949 KL of revenue water) of the total baseline water consumption of Auroville in 2014. Replacing inefficient fixtures with more efficient ones produces similar savings between 1.7% and 1.5 % of the total baseline in the case of kitchen sink tabs, cisterns, garden pipes and wash basin taps (see Figure 12). Figure 13 indicates the capital investment required for each KL of water saving by the type of interventions. The installation of water efficient hose pipe fittings for garden purposes requires an investment of INR 18 per KL of water saved and represents the most cost effective intervention, followed by the replacement of shower heads which will require an investment of INR 40 per KL of water saving. Both these interventions are highly cost attractive. They promise a cumulative water saving of about 8% to 9% on the baseline water consumption and are relatively easy to implement. For details of the investment requirements per KL of water saving for all types of fixtures/application, refer to Figure 13.

*Figure 12 Residential Sector Water Saving Potential by Type of Fixture/Application in % of Total, Auroville 2014*

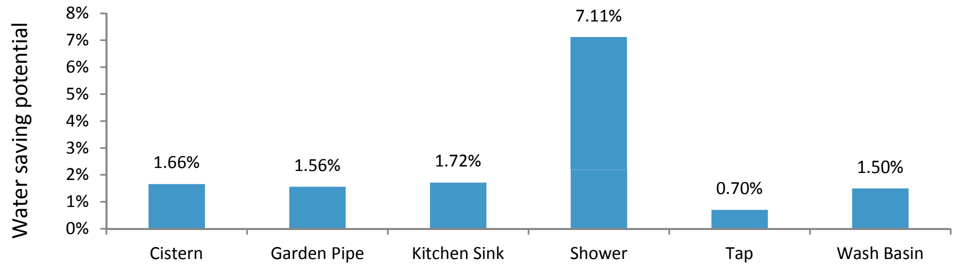



*Figure 13 Residential Sector Capital Investment in INR Required per KL of Water Saving by Type of Fixture/Application, Auroville 2014*

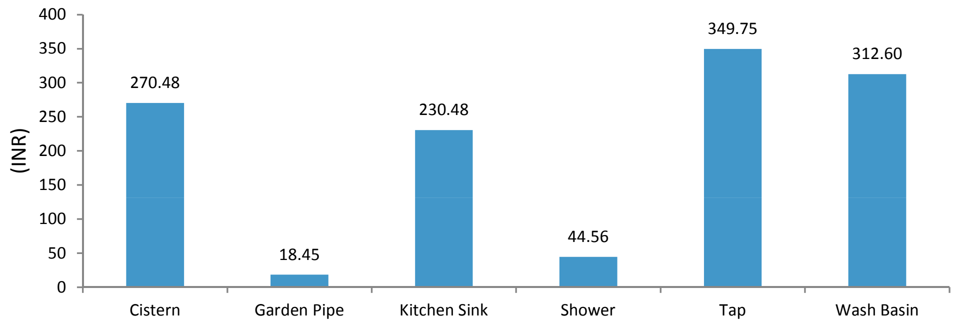



Table 13 summarizes the findings for the Residential sector and its water saving potential, investment required, number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The two most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 13 Residential Sector Water Baseline and Savings per Type of Fixture/Application, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 36,386 | 1.66% | 18,232 | 270 | 49,31,337 | 986 | 15.0 |
| Garden Pipe | 21,411 | 1.56% | 17,129 | 18 | 3,16,111 | 486 | 0.0 |
| Kitchen Sink Tap | 51,322 | 1.72% | 18,820 | 230 | 43,37,770 | 1,735 | 12.8 |
| Shower | 1,94,872 | 7.11% | 77,949 | 45 | 34,73,070 | 1,510 | 2.5 |
| Tap | 12,762 | 0.70% | 7,657 | 350 | 26,78,095 | 2,678 | 19.4 |
| Wash Basin Tap | 36,525 | 1.50% | 16,436 | 313 | 51,37,983 | 2,141 | 17.4 |
| Others | 12,646 | - | - | - | - | - | - |
| **Total** | **3,65,924** | **14.25%** | **1,56,223** | | **208,74,366** | | **7.4** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.3 MANUFACTURING & HANDICRAFT

### METHODOLOGY

The Manufacturing & Handicraft sector is a highly diverse segment with activities including textile dying, welding, carpentry, pottery, building material production etc. The water baseline was established using results from the water audits and the per capita/day consumption per worker/employee, as water meter reading data was not available for this sector. It was not possible to establish the water baseline based on a processing methodology, either, due to the sector's high diversity and the lack of production output data.

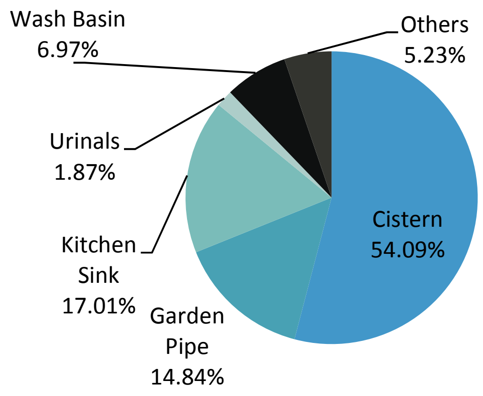
### BASELINE

The total annual revenue water consumption for the Manufacturing & Handicraft sector is estimated at 2,18,455 KL. The per capita/day consumption per worker/employee amounts to 276 L (see Table 14). In terms of water consumption by type of fixture/application, 54% (or 1, 18,156 KL) of the total water consumption for the Manufacturing & Handicraft sector is accounted for by cisterns. This is followed by kitchen sink taps (17%) and garden pipes (15%) (see Figure 14).

*Table 14 Manufacturing & Handicraft Sector Water Baseline Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 276.04 L |
| Number of Workers/Employees | 2,616 |
| Revenue Water | 218,445 KL |
| Non-Revenue Water | 93,619 KL |

*Figure 14 Manufacturing & Handicraft Sector per Fixture/Application in % of Total Water Baseline, Auroville 2014*




### SAVING POTENTIAL

The highest water saving potential for the Manufacturing & Handicraft sector was identified for cisterns with 4% (or 43,839 KL of revenue water savings) of the overall Auroville baseline water consumption 2014. The installation of efficient garden hosepipe heads and efficient kitchen sink taps promises water savings of 2.15% and 1.52%, respectively. For details please refer to Figure 15.

Figure 16 indicates the capital investment required for each KL of water saving by type of interventions. The installation of water efficient kitchen sink taps, cisterns and efficient garden hose pipe heads are the most attractive interventions both in terms of water saving achievable and in cost effectiveness, requiring an investment of INR 5 per KL water saved for garden hose pipes, INR 29 per KL water saved for kitchen sink taps and INR 82 per KL of water saved for cisterns. These three interventions promise a cumulative water saving of about 7% to 8% of the overall Auroville water consumption. In terms of implementation, the replacement of cisterns may prove to be challenging, as this requires some more extensive plumbing interventions. The interventions for garden pipes and kitchen sink taps, however, are easily implementable.

*Figure 15 Manufacturing & Handicraft Sector Water Saving Potential by Type of Fixture/Application in % of Total Water Baseline, Auroville 2014*

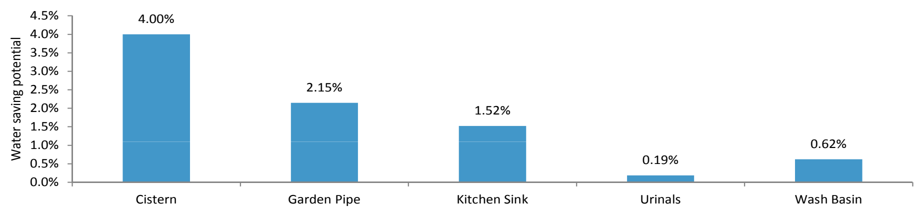



*Figure 16 Manufacturing & Handicraft Sector Capital Investment Required for per KL of Water Saved per Type of Fixture in INR*

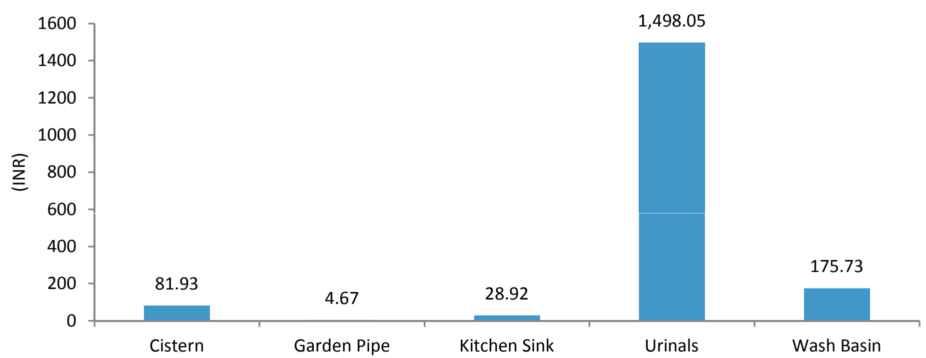



Table 15 summarizes the findings for the Manufacturing & Handicraft sector of Auroville, listing its water saving potential, the investment required, and the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The promising interventions in terms of payback period and water savings achievable are highlighted in colour.

*Table 15 Manufacturing & Handicraft Sector Water Baseline and Savings per Type of Fixture/Application, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 1,18,156 | 4.00% | 43,839 | 82 | 35,91,659 | 718 | 4.6 |
| Garden Pipe | 32,406 | 2.15% | 23,522 | 5 | 1,09,949 | 169 | 0.3 |
| Kitchen Sink | 37,150 | 1.52% | 16,718 | 29 | 4,83,530 | 193 | 0.0 |
| Urinals | 4,077 | 0.19% | 2,039 | 1,498 | 30,54,132 | 611 | 83.2 |
| Wash Basin Tap | 15,225 | 0.62% | 6,851 | 176 | 12,03,939 | 502 | 9.8 |
| Others | 11,430 | - | - | - | - | - | - |
| **Total** | **2,18,445** | **8.48%** | **92,968** | | **84,43,208** | | **5.0** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.4 PUBLIC SERVICE

### METHODOLOGY

The Public Service sector contains units such as the Auroville electrical service, Auroville water service, telephone service, gas service, library etc. As water meter reading data was not available for this sector, the water baseline was established using water audits and the per capita/day consumption per worker/employee.

### BASELINE

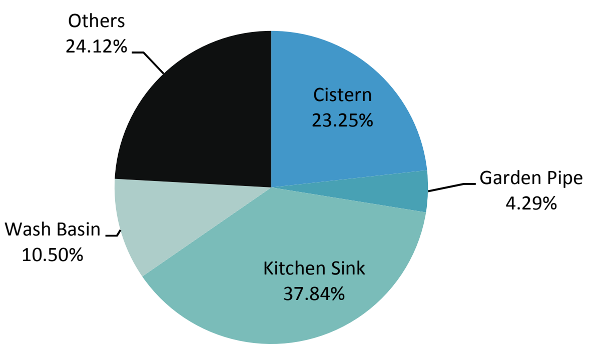
The total annual revenue water consumption for the Public Service sector is estimated at 2766 KL and the per capita/day consumption for each worker/

employee is 39 L (see Table 16). In terms of water consumption by type of fixture/application, 38% (or 1,045 KL) of the total water consumption is accounted for by kitchen sink taps. This is followed by others (24%) and cisterns (23%) (see Figure 17).

*Table 16 Public Service Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 39 L |
| Number of Workers/Employees | 236 |
| Revenue Water | 2,766 KL |
| Non-Revenue Water | 1,185 KL |

*Figure 17 Public Service Sector Water Baseline per Fixture/Application in % of Total Water Baseline, Auroville 2014*




## SAVING POTENTIAL

The highest water saving potential for the Public Service sector was identified for kitchen sink taps and cisterns with 0.04% (or 471 KL of revenue water savings) of the overall Auroville baseline water consumption 2014. This is followed by garden pipes and wash basin taps with a saving potential of 0.01% of the total for both applications (see Figure 18).

Figure 19 indicates the capital investment required for each KL of water saved by type of interventions. The installation of efficient garden pipe heads is the single most attractive intervention for this sector, requiring an investment of INR 60 per KL of water saved.

*Figure 18 Public Service Sector Water Saving Potential by Type of Fixture in % of Total, Auroville 2014*

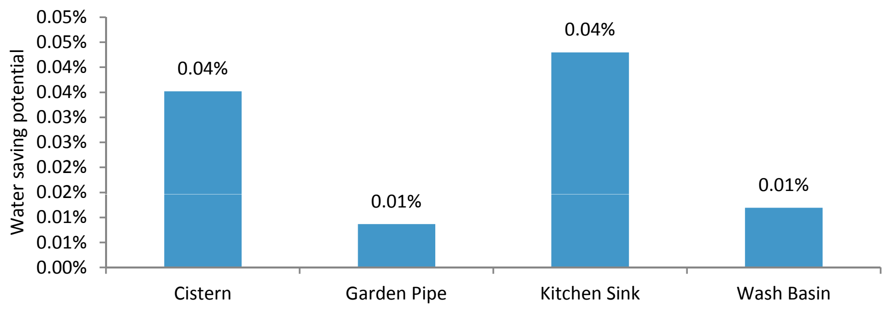



*Figure 19 Public Service Sector Capital Investment Required per KL of Water Saved per Type of Fixture in INR, Auroville 2014*

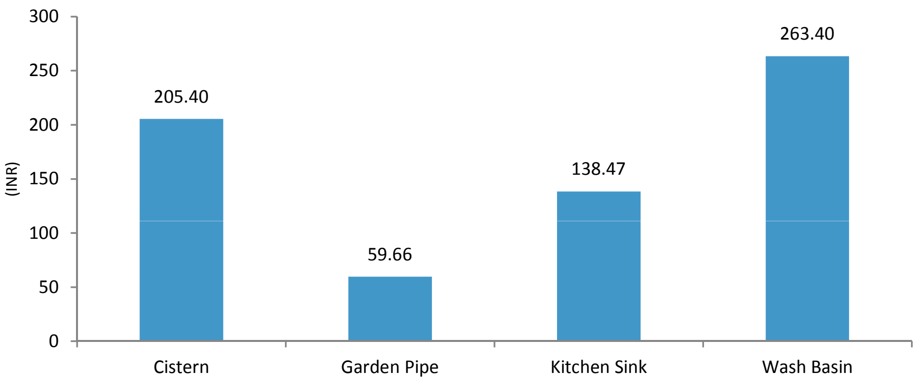



Table 17 summarizes the findings for the Public Service sector of Auroville, listing its water saving potential, the investment requirement, and the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 17 Public Service Sector Water Baseline and Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 643 | 0.04% | 386 | 205 | 79,263 | 16 | 11.4 |
| Garden Pipe | 119 | 0.01% | 95 | 60 | 5,662 | 9 | 3.3 |
| Kitchen Sink Tap | 1,047 | 0.04% | 471 | 138 | 65,222 | 26 | 7.7 |
| Shower | 0 | 0.00% | 0 | 0 | 0 | 0 | 0.0 |
| Tap | 0 | 0.00% | 0 | 0 | 0 | 0 | 0.0 |
| Urinals | 0 | 0.00% | 0 | 0 | 0 | 0 | 0.0 |
| Wash Basin Tap | 290 | 0.01% | 131 | 263 | 34,423 | 14 | 14.6 |
| Others | 667 | - | - | - | - | - | - |
| **Total** | **2,766** | **0.10%** | **1,082** | | **1,84,569** | | **9.5** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.5 GUEST HOUSES

### METHODOLOGY

The Guest Houses sector refers to units that provide guest accommodation such as guest houses, hotels and youth hostels. Home stays have not been included as they are covered under the Residential sector baseline. As with the previous sectors, water meter reading data was not available for this sector. The water baseline was established using data from the sample water audits data to establish an average per bed/day water consumption which was then extrapolated using the total number of guest beds in Auroville.

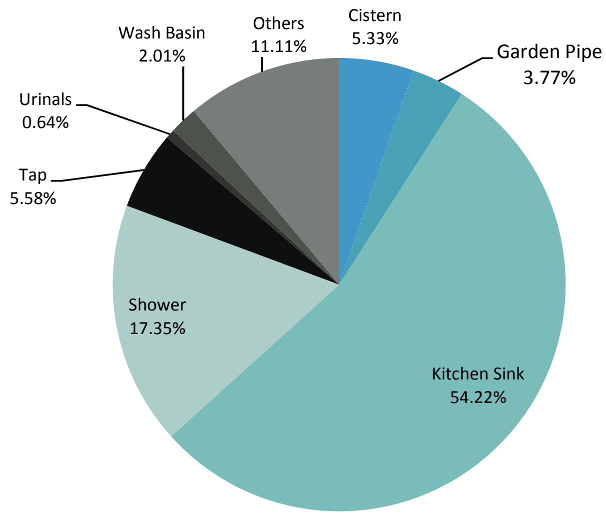
### BASELINE

The total annual revenue water consumption for the Guest Houses sector is estimated at 24,170 KL. The average per bed/day consumption is 211 L (see Table 18). In terms of water consumption by type of fixture/application, 54% (or 30,578 KL) of the total water consumption for the Guest Houses sector is accounted for by kitchen sinks taps, followed by shower (17%) and others (11%) (see Figure 20).

*Table 18 Guest Houses Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Bed/Day Water Consumption | 211 L |
| Number of Beds | 733 |
| Revenue Water | 56,397 KL |
| Non-Revenue Water | 24,170 KL |

*Figure 20 Guest Houses Sector, Water Baseline per Fixture/Application in % of Total Water Baseline, Auroville 2014*




### SAVING POTENTIAL

Replacing existing less efficient kitchen sink taps with more efficient ones promises the highest water saving potential for the Guest Houses sector, with 1.25% (or 13,683 KL of revenue water savings) of the overall Auroville baseline water consumption 2014. Water efficiency interventions for shower heads can achieve water savings of 0.36% (see Figure 21).

Figure 22 indicates the capital investment required for each KL of water saving, amounting to INR 4 for the replacement of kitchen sink taps. This represents the most attractive water efficiency intervention for the Guest Houses sector as it promises the highest water savings and is highly cost efficient. Interventions for garden hose pipes may be considered as well, as the capital investment is moderate and implementation is easily feasible.

*Figure 21 Guest Houses Sector Water Saving Potential by Type of Fixture/Application in % of Total, Auroville 2014-2015*

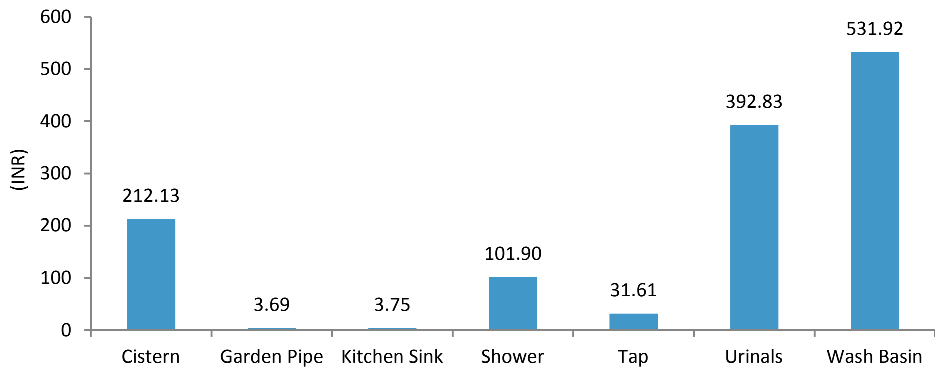



*Figure 22 Guest Houses Sector Capital Investment Required per KL of Water Saved per Type of Fixture/Application in INR, Auroville 2014*

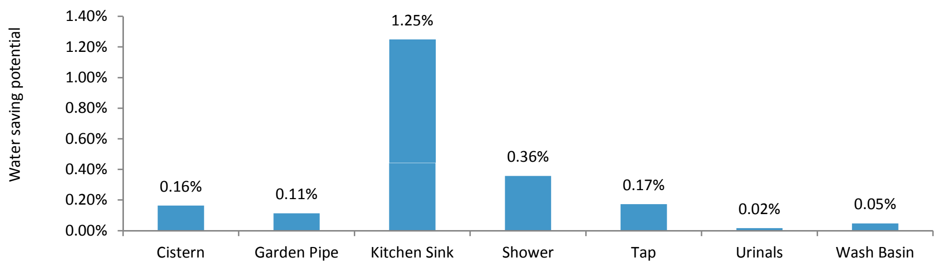



Table 19 summarizes the findings for the Guest Houses sector of Auroville, listing its water saving potential, the investment requirement, and the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 19 Guest Houses Sector Water Baseline, Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 3,006 | 0.16% | 1,804 | 212 | 3,82,579 | 77 | 11.8 |
| Garden Pipe | 2,125 | 0.11% | 1,234 | 4 | 4,555 | 7 | 0.2 |
| Kitchen Sink Tap | 30,578 | 1.25% | 13,683 | 4 | 51,274 | 21 | 0.2 |
| Shower | 9,784 | 0.36% | 3,914 | 102 | 3,98,773 | 173 | 0.0 |
| Tap | 3,149 | 0.17% | 1,889 | 32 | 59,715 | 60 | 1.8 |
| Urinals | 360 | 0.02% | 180 | 393 | 70,747 | 14 | 21.8 |
| Wash Basin Tap | 1,131 | 0.05% | 509 | 532 | 2,70,690 | 113 | 29.6 |
| Others | 6,265 | - | - | - | - | - | - |
| **Total** | **56,397** | **2.12%** | **23,212** | | **12,38,331** | | **3.0** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.6 COMMERCIAL

### METHODOLOGY

The Commercial sector includes commercial offices, architectural and consulting offices, and boutiques. The baseline for this sector has been calculated using the sample water audit findings for the per capita/day consumption per employee multiplied by the estimated total number of employees in this sector.

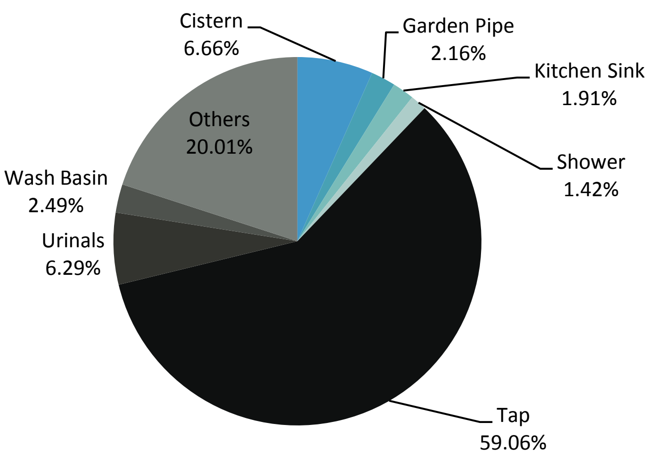
## BASELINE

The total annual revenue water consumption for the Commercial sector is estimated at 11,588 KL. The average per capita/day consumption is 154 L (see Table 20). Taps are the single most water consuming fixture/application for the Commercial sector, accounting for 59% (or 15,968 KL) of the sector's water consumption. Others (20%), cisterns (7%) and urinals (6%) are other major water consuming applications (see Figure 23).

*Table 20 Commercial Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 154.32 L |
| Number of Workers/Employees | 616 |
| Revenue Water | 27,038 KL |
| Non-Revenue Water | 11,588 KL |

*Figure 23 Commercial Sector Water Baseline per Fixture/Application in %, Auroville 2014*




## SAVING POTENTIAL

Replacing existing less efficient taps with more efficient ones has the highest water saving potential for the Commercial sector with 0.87% (or 9,581 KL of revenue water savings) of the overall Auroville baseline water consumption 2014. All other water efficiency interventions have only little water saving potential (see Figure 24).

Figure 25 indicates a capital investment requirement of INR 4 for each KL of water saving in replacing existing water taps with more efficient ones.

*Figure 24 Commercial Sector Water Saving Potential by Type of Fixture in % of Total Water Consumption, Auroville 2014*

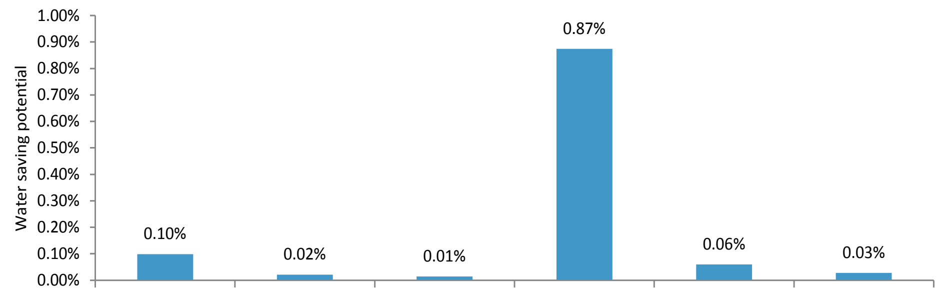



*Figure 25 Commercial Sector Capital Investment Required per KL of Water Saved per Type of Fixture in INR*

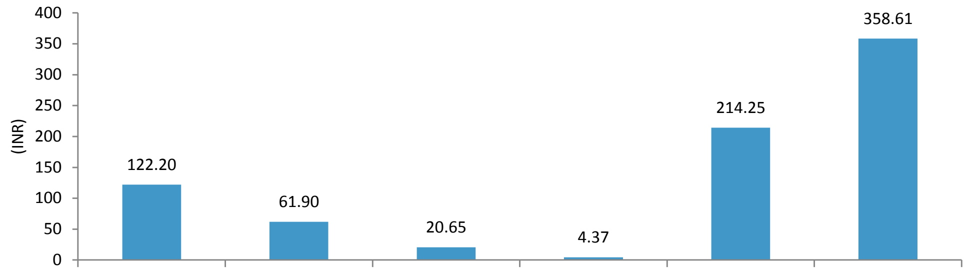



Table 21 summarizes the findings for the Commercial sector of Auroville, listing its water saving potential, the investment required, the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The single most promising intervention in terms of payback period and achievable water savings is highlighted in colour.

*Table 21 Commercial Sector Water Baseline, Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 1,800 | 0.10% | 1,080 | 122 | 1,32,001 | 26 | 0.0 |
| Garden Pipe | 583 | 0.00% | 0 | 0 | 0 | 0 | 0.0 |
| Kitchen Sink Tap | 517 | 0.02% | 233 | 62 | 14,400 | 6 | 3.4 |
| Shower | 384 | 0.01% | 153 | 21 | 3,168 | 1 | 0.0 |
| Tap | 15,968 | 0.87% | 9,581 | 4 | 41,856 | 42 | 0.2 |
| Urinals | 1,701 | 0.06% | 653 | 214 | 1,39,801 | 28 | 11.9 |
| Wash Basin Tap | 674 | 0.03% | 303 | 359 | 1,08,729 | 45 | 19.9 |
| Others | 5,411 | - | - | - | - | - | - |
| **Total** | **27,038** | **1.09%** | **12,003** | **0** | **4,39,956** | **0** | **2.0** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.7 COMMUNITY & CULTURE

### METHODOLOGY

The Community & Culture sector includes performance venues, movie hall, exhibition venues and art galleries etc. The baseline for this sector has been calculated using the sample water audit findings for the per capita/day consumption per employee multiplied by the estimated total number of employees in this sector.

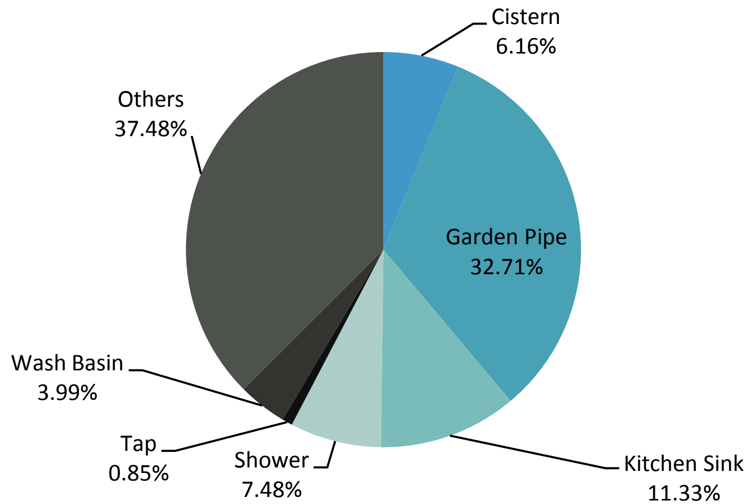
### BASELINE

For the Community & Culture sector, the total annual revenue water consumption is estimated at 57,731 KL. The average per capita/day consumption is 337 L (see Table 22). Other applications (38% or 21,638 KL) and garden pipes (33% or 18,886 KL) are the two main water consuming fixtures/applications in this sector, followed by kitchen sink taps with 11% and shower with 7% of the total water consumption of the Community & Culture sector baseline (see Figure 26).

*Table 22 Community & Culture Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 337 L |
| Number of Workers/Employees | 547 |
| Revenue Water | 57,731 KL |
| Non-Revenue Water | 24,742 KL |

*Figure 26 Community & Culture Sector Water Baseline per Fixture/Application in %, Auroville 2014*




### SAVING POTENTIAL

Garden pipes are the fixture/application with the highest water saving potential, with 1.12% (or 12,247 KL) of the overall water baseline for Auroville 2014. Replacing existing inefficient shower heads with more efficient ones can achieve water savings of 0.16%, whereas interventions for cisterns (0.12%) and kitchen sink taps (0.10%) promise a slightly lower saving potential (see Figure 27). Figure 28 indicates the capital investment required for water efficiency interventions, which amounts to INR 4 for each KL of water savings in the case of garden pipes. This intervention is both cost effective and efficient in terms of achieving water savings and is therefore recommended for the Community & Culture sector. Interventions for kitchen sink taps (INR 55 per KL of water saving) may be considered.

*Figure 27 Community & Culture Sector Water Saving Potential by Type of Fixture in % of Total Auroville Water Consumption, Auroville 2014*

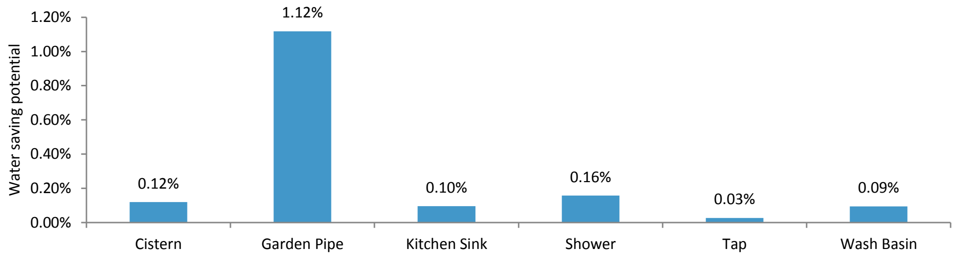



*Figure 28 Community & Culture Sector Capital Investment Required per KL of Water Saved per Type of Fixture in INR, Auroville 2014*

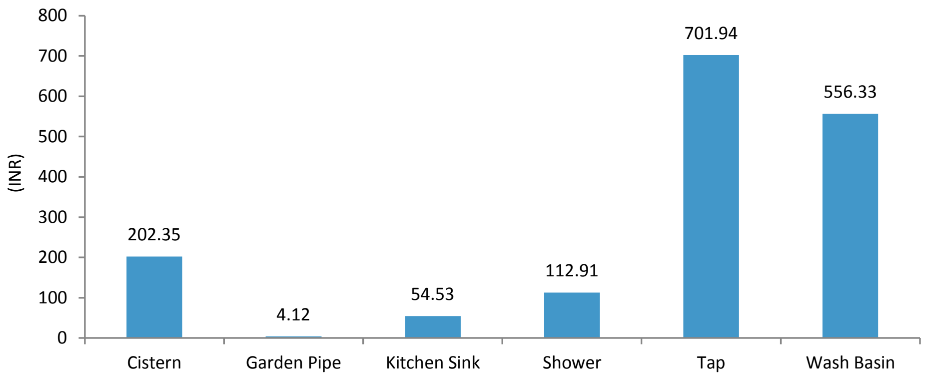



Table 23 summarizes the findings for the Community & Culture sector of Auroville, listing its water saving potential, the investment requirement, and the number of fixture required to achieve water savings and also indicates the payback period for each intervention. The most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 23 Community & Culture Water Baseline, Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 3,557 | 0.12% | 1,312 | 202 | 2,65,504 | 53 | 11.2 |
| Garden Pipe | 18,886 | 1.12% | 12,247 | 4 | 50,446 | 78 | 0.2 |
| Kitchen Sink Tap | 6,540 | 0.10% | 1,056 | 55 | 57,568 | 23 | 3.0 |
| Shower | 4,316 | 0.16% | 1,726 | 113 | 1,94,914 | 85 | 6.3 |
| Tap | 490 | 0.03% | 294 | 702 | 2,06,503 | 207 | 39.0 |
| Urinals | 0 | 0.00% | 0 | 0 | 0 | 0 | 0.0 |
| Wash Basin Tap | 2,304 | 0.09% | 1,037 | 556 | 5,76,713 | 240 | 30.9 |
| Others | 21,638 | - | - | - | - | - | - |
| **Total** | **57,731** | **1.61%** | **17,672** | | **13,51,649** | | **4.2** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.8 EDUCATION

### METHODOLOGY

The Education sector includes pre-crèche, kindergartens and school types for higher graders (up to the equivalent of 12$^{th}$ standard). The baseline for this sector has been calculated using the sample water audit findings for the per capita/day consumption per student multiplied by the estimated total number of students in this sector.

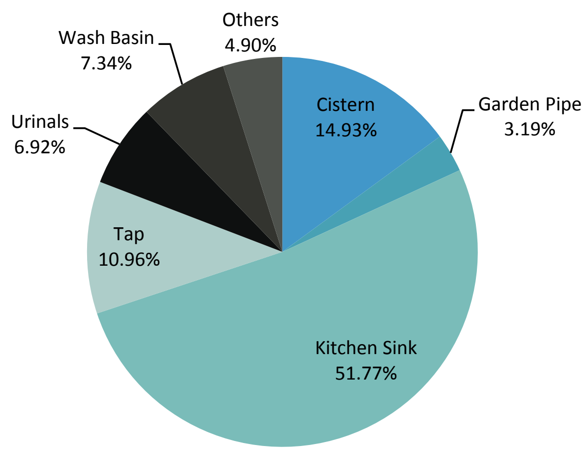
### BASELINE

For the Education sector the total annual revenue water consumption is estimated at 5,469 KL. The average per capita/day consumption per student amounts to 81.46 L (see Table 24). The highest consuming fixture/application is the kitchen sink with 52% (or 6,607 KL) of the Education sector baseline water consumption. This may be due to the fact that lunch meals are catered to the schools and the washing of plates may account for this proportionally high water consumption. Cisterns are the second highest water consumer with 15% (or 1,143 KL), followed by taps (11%), urinals and wash basin taps (7% each) (see Figure 29).

*Table 24 Education Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 81.46 L |
| Total Number of Students | 722 |
| Revenue Water | 12,767 KL |
| Non-Revenue Water | 5,469 KL |

*Figure 29 Education Sector Water Baseline per Fixture/Application in %, Auroville 2014*




## SAVING POTENTIAL

A water saving potential of 0.27% (or 2,973 KL) of the overall Auroville water baseline was identified for kitchen sink taps in the Education sector. The water saving potential amounts to 0.10% for cisterns, 0.08% for taps and 0.03% for garden pipes (see Figure 30).

As Figure 31 indicates, the water efficiency intervention for kitchen sink taps requires a capital investment of INR 80 for each KL of water saving. The lowest capital investment required per KL water savings is for garden pipes (INR 17), taps (INR 26) and urinals (INR 70). The interventions for garden pipes are recommended even though the water saving potential is not substantial, as it is a cost effective and simple intervention. Water efficiency interventions for kitchen sink tap and taps may be considered.

*Figure 30 Education Sector Water Saving Potential by Type of Fixture in % of Total Water Consumption, Auroville 2014*

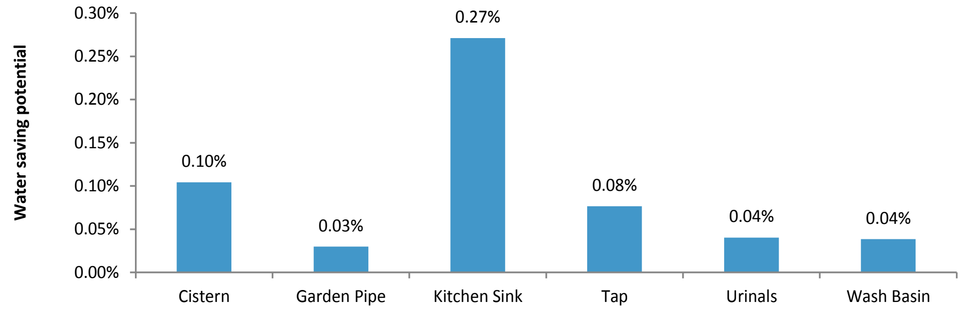



*Figure 31 Education Sector Capital Investment Required per KL of Water Saved per Type of Fixture in INR, Auroville 2014*

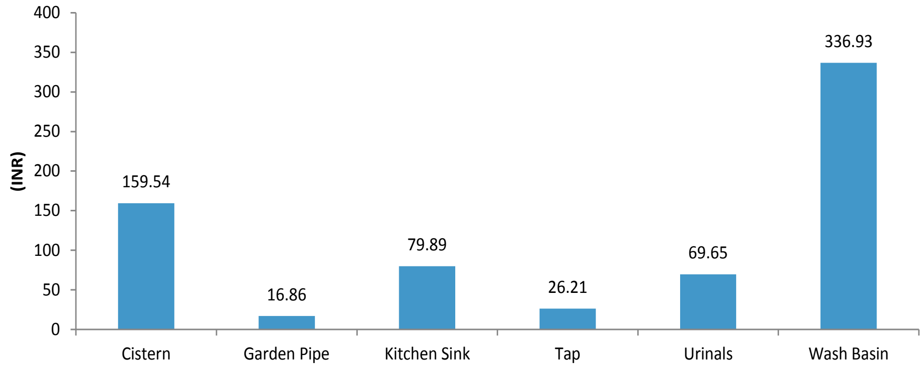



Table 25 summarizes the findings for the Education sector of Auroville, listing its water saving potential, the investment requirement, the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 25 Education Sector Water Baseline, Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 1,905 | 0.10% | 1,143 | 160 | 1,82,338 | 36 | 8.9 |
| Garden Pipe | 407 | 0.03% | 326 | 17 | 5,498 | 8 | 0.0 |
| Kitchen Sink Tap | 6,607 | 0.27% | 2,973 | 80 | 2,37,497 | 95 | 4.4 |
| Tap | 1,398 | 0.08% | 839 | 26 | 21,990 | 22 | 1.5 |
| Urinals | 883 | 0.04% | 441 | 70 | 30,743 | 6 | 3.9 |
| Wash Basin Tap | 937 | 0.04% | 422 | 337 | 1,42,058 | 59 | 18.7 |
| Others | 625 | - | - | - | - | - | - |
| **Total** | **12,762** | **0.56%** | **6,144** | | **6,20,124** | | **5.6** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.9 ADMINISTRATION

### METHODOLOGY

The Administration sector includes the Auroville town hall compound with its multiple departments, SAIIER building, SEWA, the social research centre etc. The baseline water consumption was calculated using the sample water audit findings for the per capita/day consumption per worker/employee multiplied by the estimated total number of workers/employees in this sector.

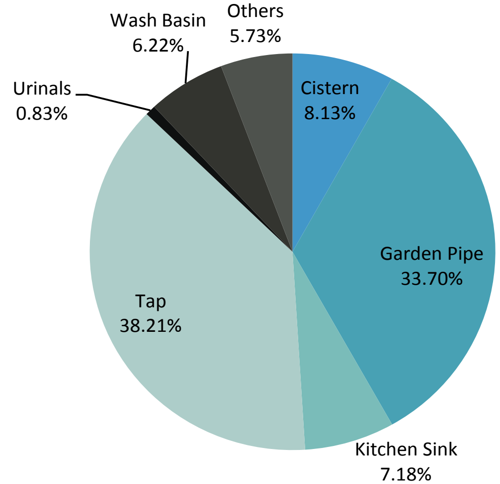
### BASELINE

The annual revenue water consumption for the Administration sector is estimated at 13,147 KL. The average per capita/day consumption per worker/employee amounts to 231 L (see Table 26). Figure 32 shows the highest water consuming fixtures/applications in this sector, namely the taps with 38% (or 5,024 KL) and garden pipes with 34% (or 4,431 KL) of the Administration sector baseline. Cisterns account for 8% of water consumption, followed by kitchen sink taps (7%), wash basin taps (6%) and others (6%).

*Table 26 Administration Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 231 L |
| Number of Workers/Employees | 202 |
| Revenue Water | 13,147 KL |
| Non-Revenue Water | 5,635 KL |

*Figure 32 Administration Sector Water Baseline per Fixture/Application in %, Auroville 2014*




### SAVING POTENTIAL

Garden pipes are the fixtures/applications with the highest water saving potential of 0.32% (or 3,544 KL) of the overall water baseline for Auroville. Replacing existing inefficient taps with more efficient ones can achieve water savings of 0.27%, whereas interventions for the other fixtures promise only minute water savings (see Figure 33).

Figure 34 indicates the capital investment required for water efficiency interventions per KL of water saving. The most cost efficient water efficiency interventions are for garden pipes and kitchen sink taps with a capital investment of INR 4 per KL of water saving for each.

*Figure 33 Administration Sector Water Saving Potential by Type of Fixture in % of Total Water Consumption, Auroville 2014*

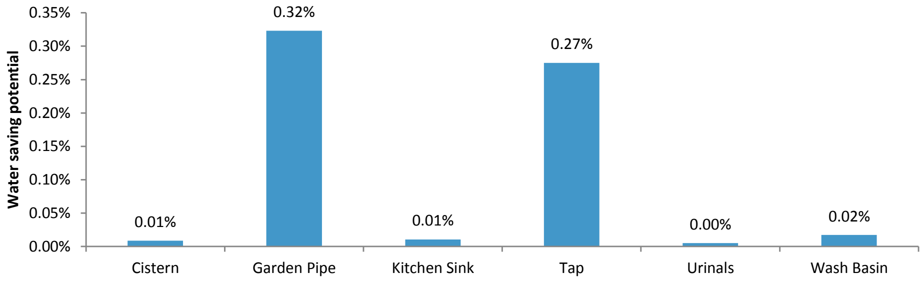



*Figure 34 Administration Sector Capital Investment Required per KL of Water Saved per Type of Fixture/Application in INR, Auroville 2014*

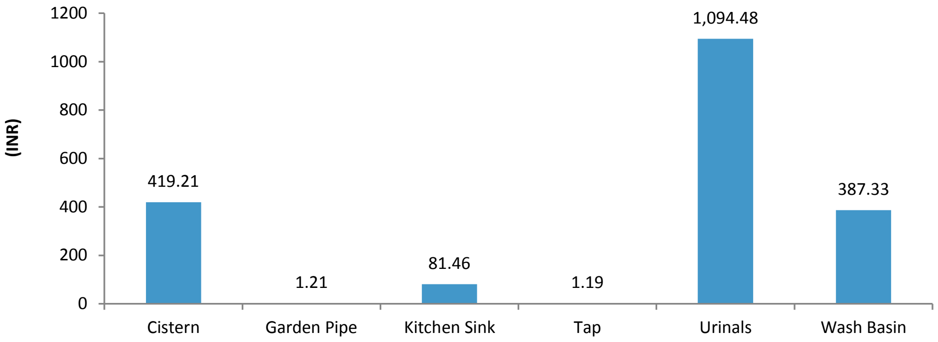



Table 27 summarizes the findings for the Administration sector of Auroville, listing its water saving potential, the investment requirement, the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 27 Administration Sector Water Baseline, Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 1,069 | 0.01% | 95 | 419 | 40,020 | 8 | 23.3 |
| Garden Pipe | 4,431 | 0.32% | 3,544 | 1 | 4,288 | 7 | 0.1 |
| Kitchen Sink Tap | 944 | 0.01% | 116 | 81 | 9,429 | 4 | 4.5 |
| Tap | 5,024 | 0.27% | 3,014 | 1 | 3,573 | 4 | 0.1 |
| Urinals | 110 | 0.00% | 55 | 1,094 | 59,935 | 12 | 60.8 |
| Wash Basin Tap | 818 | 0.02% | 187 | 387 | 72,522 | 30 | 21.5 |
| Others | 753 | - | - | - | - | - | - |
| **Total** | **13,147** | **0.64%** | **7,012** | | **1,89,767** | | **1.5** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.10 HEALTH SERVICES

### METHODOLOGY

The Health Services sector includes the Auroville Dental Clinic, Kailash Clinic and Auroville Health Service. The baseline water consumption has been calculated using the sample water audit findings for the per capita/day consumption per worker/employee multiplied by the estimated total number of workers/employees in this sector.

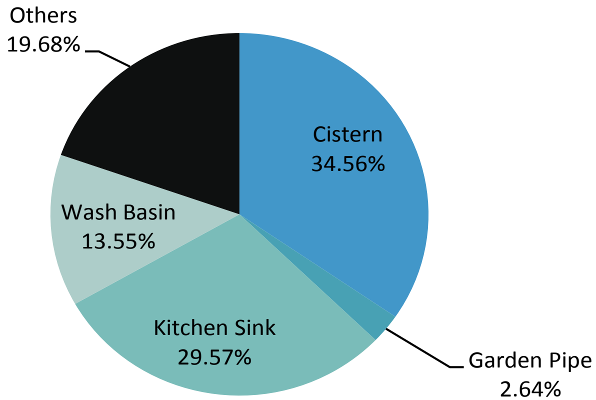
### BASELINE

The annual revenue water consumption for the Administration sector is estimated at 6,057 KL. The average per capita/day consumption per worker/employee amounts to 61 L (see Table 28). Figure 35 indicates the water consumption per type of fixture/application of the baseline for the Health services sector. The highest water consuming fixtures/applications are cisterns with 34% (or 2,092 KL) and kitchen sink taps with 30% (or 1,790 KL).

*Table 28 Health Services Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 61 L |
| Number of Workers/Employees | 317 |
| Revenue Water | 6,057 KL |
| Non-Revenue Water | 2,595 KL |

*Figure 35 Health Services Sector Water Baseline per Fixture/Application in %, Auroville 2014*




## SAVING POTENTIAL

For the Health Services sector, the highest water saving potential was identified for cisterns with 0.11% (or 1,255 KL) and kitchen sink taps with 0.07% (or 806 KL) of the overall water baseline for Auroville (see Figure 36).

Figure 37 indicates the capital investment required for water efficiency interventions per KL of water saving. The most cost efficient water efficiency interventions are for the two main water consuming fixtures in the Health Services sector, namely cisterns (INR 115) and kitchen sink taps (INR 37). While the capital investment of INR 115 for each KL of water saving for cisterns is comparatively high, the water efficiency interventions for the kitchen sink tap are recommended.

*Figure 36 Health Services Sector Water Saving Potential by Type of Fixture in % of Total Water Consumption, Auroville 2014*

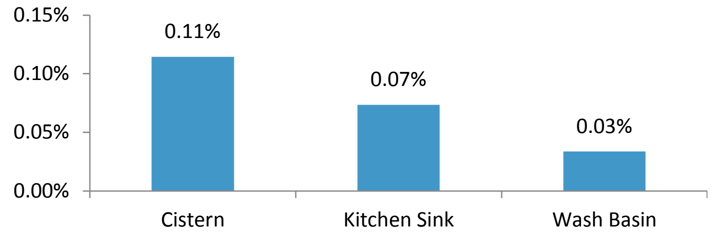



*Figure 37 Health Services Sector Capital Investment Required per KL of Water Saved per Type of Fixture in INR, Auroville 2014*

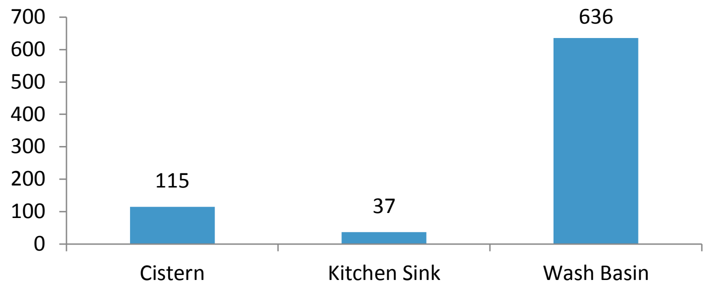



Table 29 summarizes the findings for the Administration sector of Auroville, listing its water saving potential, the investment required, the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 29 Health Services Sector Water Baseline, Savings per Fixture/Application and Financial Parameters, Auroville 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 2,092 | 0.11% | 1,255 | 115 | 1,44,138 | 29 | 6.4 |
| Garden Pipe | 160 | 0.00% | 0 | 0 | 0 | 0 | 0.0 |
| Kitchen Sink Tap | 1,790 | 0.07% | 806 | 37 | 29,651 | 12 | 2.0 |
| Wash Basin Tap | 820 | 0.03% | 369 | 636 | 2,34,739 | 98 | 35.3 |
| Others | 1,192 | - | - | - | - | - | - |
| **Total** | **6,054** | **0.22%** | **2,430** | | **4,08,527** | | **9.3** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.11 FOOD PROCESSING

### METHODOLOGY

The Food Processing sector includes restaurants and small food processing units such as bakeries, jam, tofu producers etc. The baseline for this sector has been calculated using the sample water audit findings for the per capita/day consumption per worker/employee multiplied by the estimated total number of workers/employees in this sector.

### BASELINE

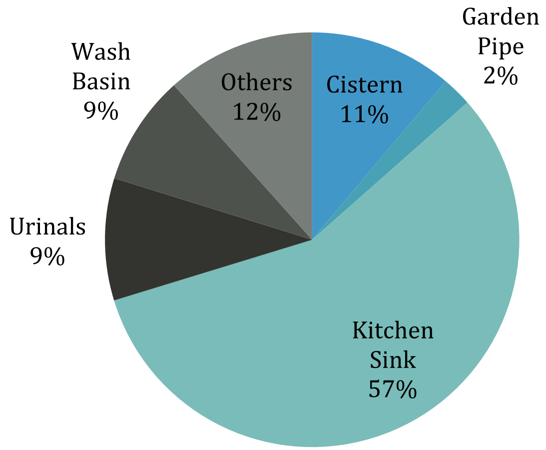
The total annual revenue water consumption for the Food Processing sector is estimated at 19,744 KL. The average per capita/day consumption per worker/employee amounts to 519 L (see Table 30).

The kitchen sink tap accounts for 54% (or 26,159 KL) of this sector's water consumption, making it the main water consuming fixture in this sector (see Figure 38). Cisterns account for 11% (5,140 KL) of water consumption, urinals and wash basins for 9%, respectively (3,957 KL).

*Table 30 Food Processing Sector Water Baseline, Auroville 2014*

| | |
|---|---|
| Per Capita/Day Water Consumption | 219 L |
| Number of Workers/Employees | 519 |
| Revenue Water | 46,070 KL |
| Non-Revenue Water | 19,744 KL |

*Figure 38 Food Processing Sector Water Baseline per Fixture/Application in %, Auroville 2014*




### SAVING POTENTIAL

For the Food Processing sector, the highest water saving potential was found for kitchen sink taps with 1.07% (11,771 KL), followed by cisterns with 0.28% (3,084 KL) and urinals with 0.20% (2,193 KL) of the total Auroville water consumption (see Figure 39).

Figure 40 indicates the capital investment required for water efficiency interventions per KL of water saving. The most cost efficient water efficiency interventions are for urinals and garden pipes with a capital investment requirement of INR 4 per KL of water saving. Replacing inefficient kitchen sink taps with more efficient ones requires a capital investment per KL of water saving of INR 21. This intervention is both cost effective and can achieve high water savings and is therefore recommended.

*FIGURE 39 FOOD PROCESSING SECTOR WATER SAVING POTENTIAL BY TYPE OF FIXTURE IN % OF TOTAL, AUROVILLE 2014*

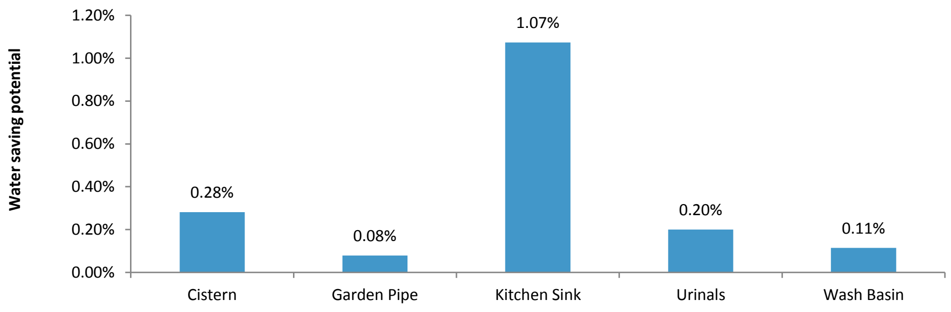



*FIGURE 40 FOOD PROCESSING SECTOR CAPITAL INVESTMENT REQUIRED PER KL OF WATER SAVED PER TYPE OF FIXTURE/APPLICATION IN INR, AUROVILLE 2014*

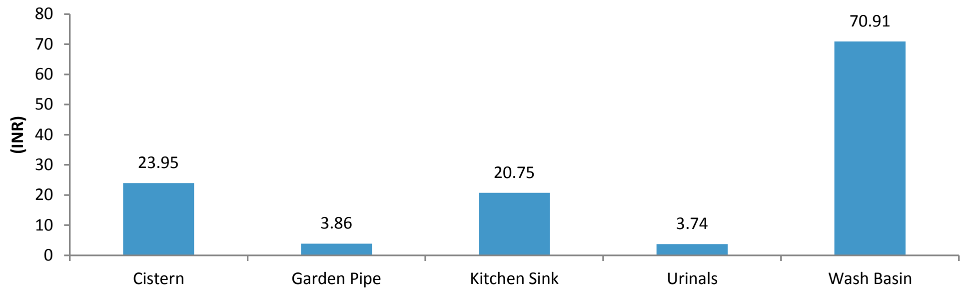



Table 31 summarizes the findings for the Food Processing sector of Auroville, listing its water saving potential, the investment required, the number of fixtures required to achieve water savings and also indicates the payback period for each intervention. The most promising intervention in terms of payback period and achievable water savings is highlighted in colour.

*TABLE 31 FOOD PROCESSING SECTOR WATER BASELINE, SAVINGS PER FIXTURE/APPLICATION AND FINANCIAL PARAMETERS, AUROVILLE 2014*

| Fixtures | Revenue Water in KL | Water Savings in % of Total | Water Savings in KL | Investment per KL of Water Saved in INR | Investment in INR | No. of Fixtures | Payback Period in yr. |
|---|---|---|---|---|---|---|---|
| Cistern | 5,140 | 0.28% | 3,084 | 24 | 73,871 | 15 | 0.0 |
| Garden Pipe | 1,075 | 0.08% | 860 | 4 | 3,322 | 5 | 0.2 |
| Kitchen Sink Tap | 26,159 | 1.07% | 11,771 | 21 | 2,44,281 | 98 | 1.2 |
| Urinals | 4,386 | 0.20% | 2,193 | 4 | 8,208 | 2 | 0.2 |
| Wash Basin Tap | 3,957 | 0.11% | 1,250 | 71 | 88,614 | 37 | 3.9 |
| Others | 5,353 | - | - | - | - | - | - |
| **Total** | **46,070** | **1.75%** | **19,158** | | **4,18,296** | | **1.2** |

*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.12 AGRICULTURE

### METHODOLOGY

Currently, there are 17 established farms in Auroville with a cumulative area of active cultivation of 147 acres. The average water consumption per acre was established using existing water meter readings of three farms for a period of one year. Details on crop patterns and their existing water requirements were not available. Hence, the average of existing data's per acre water consumption was used to establish the water baseline for the Agriculture sector.

### BASELINE & SAVING POTENTIAL

The total annual water consumption for the Agriculture sector is estimated at 2, 29,699 KL or 1,558 KL per cultivated acre. Out of the total 147 acres of cultivated farmland, about 88 acres are irrigated using more efficient water technologies such as sprinklers and drip irrigation. For the remaining 59 acres of farmland, a saving potential of 3.35% (36,751 KL) of the total Auroville water baseline was identified. To realise this water saving potential, a total capital investment of INR 14.47 lakh or INR 40 per KL of water saving is required.

*Table 32 Agriculture Sector Baseline and Water Saving Potential, Auroville 2014*

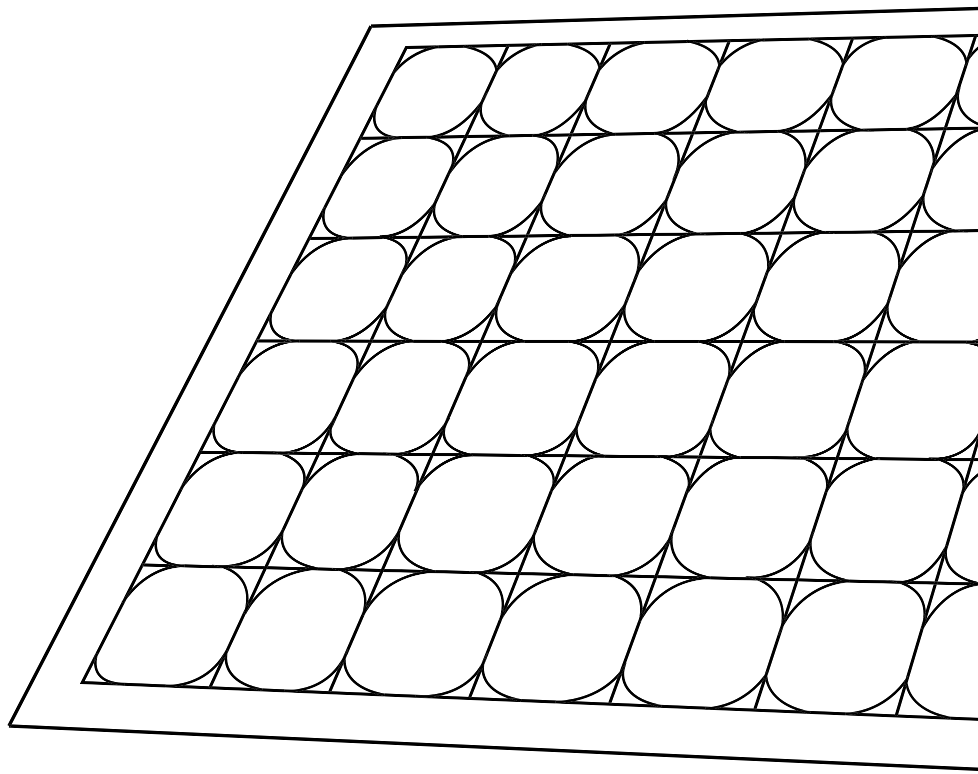
| | |
|---|---|
| Total Number of Acres Cultivated 2014 | 147 acres |
| Acres under Micro Irrigation | 88 acres |
| Acres under Conventional Irrigation | 59 acres |
| Per Acres Water Consumption/yr. | 15,58,334 L |
| Revenue Water | 2,29,699 KL |
| Saving Potential by Micro Irrigation (40 %)* | 36,751 KL |
| Saving Potential in % of Total | 3.35% |
| Investment per KL of Water Saved | 40 INR |
| Total Investment | 14,74,000 INR |
| Payback Period | 2.3 yr. |

** assumed*

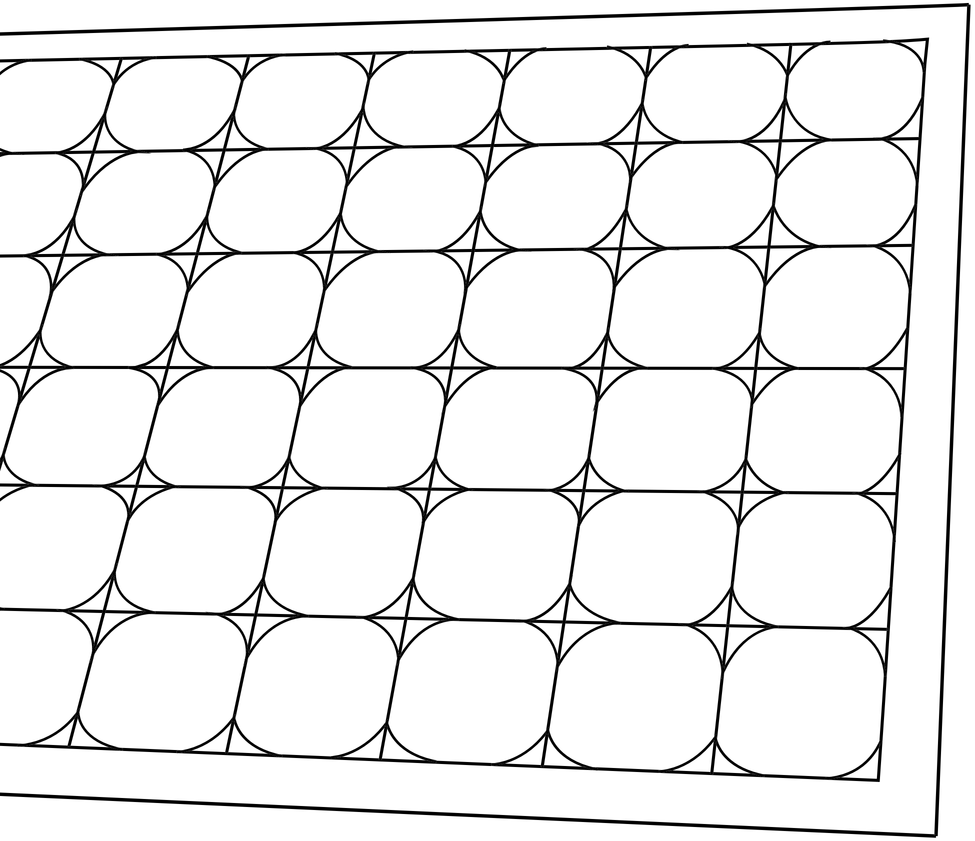
*For calculating the payback period, an average price per KL of water of INR 18 has been considered.*

## 3.13 GOOD WATER SAVING PRACTICES AUROVILLE

- **AFSANAH GUEST HOUSE:** use of small cartoon illustrations to instruct guests and request for water conservation practices
- **CITADINE, RESIDENTIAL COMMUNITY:** reuse of recycled waste water for landscaping and urban farming purposes
- **SAIIER, OFFICE BUILDING:** installation of aerated, highly water efficient water taps and low volume flush toilets
- **AUROVILLE PAPERS, MANUFACTURING:** use of pull-up-and-release taps as an efficient method of instant closing of the running tap when not in use, increasing water consumption efficiency
- **PITANGA COMMUNITY CENTRE:** use of highly water efficient, low-flow sensor type wash basin taps
- **AUROVILLE TOWN HALL:** use of water-less urinals which saves almost 100% water lost in urinals



# 2. ENERGY BASELINE SAVING OPPORTUNITIES



# 4. ENERGY BASELINE & SAVING OPPORTUNITIES

## 4.1 OVERALL FINDINGS

### METHODOLOGY

The energy baseline for Auroville has been established using multiple data sources. Data for electric energy consumption per service connection number and sub-meters was available for a period of five years.

Table 33 lists the number of sites per sector, the number of installed electric meters and the number of energy audits conducted for establishing this master plan. Data on the installed capacity of renewable energy technologies was obtained from the local solar PV installers. Data on firewood and diesel consumption for operating diesel generators was collected via telephone survey. The data for LPG gas was obtained by the Auroville Gas services, with additional telephone surveys to cover the Manufacturing & Handicraft and Food Processing sectors.

Energy saving opportunities were exclusively established for electric energy. The findings from sample energy audits were used to estimate the total saving potential by type of fixture/application for each sector. Only those fixtures are proposed for replacement by more efficient ones where the payback period is shorter than the life span of the new fixtures.

*Table 33 Number of Sites, TNEB Meters and Audits Conducted per Sector, Auroville 2014*

| Sector | Sites | TNEB Meters | Energy Audits |
|---|---|---|---|
| Administration | 7 | 9 | 3 |
| Agriculture | 9 | 12 | 0 |
| Commercial | 32 | 33 | 2 |
| Community & Culture | 22 | 25 | 4 |
| Municipal Pump | 30 | 32 | 4 |
| Education | 37 | 50 | 3 |
| Food Processing | 15 | 15 | 4 |
| Guest Houses | 22 | 25 | 4 |
| Health Services | 2 | 4 | 1 |
| Manufacturing & Handicraft | 46 | 47 | 3 |
| Public Service | 16 | 16 | 2 |
| Residential | unknown | 799 | 12 |

*For a more detailed listing of units under the various sectors refer to Annexure 1.*

### BASELINE

Auroville's total energy demand for 2014 is estimated at 9,299 MWh. This represents a total $CO_2$ footprint of 4,812 tonnes (see Figure 41). Electric energy from the utility grid caters to 43% of the total energy supply. Thermal energy sources such as firewood and LPG account for 25%, diesel and petrol for 19%, while renewable energy technologies cover 14% of Auroville's energy demand (see Table 34). Renewable energy technologies deployed at Auroville are solar PV (off and on-grid), solar thermal (water heaters and concentrators for steam generation), biogas digesters and wind (mechanical turbines for water pumping and mini-wind turbines for electric energy production). Figure 42 indicates the annual power generation by the various renewable energy technologies deployed by sector. Auroville has a total installed wind capacity of 3.2 MW in the Coimbatore area of Tamil Nadu, producing an average of 5,690 MWh of electricity per annum. These wind turbines have not been considered in the energy baseline. Currently, the electric energy produced by the wind turbines is sold to the state utility. Future plans for wheeling of this wind energy are being explored. The total $CO_2$ offsets of the wind turbines is 9,016 $TCO_2E$/year. The total estimated $CO_2$ footprint for Auroville 2014 is estimated at 4,812 $TCO_2E$/year. Considering the $CO_2$ offset of the wind turbines, Auroville has a net positive balance in $CO_2$ footprint of 4,204 $TCO_2E$/year.

*Table 34 Overview of Energy Data, Auroville 2014*

| Sources | Consumption in MWh/yr. | % of Total | $CO_2$ Emissions in $TCO_2E$/yr. | % of Total |
|---|---|---|---|---|
| TNEB | 3,965 | 43% | 3,767 | 78% |
| Renewables | 1,260 | 14% | - | 0% |
| Diesel & Petrol * | 1,753 | 19% | 373 | 8% |
| Thermal ** | 2,322 | 25% | 672 | 14% |
| Total | 9,299 | 100% | 4,812 | 100% |

** Diesel & Petrol contains fuel for diesel generators and motorized transport.*
*** Thermal contains LPG and fire wood.*

*Figure 41 Energy and $CO_2$ Baseline by Source, Auroville 2014*

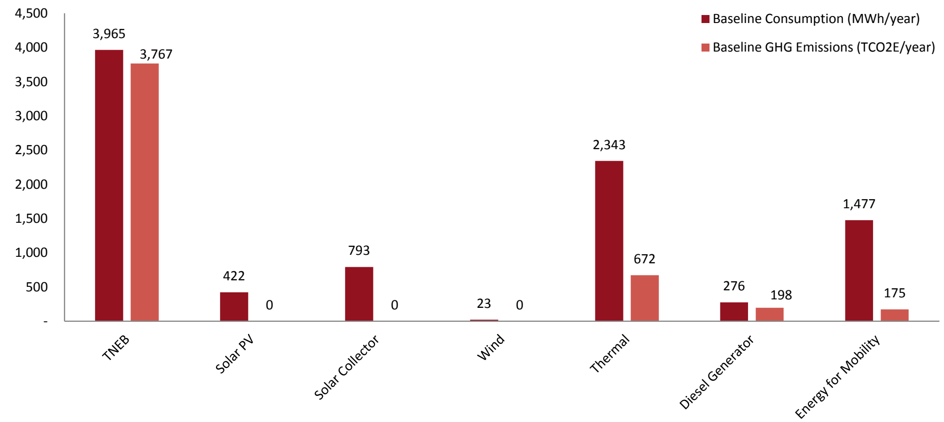
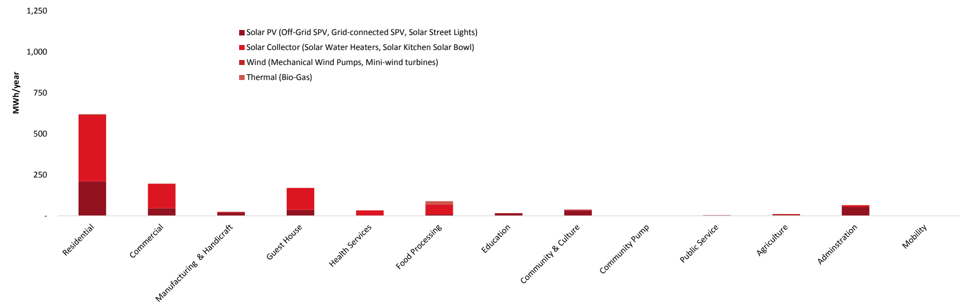



*Figure 42 Energy Source from Renewable Technologies, Auroville 2014*




The average per capita/year energy consumption for Auroville is estimated at 4,019 kWh, which is low compared with the equivalent value for India of 7,592 kWh in 2014 (Wikipedia, 2012). However, for the energy baseline of Auroville, the transport sector (taxi services and petrol consumption for tractors and machinery) was not included as no data recordings were available. The average annual per capita electricity consumption for Auroville is estimated at 2,023 kWh, while the equivalent value for Tamil Nadu is only 1,277 kWh in 2014 (Wikipedia, 2013). The average per capita household electricity consumption for Auroville stands at 990 kWh per annum and compares to 1,131 kWh for Tamil Nadu in 2014 (Deccan Chronicle, 2014). The overall per capita consumption of LPG (including all sectors) in Auroville amounts to 523 kWh per annum, with an equivalent value for Tamil Nadu of 509 kWh in 2014 (Ministry of Statistics and Programme Implementation, 2012). Table 35 indicates the annual total and per capita consumption for various sources in Auroville.

*Table 35 Per Capita/Year and Total Energy Consumption by Selected Types, Auroville 2014*

| Item | Per capita/yr. in kW | Total 2014-15 in MWh |
|---|---|---|
| Energy | 4,019 | 9,299 |
| Electricity | 2,023 | 4,681 |
| LPG | 523 | 1,211 |
| Petrol & Diesel (for Transport) | 638 | 1,477 |
| Household Electricity | 990 | 2,290 |

The Residential sector is the most energy-intensive sector of Auroville and accounts for 36%, or 3,330 MWh, of total energy consumption per annum. It is also responsible for 44% of $CO_2$ emissions. The mobility sector makes up 16% of the annual energy consumption, which equates to 9,299 MWh. The Manufacturing & Handicraft sector and the Food Processing sector each account for 7% of Auroville's energy demand, followed by the Commercial and Guest Houses sector with 6% of the energy demand each. For a sector wise listing refer to Table 36 and Figure 43.

*FIGURE 43 ENERGY AND $CO_2$ BASELINE BY SECTOR, AUROVILLE 2014*

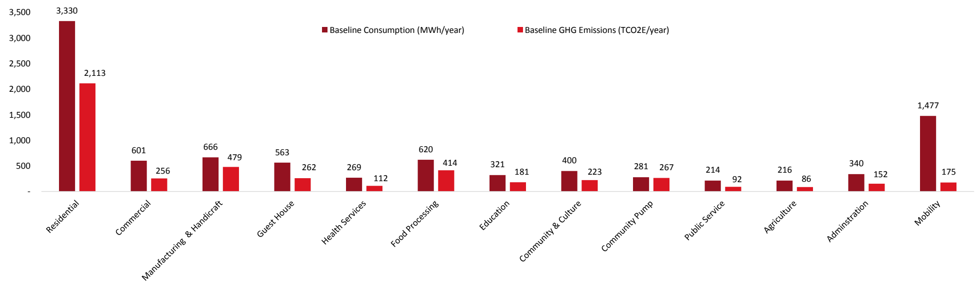



*TABLE 36 ENERGY AND $CO_2$ BASELINE BY SECTOR, AUROVILLE 2014*

| Sectors | Baseline Consumption in MWh/yr. | % | Baseline GHG Emissions in $TCO_2E$/yr. | % |
|---|---|---|---|---|
| Residential | 3,330.45 | 36% | 2,112.83 | 44% |
| Commercial | 601.18 | 6% | 255.51 | 5% |
| Manufacturing & Handicraft | 666.03 | 7% | 479.03 | 10% |
| Guest Houses | 562.73 | 6% | 262.09 | 5% |
| Health Services | 269.12 | 3% | 111.70 | 2% |
| Food Processing | 620.45 | 7% | 414.21 | 9% |
| Education | 321.15 | 3% | 180.88 | 4% |
| Community & Culture | 400.31 | 4% | 223.32 | 5% |
| Municipal Pumps | 281.07 | 3% | 267.02 | 6% |
| Public Sector | 214.43 | 2% | 91.92 | 2% |
| Agriculture | 215.70 | 2% | 85.76 | 2% |
| Administration | 340.31 | 4% | 152.11 | 3% |
| Transport | 1,476.54 | 16% | 175.20 | 4% |
| **Total** | **9,299.49** | **100%** | **4,811.60** | **100%** |

The local state utility grid is the main source of Auroville's electric energy supply, covering 85% or 3,965 MWh of Auroville's annual electric energy demand. Locally installed renewable energy technologies supply 9%, or 439 MWh, and back-up diesel generators account for 6%, or 276 MWh, of Auroville's annual electric energy supply (see Figure 44).

Figure 45 indicates the electric energy consumption by sector for 2014. The Residential sector accounts for a total of 49% of Auroville's electric energy demand (2,290 MWh). The Manufacturing & Handicraft sector accounts for 11% (493 MWh), Guest Houses, Commercial sector and Municipal Pumps account for 6% each of the electricity demand.

The current 439 MWh of renewable electricity supply is primarily generated by solar PV off-grid technologies. Figure 46 indicates, however, that especially the Manufacturing & Handicraft, Education and the Administration sectors rely substantially on solar PV grid connected systems for their renewable energy supply.

*FIGURE 44 ELECTRICITY BASELINE BY SOURCE (MWH/YEAR), AUROVILLE 2014*

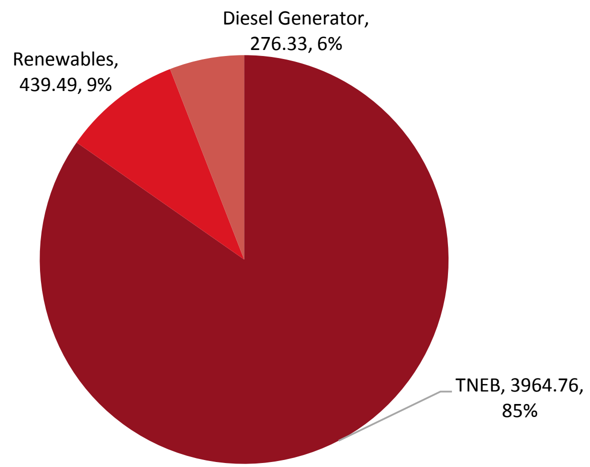


*Figure 45 Electricity Baseline by Sector, Auroville 2014*

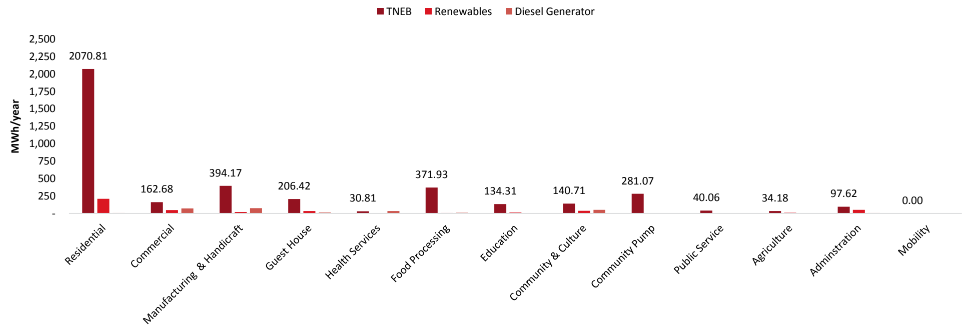



*Figure 46 Electricity from Renewables by Sector, Auroville 2014*

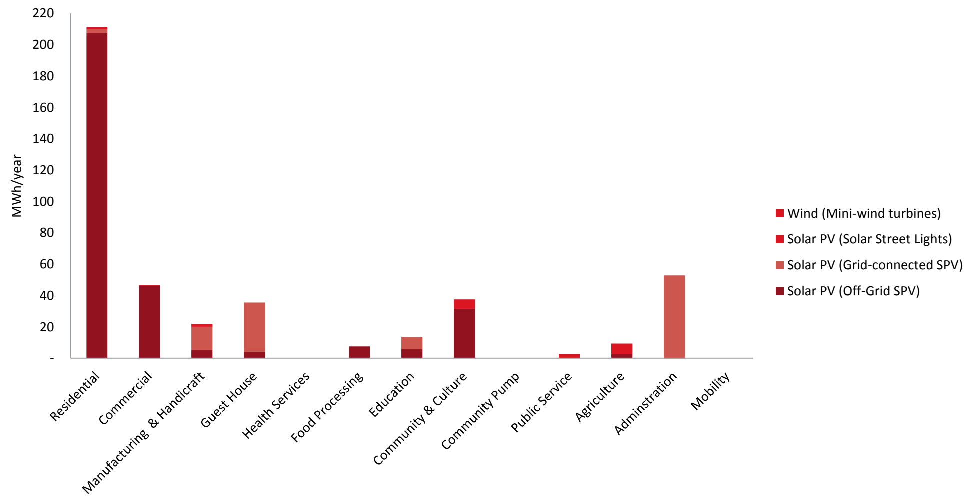
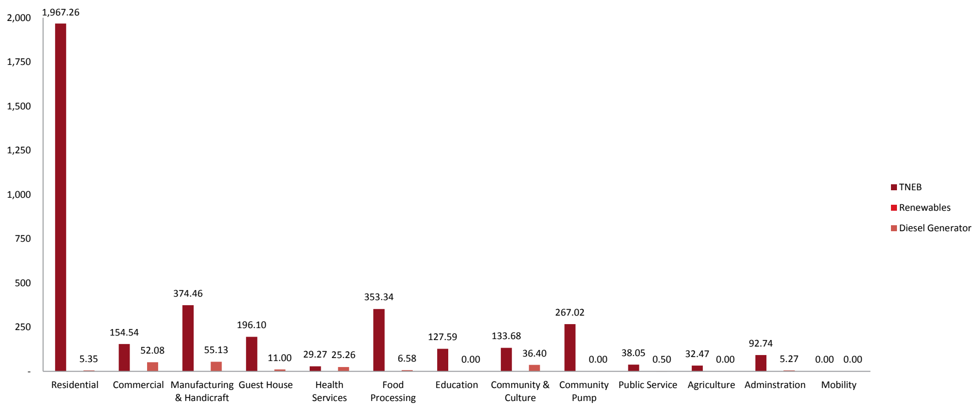
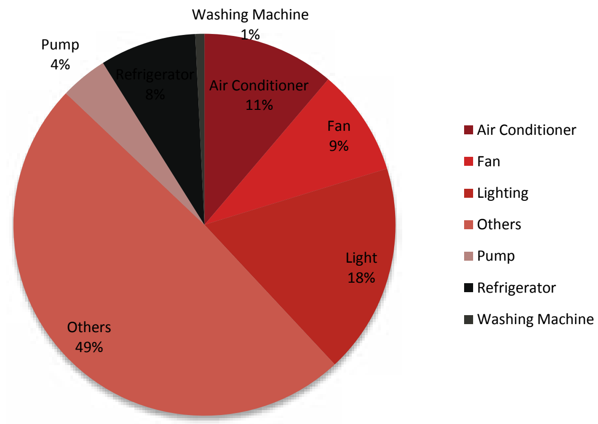



*Figure 47 Baseline $CO_2$ Emissions by Sector, Auroville 2014*




The analysis of overall energy consumption by type of electric fixture/application indicates that 49% of the total electric energy consumption is consumed by the segment Others. This includes manufacturing machinery, food processing machinery and equipment, cold storage, electric water heaters and IT equipment. Lighting accounts for 18% (or 7, 77,553 kWh) of Auroville's energy consumption, followed by air conditioners with 11% (4, 88,770 kWh), fans with 9% (3, 93,357 kWh) and refrigerators with 8% (3, 54,523 kWh). Refer to Figure 48 for the distribution of electricity consumption by type of fixture/application in 2014.

*Figure 48 Electricity Consumption by Type of Fixture/Application, Auroville 2014*



## SAVING POTENTIAL

The total electric energy saving potential identified is 12, 59,595 kWh per annum or 26.9% of the total electricity consumption for Auroville in 2014.

A sector-wise analysis in Figure 49 indicates that the Residential sector promises the highest electricity saving potential with 11.86% (5, 55,081 kWh) of total consumption. Other sectors with substantial energy saving potential are Municipal Pumps with 4.80% (2, 24,606 kWh), Culture & Community with 3.05% (1, 42,792 kWh) and Manufacturing & Handicraft with 2.30% (1, 07,837 kWh) of total energy consumption. It may be noted that the electric energy saving potential in the Agriculture sector is exclusively due to the previously identified water saving potential, which will consequently reduce the electric energy demand for running water pumps. The savings from municipal pumps reflect energy efficiency interventions, such as the installation of more efficient pumps and improved system management, as well as the electricity savings resulting from reduced pumping requirements after the successful implementation of water conservation measures.

Figure 50 indicates the total electricity saving potential by type of fixture/application for Auroville. The highest saving potential is found for lighting with 7.72% or 3, 61,390 kWh of savings per annum. This can be achieved by replacing existing less efficient lights such as T12 tube lights, T8 tube lights, incandescent bulbs and CFLs with more efficient technologies such as T5 tubes, LED tubes, LEDs etc., wherever the payback is within the light fixture's life span. Municipal pumps indicate a saving potential of 4.80% or 2, 24,606 kWh per year. Fans (4.67%), refrigerators (4.45%) and air conditioners (3.19%) still indicate a substantial saving potential.

*FIGURE 49 ELECTRICITY SAVING POTENTIAL BY SECTOR OF TOTAL ELECTRICITY CONSUMPTION, AUROVILLE 2014*

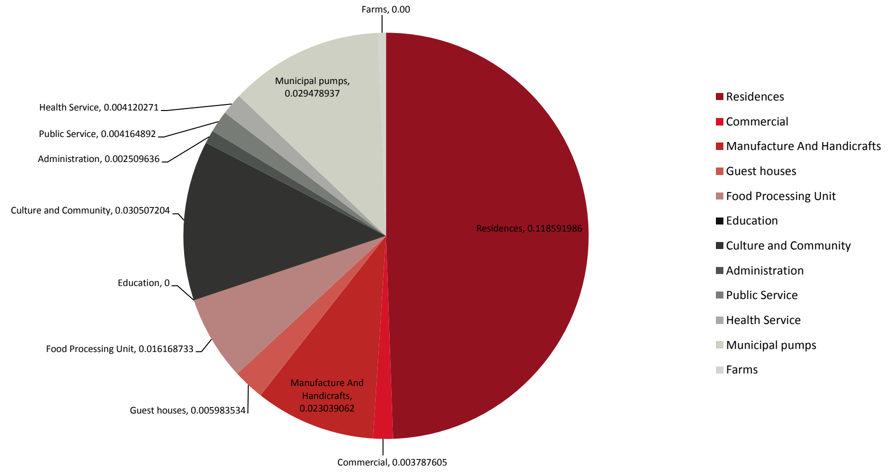
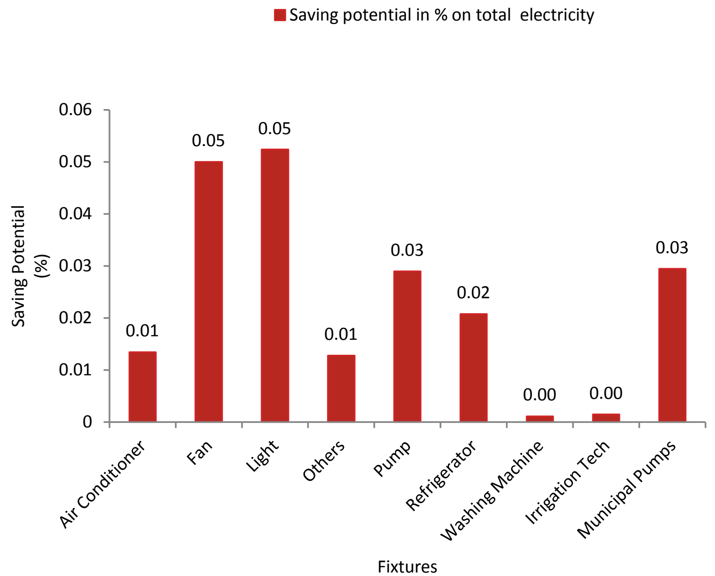
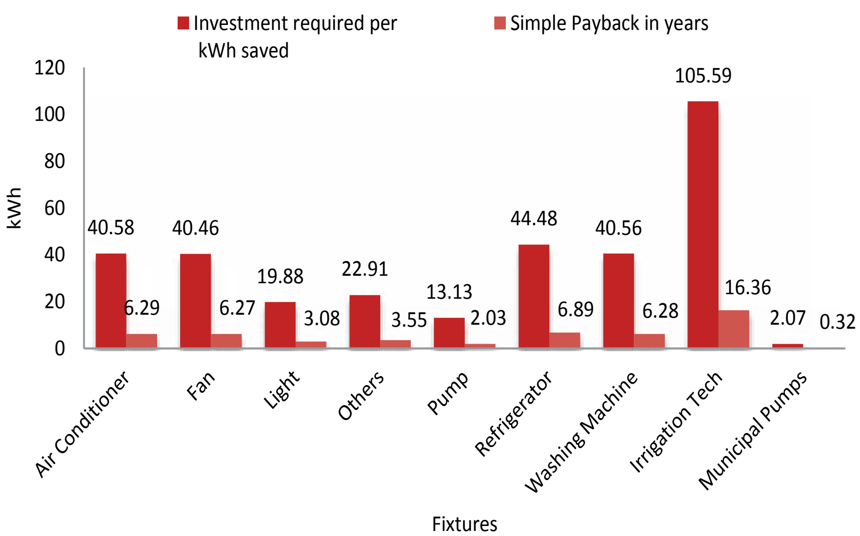



*FIGURE 50 ELECTRICITY SAVING POTENTIAL BY TYPE OF FIXTURE/APPLICATION OF TOTAL CONSUMPTION, AUROVILLE 2014*



The most cost efficient energy efficiency interventions were identified in the Municipal Pump sector with a capital investment requirement of INR 13.13 per kWh electricity saving and a payback period of less than one year. For lighting, the capital investment required per kWh of saving is estimated to be INR 19.88 with a payback period of less than 4 years. Air conditioners indicate a capital investment of INR 40.58 per kWh saving and a payback of 5 years, and fans show an investment requirement of INR 40.46 per kWh of saving and a payback of 7 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period refer to Figure 51.

*Figure 51 Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*




Irrigation technology refers to the electric energy savings due to the water saving potential identified for the Agriculture sector in the water chapter. Even though the investment to achieve energy savings appears disproportionately high, this intervention will result in both water and electric energy savings.

Table 37 summarizes the findings with regard to the electricity saving potential due to energy efficiency interventions. It lists the electricity and financial saving potential, the investment required and the payback period. The most promising interventions in terms of payback period and achievable water savings are highlighted in colour.

*Table 37 Summary of Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 4,88,770 | 10.44% | 19,13,110 | 3.19% | 149377.9 | 926746.6 | 47,43,082 | 5.12 |
| Fan | 3,93,357 | 8.40% | 26,10,605 | 4.67% | 218798.8 | 1514021. | 109,39,602 | 7.23 |
| Light | 7,75,553 | 16.57% | 45,19,244 | 7.72% | 361390.5 | 2309880. | 78,22,359 | 3.39 |
| Others | 21,35,722 | 45.63% | 101,37,543 | 0.31% | 14300.68 | 84859.21 | 3,25,663 | 3.84 |
| Pump | 1,74,237 | 3.72% | 3,21,994 | 0.00% | 0.00 | 0.00 | - | 0.00 |
| Refrigerator | 3,54,523 | 7.57% | 47,41,311 | 4.45% | 208390.7 | 1451618. | 66,20,960 | 4.56 |
| Washing Machine | 33,738 | 0.72% | 6,79,301 | 1.62% | 75750.14 | 444934.0 | 30,72,238 | 6.90 |
| Water Efficiency | 43,622 | 0.93% | 2,81,637 | 0.15% | 6979.52 | 45061.84 | 7,37,000 | 16.36 |
| Municipal Pumps | 2,81,074 | 6.01% | 18,14,697 | 4.80% | 224606.0 | 1450122. | 2,85,000 | 0.20 |
| **Total** | **46,80,596** | **100%** | **270,19,442** | **26.91%** | **12,59,594** | **82,27,244** | **345,45,908** | **4.20** |

## 4.2 RESIDENTIAL

### METHODOLOGY

The electricity baseline for the Residential sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through the energy audits conducted in residences and was then applied to the overall Residential sector.

### BASELINE

Figure 52 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$). Electric energy from the utility grid accounts for the majority of this sector's energy consumption, followed by thermal energy (LPG, biogas and firewood) and energy by solar thermal collectors for water heating. The total residential electricity consumption for 2014 is estimated at 2,289 MWh. 90.44% of this demand is sourced from the utility grid, 9.23% is supplied by decentralized renewable technologies and 0.33% by stand-by diesel generators. The average per capita/year electricity consumption amounts to 989.51 kWh (see Table 38). Most of the renewable electricity is supplied by solar PV systems with 210 MWh per annum. The few mini wind turbines account for 2 MWh of annual electricity supply (see Figure 53).

*FIGURE 52 RESIDENTIAL SECTOR ENERGY CONSUMPTION AND $CO_2$ BASELINE BY SOURCE,*

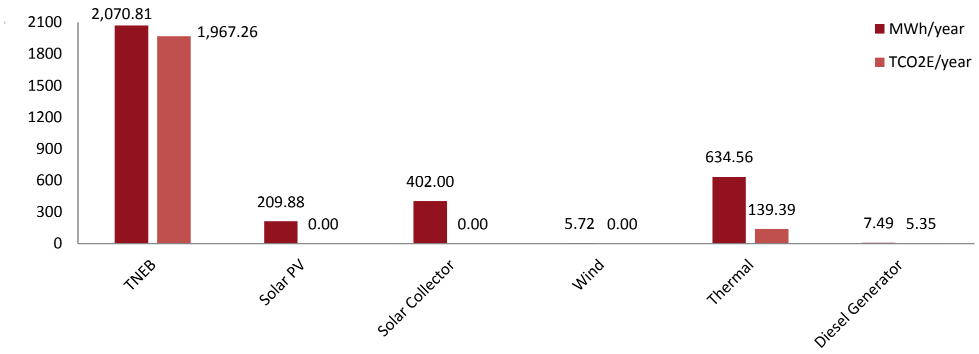
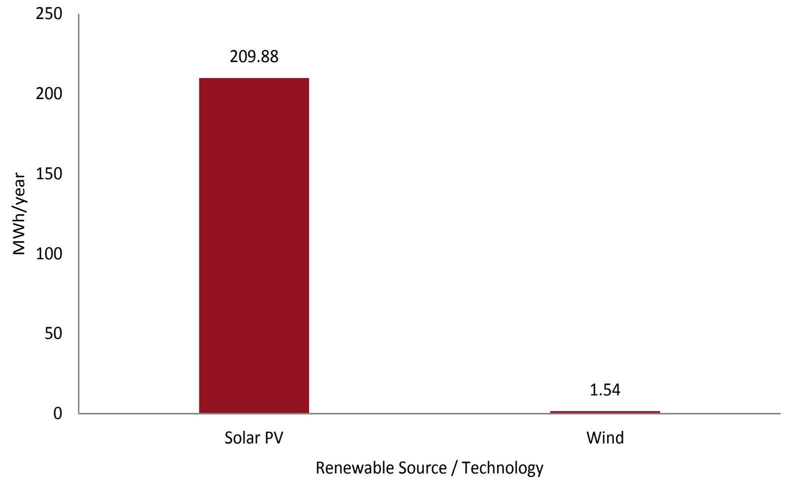



*TABLE 38 RESIDENTIAL SECTOR ELECTRICITY BASELINE BY SOURCE AND PER CAPITA ELECTRICITY CONSUMPTION, AUROVILLE 2014*

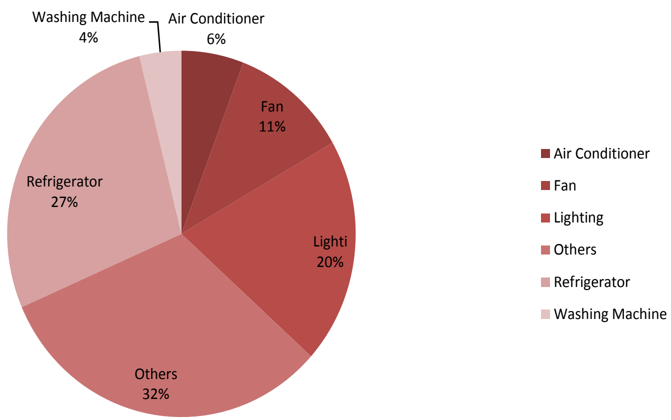
| | | |
|---|---|---|
| TNEB | 20,70,805 kWh | 90.44% |
| Renewables | 2,11,423 kWh | 9.23% |
| Diesel Generator | 7,488 kWh | 0.33% |
| Total Electric Energy Demand | 22,89,716 kWh | 100% |
| **Per Capita/Day** | **989.51 kWh** | |

*FIGURE 53 RESIDENTIAL RENEWABLE ENERGY BY TYPE, AUROVILLE 2014*




The analysis of overall energy consumption by type of electric fixture/application indicates that 32% of the total electric energy consumption is consumed by the segment Others. This includes electric water heaters, kitchen equipment, stoves, television, mobile phones, computes and other IT equipment. Refrigerators account for 27% or 6, 33,593 kWh of the Residential sector's electricity consumption, followed by light with 20% (4, 56,715 kWh) and fans with 11% (2, 50,191 kWh). Refer to Figure 54 for the distribution of electricity consumption by type of fixture/application in 2014.

*FIGURE 54 RESIDENTIAL SECTOR ELECTRICITY CONSUMPTION BY TYPE OF FIXTURE/APPLICATION, AUROVILLE 2014*



## SAVING POTENTIAL

Figure 55 indicates the electricity saving potential by type of fixture/application for the Residential sector. The total saving potential for the Residential sector amounts to 5, 55,081 kWh or 11.86% of the total electricity consumption in Auroville. Light applications show the highest saving potential with 4.52% or 2, 11,387 kWh of electricity saving per annum. The identified saving potential for air conditioners is 2.50% or 1, 17,175 kWh per year, 2.06% for refrigerators and 1.17% for fans.

The most cost efficient energy efficiency intervention is for lights with a capital investment requirement of INR 16.24 per kWh electricity saving and a payback period of less than 3 years. Energy efficiency interventions for air conditioners are expected to result in a payback period of 4.6 years, less than 5 years for refrigerators and about 6 years for fans. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 56.

*FIGURE 55 ELECTRICITY SAVING POTENTIAL BY TYPE OF FIXTURE/APPLICATION OF TOTAL CONSUMPTION, AUROVILLE 2014*

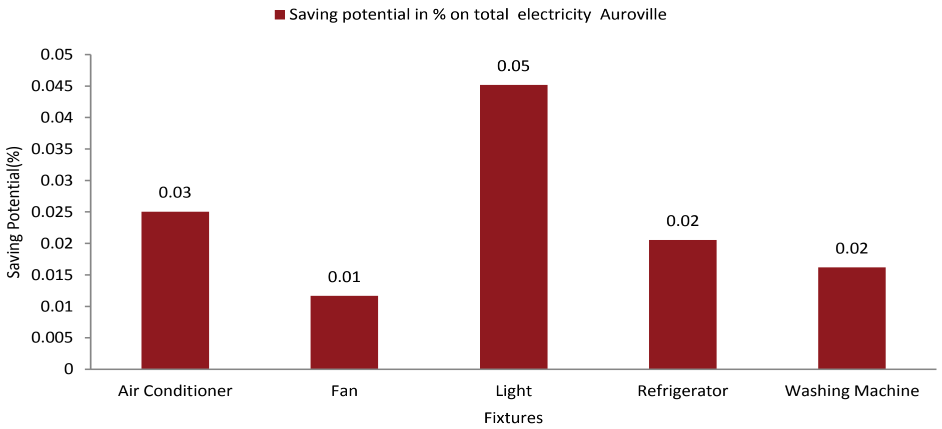



*FIGURE 56 PAYBACK AND INVESTMENT REQUIRED PER KWH SAVING BY FIXTURE/APPLICATION IN INR, AUROVILLE 2014*

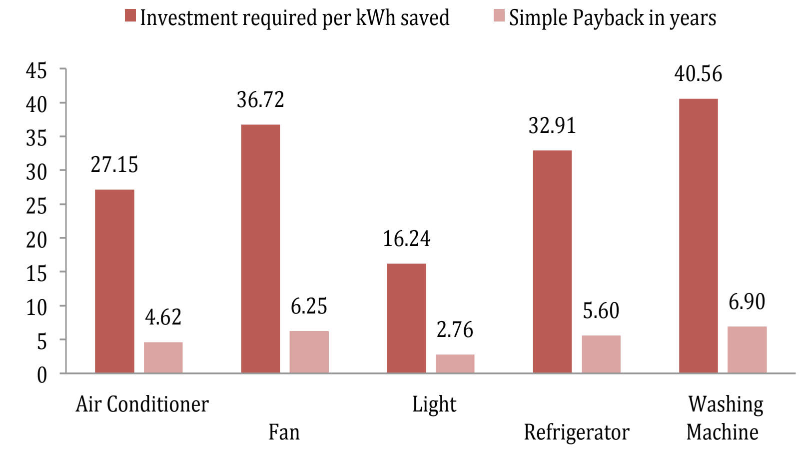



Table 39 summarizes the findings with regard to electricity saving potential through energy efficiency interventions for the Residential sector of Auroville. It lists the electricity and financial saving potential, the investment required and the payback period. The most promising intervention in terms of payback period and achievable electricity savings is highlighted in colour.

*TABLE 39 RESIDENTIAL SECTOR ELECTRICITY SAVING OPPORTUNITIES, AUROVILLE 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 1,32,310 | 6% | 7,77,150 | 2.50% | 1,17,175 | 6,88,249 | 31,81,866 | 4.62 |
| Fan | 2,50,191 | 11% | 14,69,548 | 1.17% | 54,567 | 3,20,513 | 20,03,829 | 6.25 |
| Light | 4,56,715 | 20% | 26,82,611 | 4.52% | 2,11,387 | 12,41,627 | 34,32,120 | 2.76 |
| Others | 7,28,100 | 32% | 42,76,646 | 0.00% | - | - | - | - |
| Refrigerator | 6,33,593 | 28% | 37,21,538 | 2.06% | 96,202 | 5,65,061 | 31,66,230 | 5.60 |
| Washing Machine | 88,806 | 4% | 5,21,623 | 1.62% | 75,750 | 4,44,934 | 30,72,239 | 6.90 |
| **Total** | **22,89,716** | **100%** | **134,49,116** | **11.86%** | **5,55,081** | **32,60,383** | **148,56,284** | **4.56** |

## 4.3 MANUFACTURING & HANDICRAFT

### METHODOLOGY

The electricity baseline for the Manufacturing & Handicraft sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. Saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Manufacturing & Handicraft sector.

### BASELINE

Figure 57 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Manufacturing & Handicraft sector. Electric energy from the utility grid accounts for the majority of this sector's energy consumption with 394 MWh/year, followed by thermal energy (LPG) with 171 MWh/year.

The total electricity consumption of the sector is estimated at 493 MWh per annum. 80% of this demand is sourced from the utility grid, 16% is supplied by decentralized renewable energy technologies and 4% by stand-by diesel generators (see Table 40). Most of the renewable electricity is supplied by solar PV systems with 20 MWh per annum. Mini wind turbines contribute 2 MWh of annual electricity supply (see Figure 59).

*Figure 57 Manufacturing & Handicraft Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

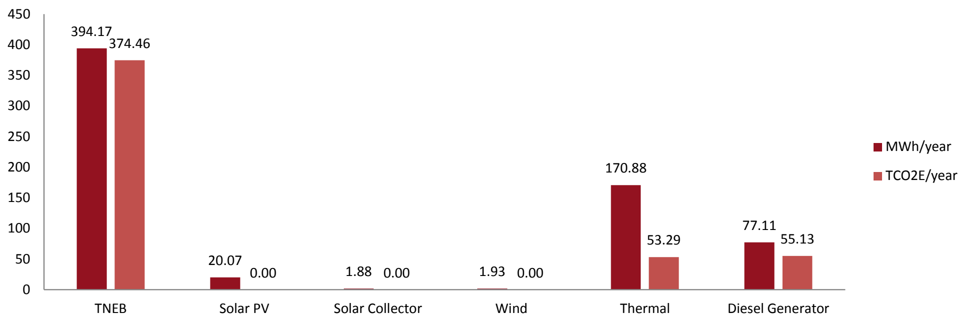



*Table 40 Manufacturing & Handicraft Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 3,94,171 kWh | 80% |
| Renewables | 77,107 kWh | 16% |
| Diesel Generator | 21,997 kWh | 4% |
| **Total Electric Energy Demand** | **4,93,275 kWh** | **100%** |

*Figure 58 Manufacturing & Handicraft Sector, Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*

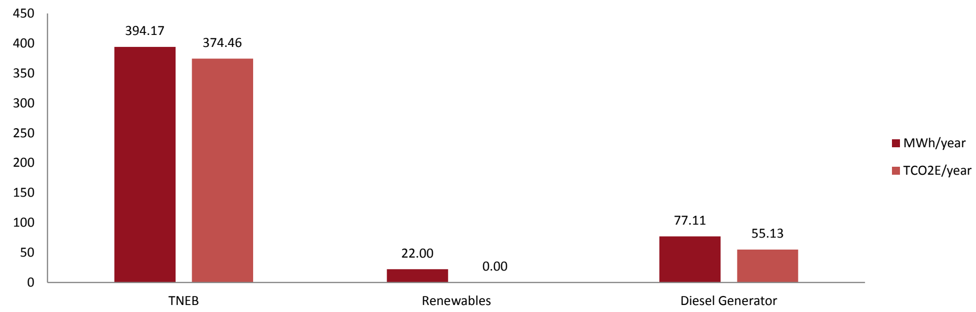
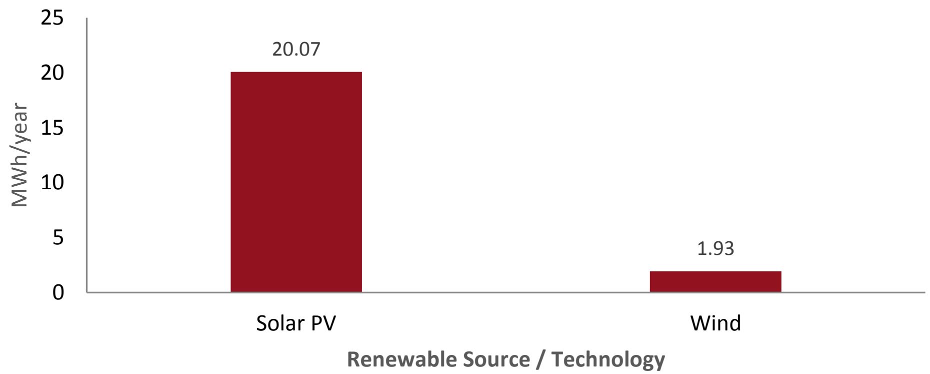
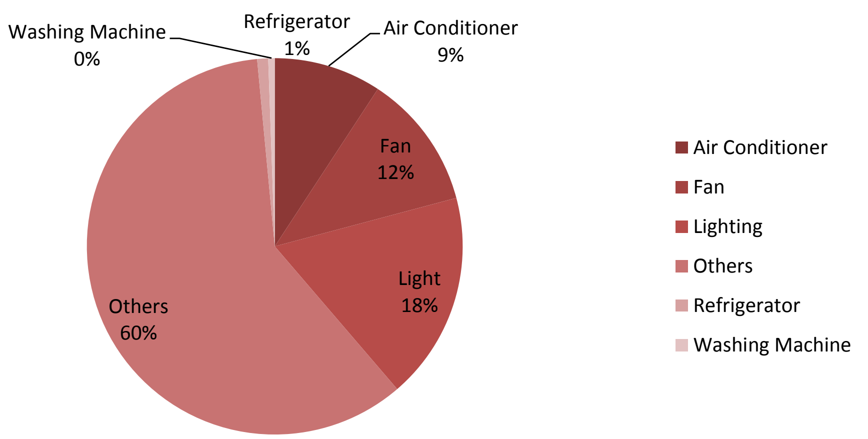



*Figure 59 Manufacturing & Handicraft Sector Renewable Energy by Type, Auroville 2014*



The analysis of overall energy consumption by type of electric fixture/application indicates that 60% of the sector's electricity consumption is consumed by the segment Others. This includes machinery for manufacturing, power tools, and IT equipment. Light accounts for 18% or 80,025 kWh of the sector's electricity consumption, followed by fans with 12% (57,299 kWh). Refer to Figure 60 for a detailed distribution of electricity consumption by type of fixture/application for the Manufacturing & Handicraft sector.

*FIGURE 60 MANUFACTURING & HANDICRAFT SECTOR ELECTRICITY CONSUMPTION BY TYPE OF FIXTURE/APPLICATION, AUROVILLE 2014*




## SAVING POTENTIAL

Figure 61 indicates the electricity saving potential by type of fixture/application for the Manufacturing & Handicraft sector. The total saving potential for the Manufacturing & Handicraft sector amounts to 1, 07,837 kWh or 2.30% of Auroville's total electricity consumption. The highest saving potential was found for fans with 48,778 kWh or 1.04% of Auroville's total electricity consumption. The light segment indicates a saving potential of 0.87% or 40,829 kWh per year.

The most cost efficient energy efficiency intervention is for lights with a capital investment requirement of INR 39.31 per kWh electricity saving and a payback period of 5.3 years. Energy efficiency interventions for fans will result in a payback period of less than 7 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 62.

*FIGURE 61 MANUFACTURING & HANDICRAFT SECTOR ELECTRICITY SAVING POTENTIAL BY TYPE OF FIXTURE/APPLICATION OF TOTAL CONSUMPTION, AUROVILLE 2014*

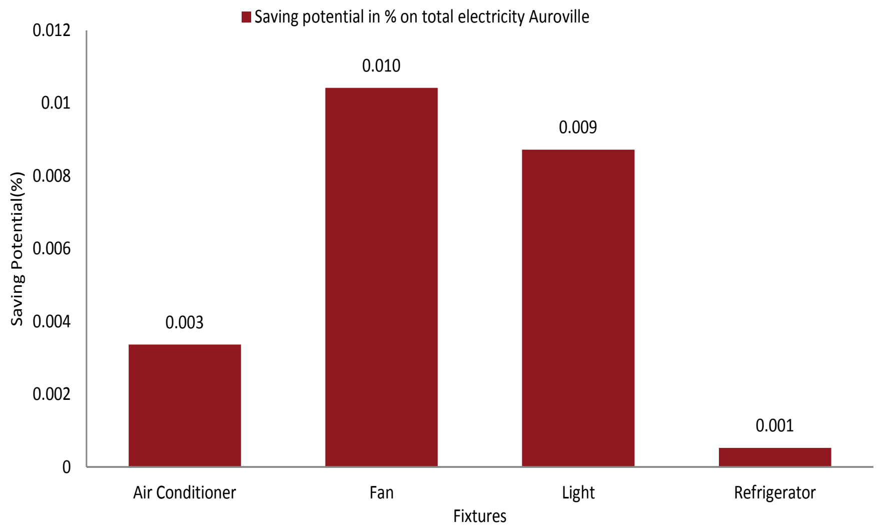



*FIGURE 62 MANUFACTURING & HANDICRAFT SECTOR PAYBACK AND INVESTMENT REQUIRED PER KWH SAVING BY FIXTURE/APPLICATION IN INR, AUROVILLE 2014*

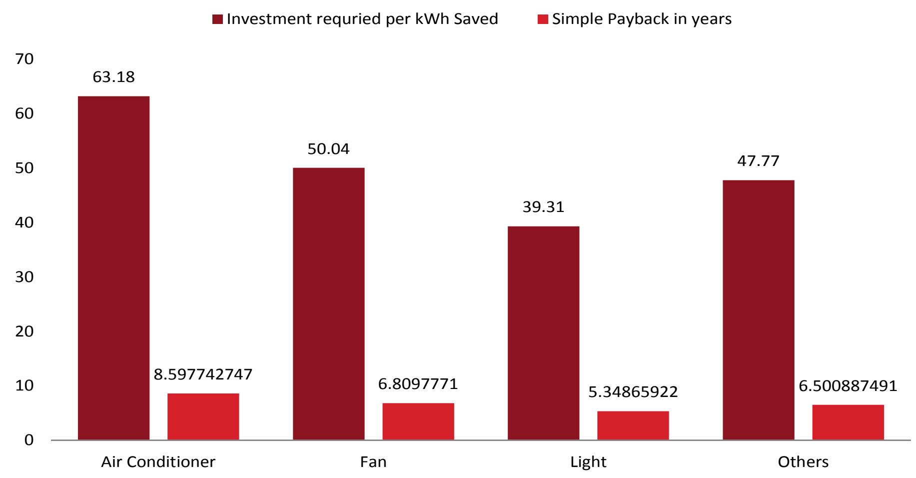


Table 41 summarizes the findings with regard to the electricity saving potential from energy efficiency interventions for the Manufacturing & Handicraft sector of Auroville. It lists the electricity and financial saving potential, the investment requirement and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*TABLE 41 MANUFACTURING & HANDICRAFT SECTOR ELECTRICITY SAVING OPPORTUNITIES, AUROVILLE 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 45,594 | 9% | 16,266 | 0.34% | 15,753 | 1,15,766 | 9,95,322 | 8.60 |
| Fan | 57,299 | 12% | 20,442 | 1.04% | 48,778 | 3,58,451 | 24,40,973 | 6.81 |
| Light | 88,025 | 18% | 31,403 | 0.87% | 40,829 | 3,00,037 | 16,04,796 | 5.35 |
| Others | 2,94,957 | 60% | 1,05,227 | 0.00% | - | - | - | - |
| Refrigerator | 4,645 | 1% | 1,657 | 0.05% | 2,477 | 18,205 | 1,10,591 | 6.07 |
| Washing Machine | 2,756 | 1% | 983 | 0.00% | - | - | - | - |
| **Total** | **4,93,275** | **100%** | **1,75,978** | **2.30%** | **1,07,837** | **7,92,458** | **51,51,682** | **6.50** |

## 4.4 PUBLIC SERVICE

### METHODOLOGY

The electricity baseline for the Public Service sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Public Service sector.

### BASELINE

Figure 63 indicates the total annual energy consumption for 2014 by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Public Service sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with about 171 MWh equivalent, followed by 40 MWh of electricity consumed from the utility grid in 2014.

The total electricity consumption is estimated at 43.55 MWh per annum. 92% of this demand is sourced from the utility grid, 2% is supplied by decentralized renewable technologies and 6% by stand-by diesel generators (see Table 42). All the renewable electricity supplied in this sector comes from solar PV systems with 3 MWh per annum (see Figure 63).

*FIGURE 63 PUBLIC SERVICE SECTOR ENERGY CONSUMPTION AND $CO_2$ BASELINE BY SOURCE, AUROVILLE 2014*

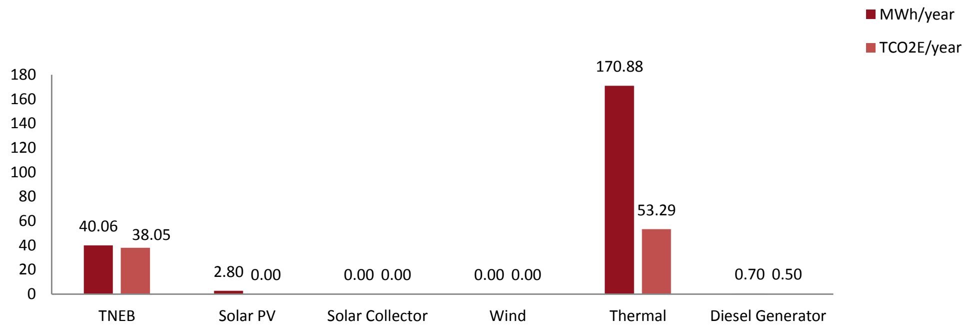
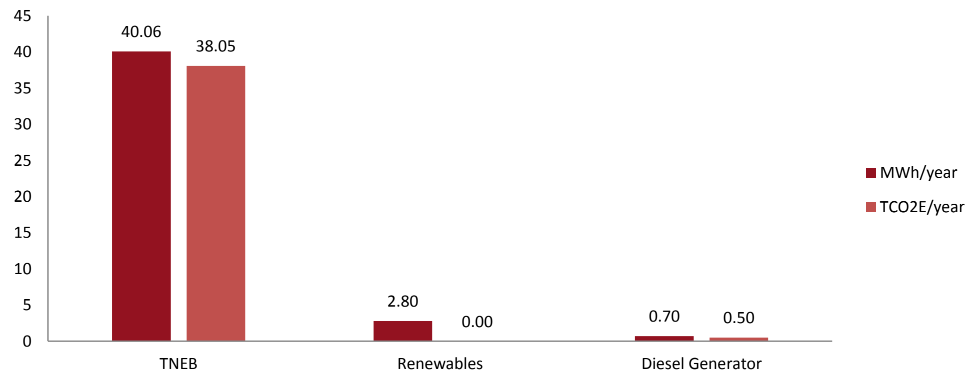



*TABLE 42 PUBLIC SERVICE SECTOR ELECTRICITY BASELINE BY SOURCE AND PER CAPITA ELECTRICITY CONSUMPTION, AUROVILLE 2014*

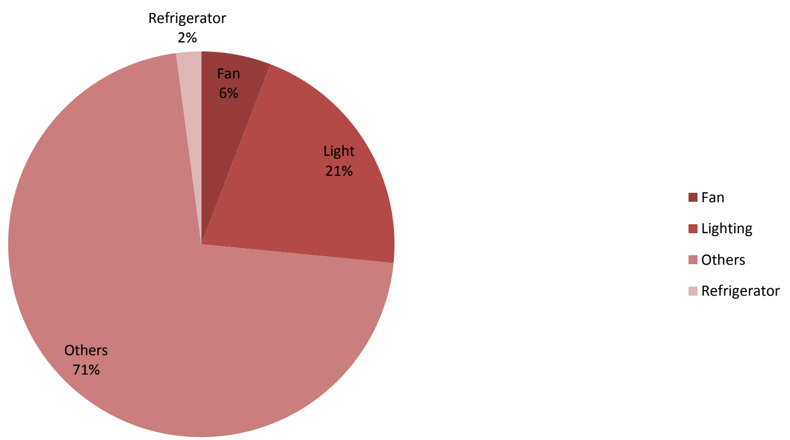
| | | |
|---|---|---|
| TNEB | 40,056 kWh | 92% |
| Renewables | 698 kWh | 2% |
| Diesel Generator | 2,795 kWh | 6% |
| **Total Electric Energy Demand** | **43,549 kWh** | **100%** |

*Figure 64 Public Service Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*




The analysis of overall energy consumption by type of electric fixture/application indicates that 71% of the sector's electricity is consumed by the segment Others. This includes primarily scanners and copy machines, computers and other IT equipment. Lights account for 21% or 9,022 kWh of the sector's electricity consumption, followed by fans with 6% (2,543 kWh) and refrigerators with 2% (914 kWh). Refer to Figure 65 for a detailed distribution of electricity consumption by type of fixture/application for the Public Service sector.

*Figure 65 Public Service Sector Electricity Consumption by Type of Fixture/Application, Auroville 2014*




## SAVING POTENTIAL

Figure 66 indicates the electricity saving potential by type of fixture/application for the Public Service sector. The total saving potential amounts to 19, 494 kWh or 0.42% of the total Auroville electricity consumption. The highest saving potential was identified for the segment Others with 11,590 kWh or 0.25% on the total Auroville electricity consumption. The light segment indicates a saving potential of 0.12% or 5,426 kWh.

The most cost efficient energy efficiency intervention is for lighting with a capital investment requirement of INR 16.11 per kWh electricity saving and a payback period of 2.7 years. Energy efficiency interventions for fans will result in a payback period of 7 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 67.

*Figure 66 Public Service Sector Electricity Saving Potential by Type of Fixture/Application of Total Consumption, Auroville 2014*

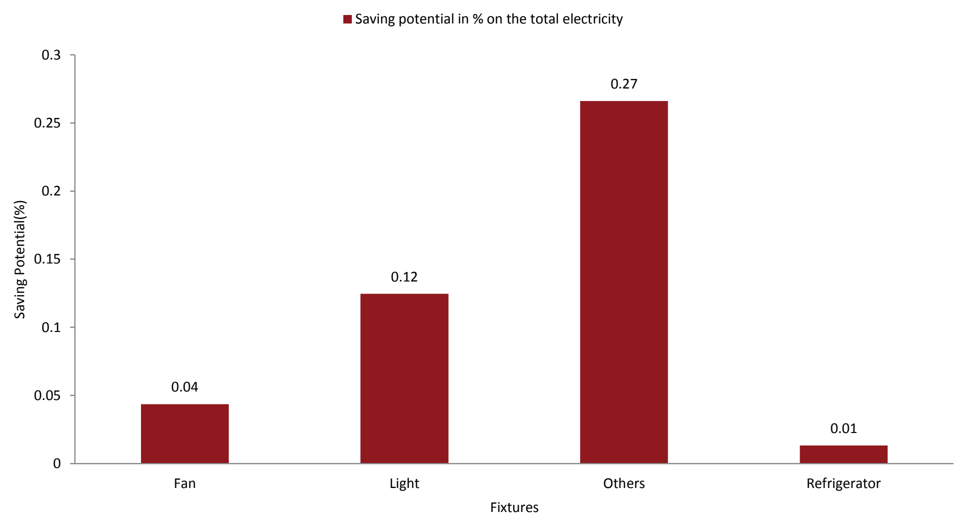


*Figure 67 Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

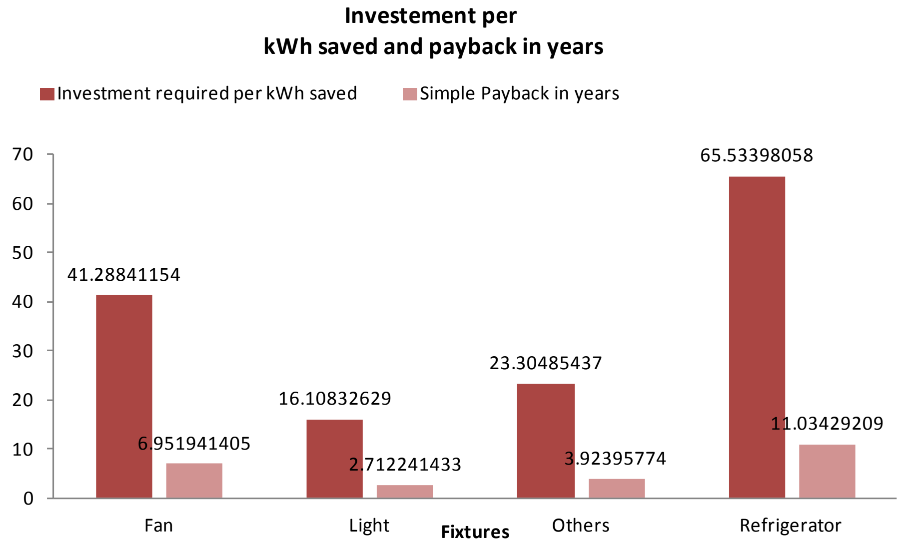



Table 43 summarizes the findings with regard to the electricity saving potential through energy efficiency interventions for the Manufacturing & Handicraft sector of Auroville. It lists the electricity and financial saving potential, the investment required and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*Table 43 Public Service Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Fan | 2,543 | 6% | 15,101 | 0.04% | 1,901 | 11,290 | 78,485 | 6.95 |
| Light | 9,022 | 21% | 53,581 | 0.12% | 5,424 | 32,213 | 87,369 | 2.71 |
| Others | 31,070 | 71% | 1,84,531 | 0.25% | 11,590 | 68,834 | 2,70,102 | 3.92 |
| Refrigerator | 914 | 2% | 5,430 | 0.01% | 579 | 3,442 | 37,977 | 11.03 |
| **Total** | **43,549** | **100%** | **2,58,643** | **0.42%** | **19,494** | **1,15,778** | **4,73,933** | **4.09** |

## 4.5 GUEST HOUSES

### METHODOLOGY

The electricity baseline for the Guest Houses sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through the energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Guest Houses sector.

### BASELINE

Figure 68 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Guest Houses sector. Electric energy from the utility grid accounts for the majority of this sector's energy consumption with 206 MWh/year, followed by thermal energy (LPG) with 171 MWh/year. The total electricity consumption is estimated at 563 MWh per annum. 80% of this demand is sourced from the utility grid, 14% is supplied by decentralized renewable technologies and 6% by stand-by diesel generators (see Table 44). Most of the renewable electricity is supplied by solar PV systems with 36 MWh per annum (see Figure 68).

*Table 44 Guest Houses Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 206 kWh | 80% |
| Renewables | 36 kWh | 14% |
| Diesel Generator | 15 kWh | 6% |
| **Total Electric Energy Demand** | **257 kWh** | **100%** |

*Figure 68 Guest Houses Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

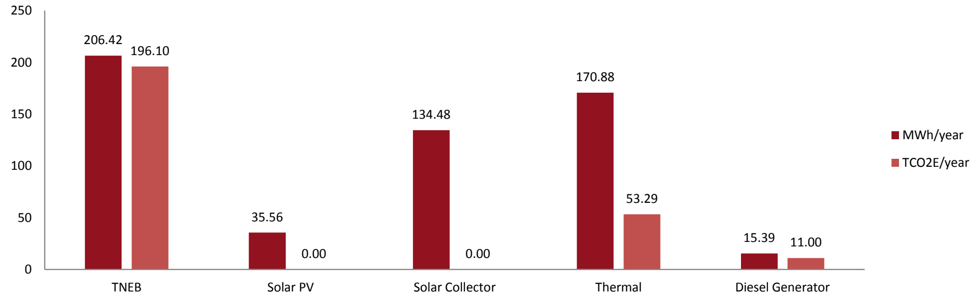
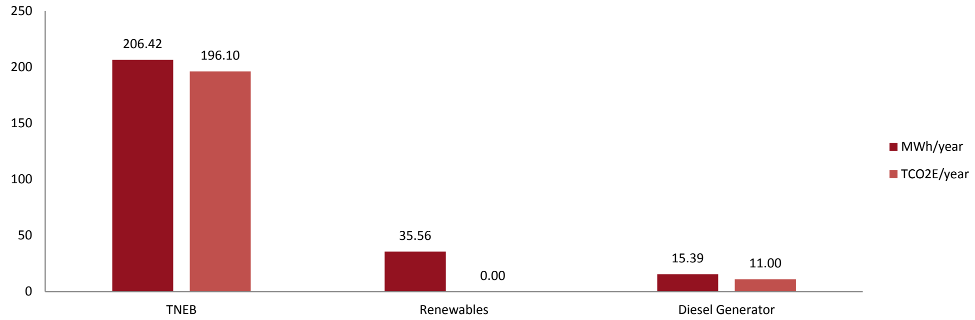
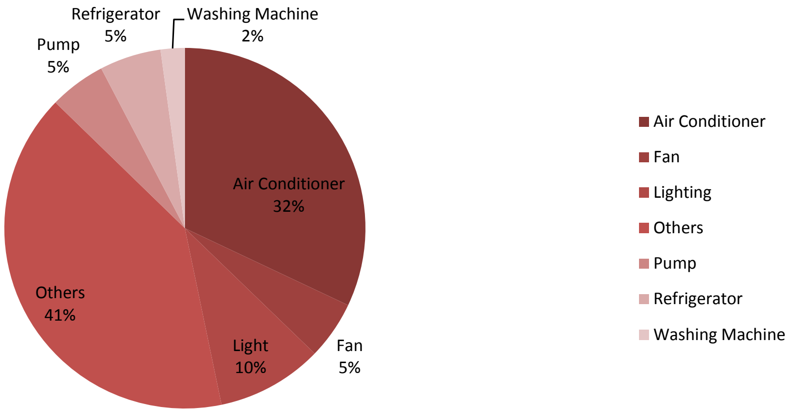



*Figure 69 Guest Houses Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*




The analysis of overall energy consumption by type of electric fixture/application indicates that 41% of the sector's electricity demand is accounted for by the segment Others. This includes water heaters, kitchen appliances, computers and other IT equipment. Air conditioners are the second largest consumer and accounts for 82,412 kWh or 32%, followed by lights with 10% or 24,476 kWh of the sector's electricity consumption. Refer to Figure 70 for a detailed distribution of electricity consumption by type of fixture/application for the Guest Houses sector.

*Figure 70 Guest Houses Sector Electricity Consumption by Type of Fixture/Application, Auroville 2014*




## SAVING POTENTIAL

Figure 71 indicates the electricity saving potential by type of fixture/application for the Guest Houses sector. The total saving potential for the Guest Houses sector amounts to 28,007 kWh or 0.60% of Auroville's total electricity consumption. The highest saving potential is found for air conditioners with 8,681 kWh or 0.19% of the total Auroville electricity consumption. Second is the refrigerator segment, indicating a saving potential of 0.15% or 7222 kWh per year.

The most cost efficient energy efficiency intervention is found in the light segment with a capital investment requirement of INR 36.72 per kWh electricity saving and a payback period of 5.59 years. Energy efficiency interventions for air conditioners will result in a payback period of 7.13 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 72.

*Figure 71 Guest Houses Sector Electricity Saving Potential by Type of Fixture/ Application of Total Consumption, Auroville 2014*

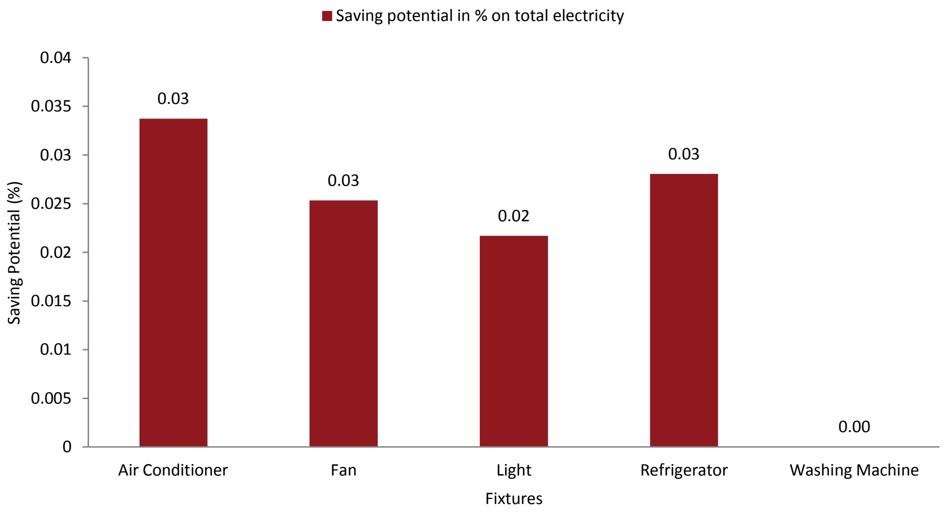



*Figure 72 Guest Houses Sector Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

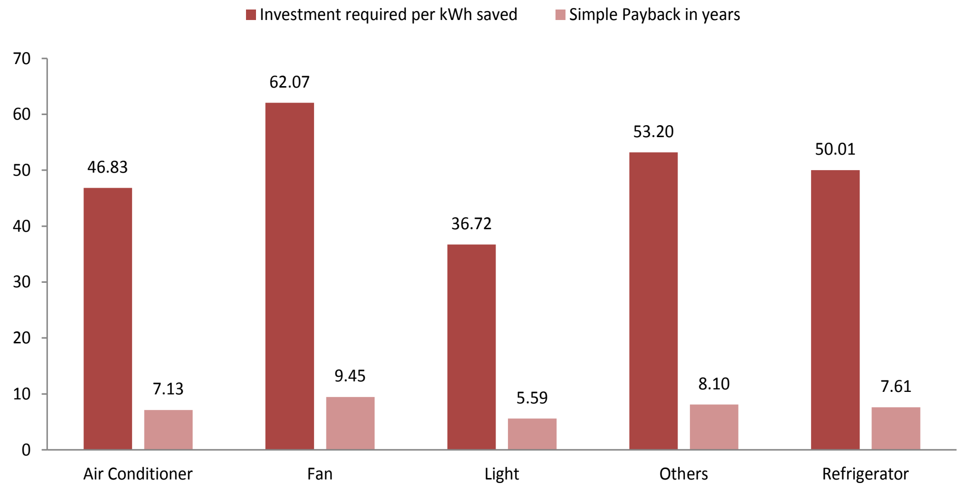



Table 45 summarizes the findings with regard to the electricity saving potential from energy efficiency interventions in the Guest Houses sector of Auroville. It lists the electricity and financial saving potential, the investment requirement and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*Table 45 Guest Houses Sector Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 82,412 | 32% | 5,41,400 | 0.19% | 8,681 | 57,027 | 4,06,502 | 7.13 |
| Fan | 13,407 | 5% | 88,079 | 0.14% | 6,521 | 42,842 | 4,04,786 | 9.45 |
| Light | 24,476 | 10% | 1,60,792 | 0.12% | 5,583 | 36,674 | 2,05,007 | 5.59 |
| Others | 1,04,332 | 41% | 6,85,403 | 0.00% | - | - | - | - |
| Pump | 13,007 | 5% | 85,452 | 0.00% | - | - | - | - |
| Refrigerator | 14,178 | 6% | 93,143 | 0.15% | 7,222 | 47,444 | 3,84,231 | - |
| Washing Machine | 5,557 | 2% | 36,508 | 0.00% | - | - | - | - |
| **Total** | **2,57,369** | **100%** | **16,90,777** | **0.60%** | **28,007** | **1,83,988** | **14,00,526** | **7.61** |

## 4.6 COMMERCIAL

### METHODOLOGY

The electricity baseline for the Commercial sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. Saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline of the Commercial sector.

### BASELINE

Figure 73 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Commercial sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with 171 MWh/year, followed by electric energy from the utility grid with 163 MWh/year.

The total electricity consumption is estimated at 282 MWh per annum. 58% of this demand is sourced from the utility grid, 17% is supplied by decentralized renewable technologies and 26% by stand-by diesel generators (see Table 46). Most of the renewable electricity is supplied by solar PV systems with 46 MWh per annum. Mini wind turbines contribute 1 MWh of annual electricity supply (see Figure 74).

*Figure 73 Commercial Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

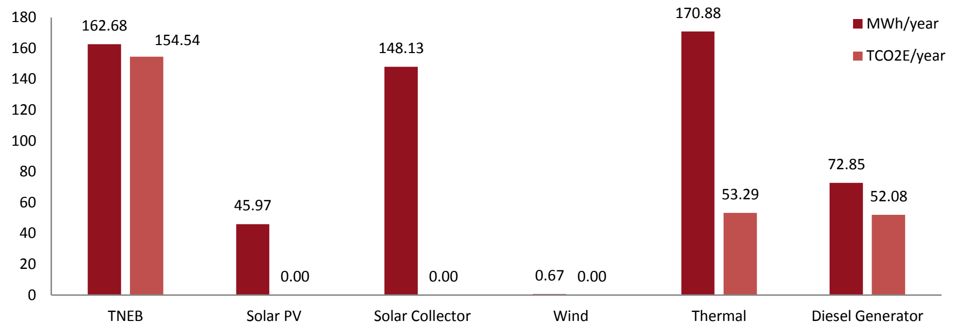



*Table 46 Commercial Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 1,62,676 kWh | 58% |
| Renewables | 46,646 kWh | 17% |
| Diesel Generator | 72,849 kWh | 26% |
| **Total Electric Energy Demand** | **2,82,172 kWh** | **100%** |

*Figure 74 Commercial Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*

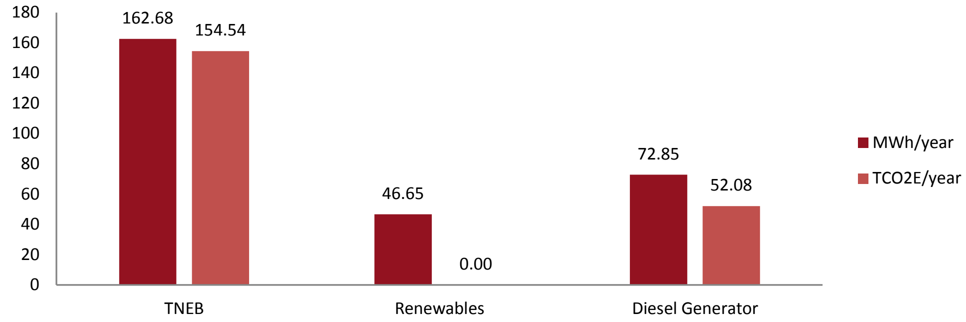
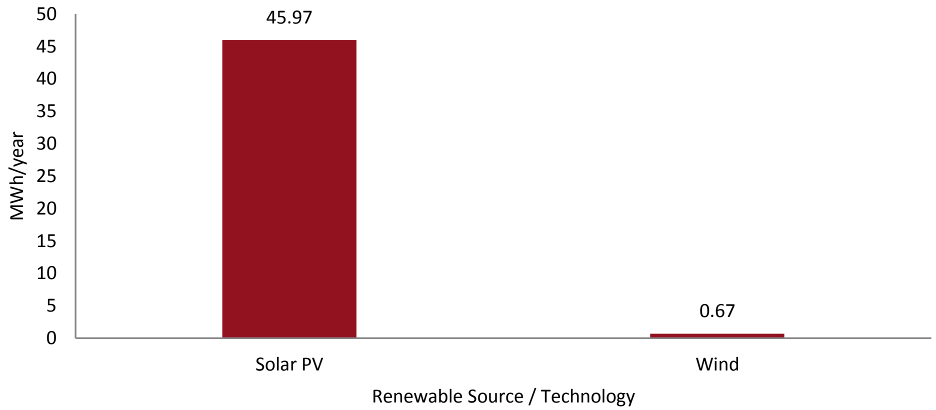
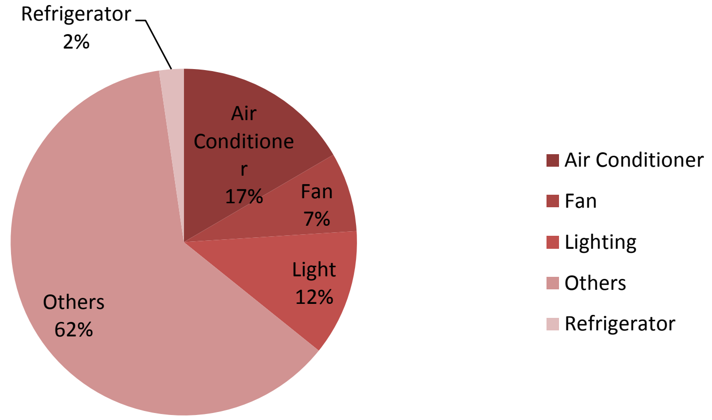



*Figure 75 Commercial Sector Renewable Energy by Type, Auroville 2014*




In this sector, 62% or 1, 74,766 kWh of electricity is consumed by appliances in the segment Others. Air conditioners are the second largest consumers and account for 46,827 kWh or 17%, followed by lights with 12% or 33,235 kWh of the sector's electricity consumption. Refer to Figure 76 for a detailed distribution of electricity consumption by type of fixture/application for the Commercial sector.

*Figure 76 Commercial Sector Electricity Consumption by Type of Fixture/Application, Auroville 2014*




## SAVING POTENTIAL

Figure 77 indicates the electricity saving potential by type of fixture/application for the Commercial sector. The total saving potential for the Commercial sector amounts to 17,728 kWh or 0.38% of Auroville's total electricity consumption. The highest saving potential was identified for air conditioners with 7,108 kWh or 0.15% of the total electricity consumption. The fan segment indicates a saving potential of 0.10% or 4825 kWh per year.

The most cost efficient energy efficiency intervention is for air conditioners with a capital investment requirement of INR 9.61 per kWh electricity saving and a payback period of 1.1 years. Energy efficiency interventions for refrigerators will result in a payback period of 3.9 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback periods, refer to Figure 78.

*Figure 77 Commercial Sector Electricity Saving Potential by Type of Fixture/Application of Total Consumption, Auroville 2014*

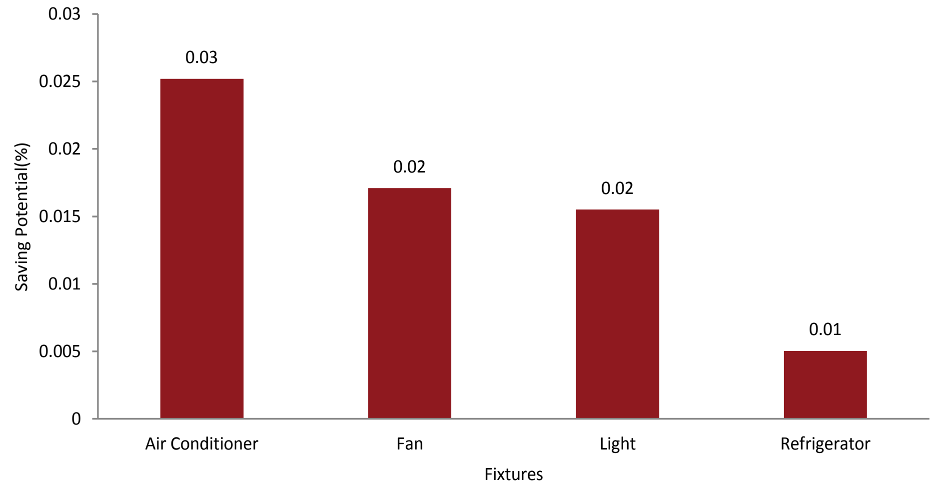



*Figure 78 Commercial Sector Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

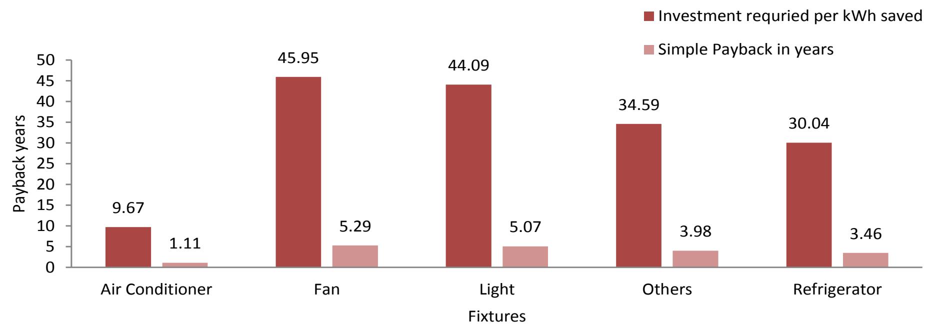


Table 47 summarizes the findings with regard to the electricity saving potential from energy efficiency interventions in the Commercial sector of Auroville. It lists the electricity and financial saving potential, the investment requirement and the payback period. The most promising intervention in terms of payback period and achievable electricity savings is highlighted in colour.

*Table 47 Commercial Sector Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 46,827 | 17% | 4,07,080 | 0.15% | 7,109 | 61,799 | 68,766 | 1.11 |
| Fan | 20,865 | 7% | 1,81,382 | 0.10% | 4,825 | 41,941 | 2,21,701 | 5.29 |
| Light | 33,235 | 12% | 2,88,924 | 0.09% | 4,376 | 38,037 | 1,92,918 | 5.07 |
| Others | 1,74,766 | 62% | 15,19,288 | 0.00% | - | - | - | - |
| Refrigerator | 6,478 | 2% | 56,317 | 0.00% | 1,419 | 12,339 | 49,099 | 3.98 |
| **Total** | **2,82,171** | **100%** | **24,52,991** | **0.35%** | **17,728** | **1,54,117** | **5,32,483** | **3.46** |

## 4.7 COMMUNITY & CULTURE

### METHODOLOGY

The electricity baseline for the Community & Culture sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through the energy audits conducted in units of this sector and was then extrapolated on the electricity baseline of the Community & Culture sector.

### BASELINE

Figure 79 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Community & Culture sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with 171 MWh/year, followed by electric energy from the utility grid with 141 MWh/year.

The total electricity consumption is estimated at 229 MWh per annum. 61% of this demand is sourced from the utility grid, 16% is supplied by decentralized renewable technologies and 22% by stand-by diesel generators (see Table 48). Most of the electricity from renewable sources is supplied by solar PV systems with 32 MWh per annum. Mini wind turbines contribute 6.2 MWh of annual electricity supply (see Figure 81).

*Figure 79 Community & Culture Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

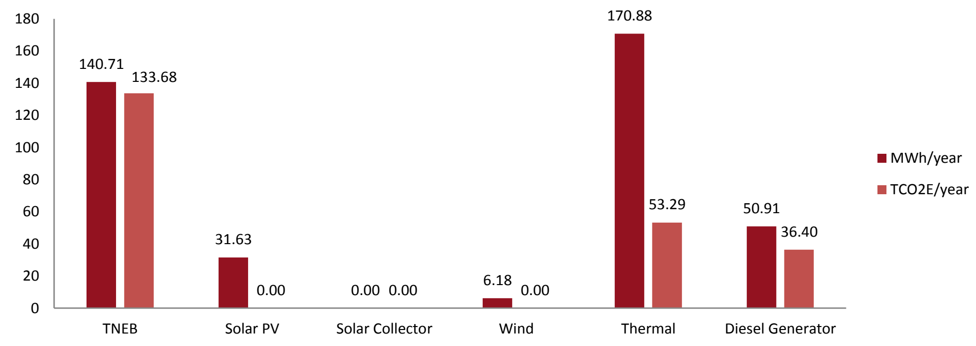



*Table 48 Community & Culture Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 1,40,711 kWh | 62% |
| Renewables | 37,512 kWh | 16% |
| Diesel Generator | 50,907 kWh | 22% |
| **Total Electric Energy Demand** | **2,29,130 kWh** | **100%** |

*Figure 80 Community & Culture Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*

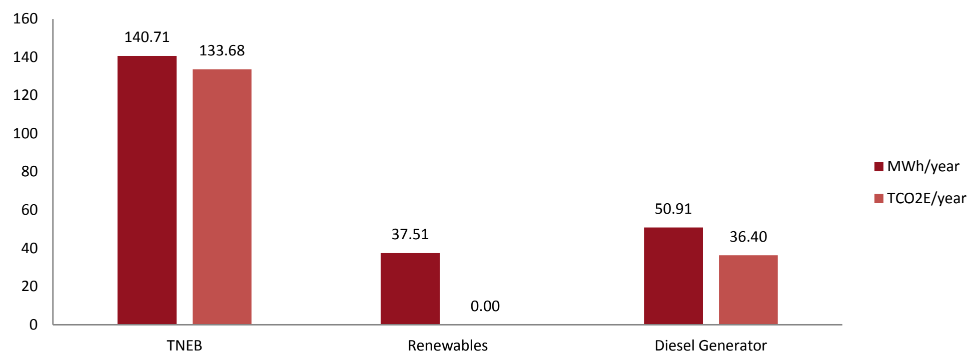


*Figure 81 Community & Culture Sector Renewable Energy by Type, Auroville 2014*

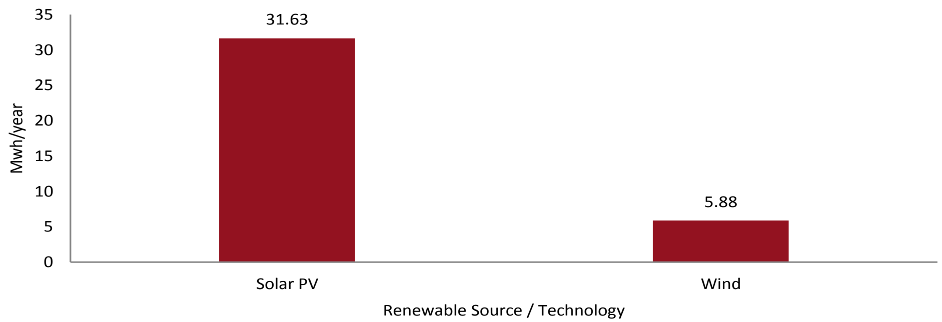
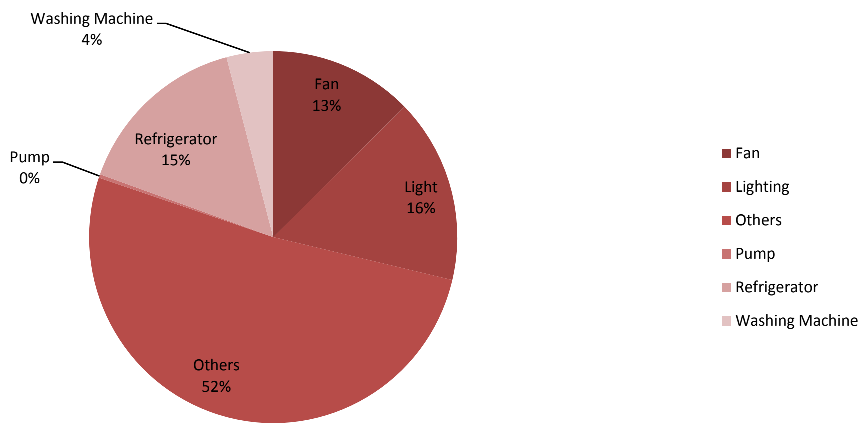



Figure 82 indicates the overall energy consumption by type of electric fixture/application. Other appliances account for 52% or 1, 17,931 kWh of the sector's electricity demand, followed by lights with 16%, refrigerators with 15% and fans with 13%.

*Figure 82 Community & Culture Sector Electricity Consumption by Type of Fixture/Application, Auroville 2014*




## Saving Potential

Figure 83 indicates the electricity saving potential by type of fixture/application for the Community & Culture sector. The total saving potential for this sector amounts to 1, 42,791 kWh or 3.05% of Auroville's total electricity consumption. The highest saving potential was identified for refrigerators with 71,943 kWh or 1.54% of the total Auroville electricity consumption. The fan segment indicates a saving potential of 0.92% or 43,161 kWh per year.

The most cost efficient energy efficiency intervention was identified for refrigerators with a capital investment requirement of INR 22.46 per kWh electricity saving and a payback period of 2.7 years. Energy efficiency interventions for lights will result in a payback period of 6.1 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 84.

*Figure 83 Community & Culture Sector Electricity Saving Potential by Type of Fixture/Application of Total Consumption, Auroville 2014*

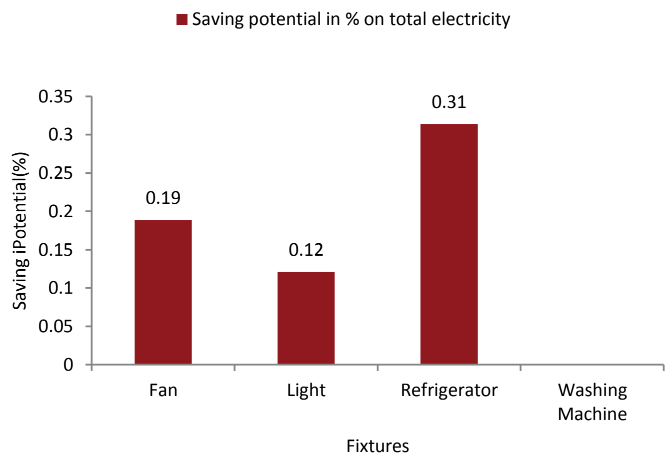


*FIGURE 84 COMMUNITY & CULTURE SECTOR PAYBACK AND INVESTMENT REQUIRED PER KWH SAVING BY FIXTURE/APPLICATION IN INR, AUROVILLE 2014*

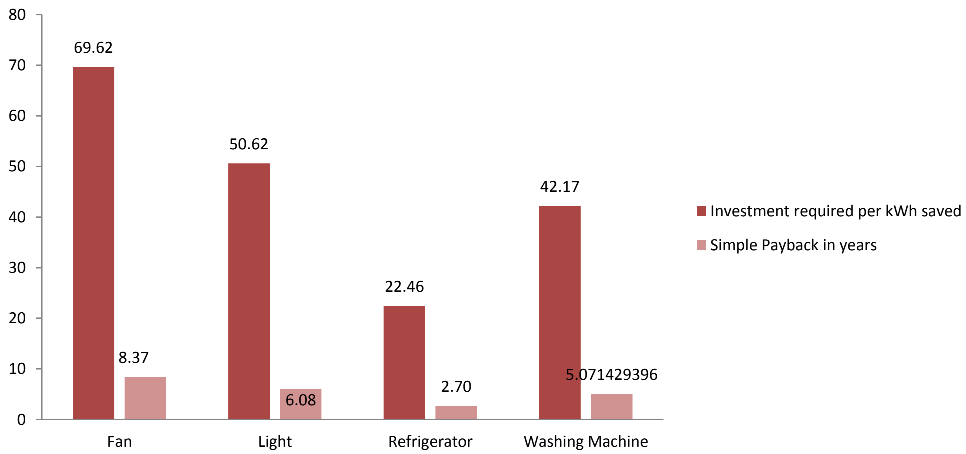



Table 49 summarizes the findings with regard to the electricity saving potential through energy efficiency interventions in the Community & Culture sector of Auroville. It lists the electricity and financial saving potential, the investment required and the payback period. The most promising intervention in terms of payback period and achievable electricity savings is highlighted in colour.

*TABLE 49 COMMUNITY & CULTURE SECTOR SAVING OPPORTUNITIES, AUROVILLE 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Fan | 28,949 | 13% | 2,40,733 | 0.92% | 43,161 | 3,58,919 | 30,04,993 | 8.37 |
| Light | 36,824 | 16% | 3,06,219 | 0.59% | 27,688 | 2,30,247 | 14,01,428 | 6.09 |
| Others | 1,17,931 | 51% | 9,80,695 | 0.00% | - | - | - | - |
| Pump | 703 | 0% | 5,843 | 0.00% | - | - | - | - |
| Refrigerator | 35,352 | 15% | 2,93,978 | 1.54% | 71,943 | 5,98,266 | 16,15,556 | 2.70 |
| Washing Machine | 9,372 | 4% | 77,936 | 0.00% | - | - | - | - |
| **Total** | **2,29,130** | **100%** | **19,05,404** | **3.05%** | **1,42,792** | **11,87,432** | **60,21,976** | **5.07** |

## 4.8 EDUCATION

### METHODOLOGY

The electricity baseline for the Education sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of the sector and was then extrapolated on the electricity baseline for the Education sector.

### BASELINE

Figure 85 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Education sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with 171 MWh/year, followed by electric energy from the utility grid with 134 MWh/year.

The total electricity consumption is estimated at 148 MWh per annum. 91% of this demand is sourced from the utility grid and 9% is supplied by decentralized renewable sources (see Table 50). Most of the renewable electricity is supplied by solar PV systems with 13 MWh per annum. Mini wind turbines contribute 0.4 MWh of annual electricity supply (see Figure 87).

*FIGURE 85 EDUCATION SECTOR ENERGY CONSUMPTION AND $CO_2$ BASELINE BY SOURCE, AUROVILLE 2014*

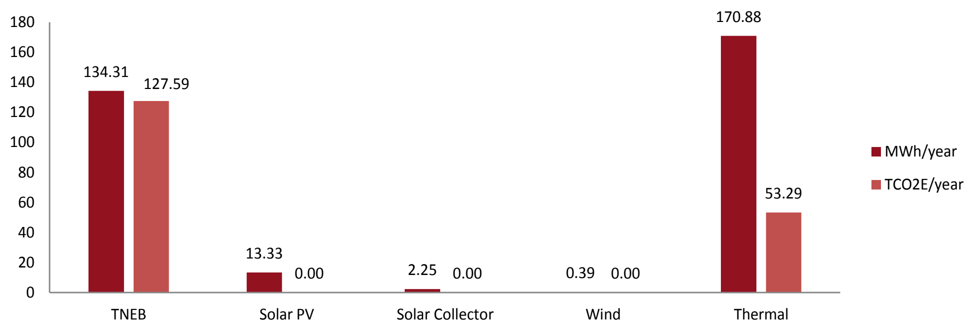


*Table 50 Education Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 1,34,306 kWh | 91% |
| Renewables | 13,711 kWh | 9% |
| Diesel Generator | 0 kWh | 0% |
| **Total Electric Energy Demand** | **1,48,017 kWh** | **100%** |

*Figure 86 Education Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*

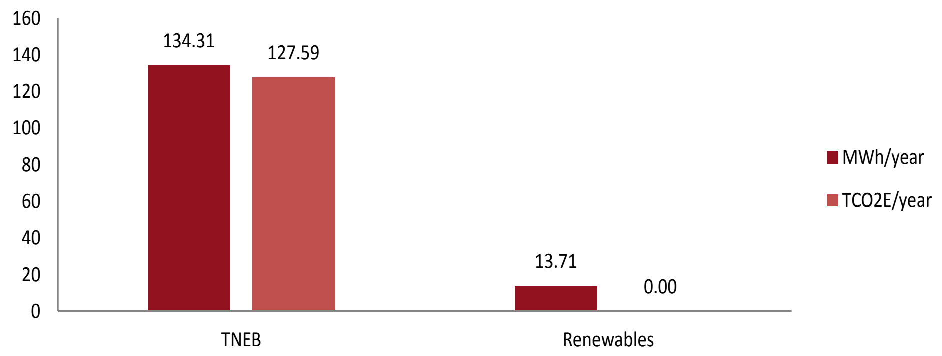
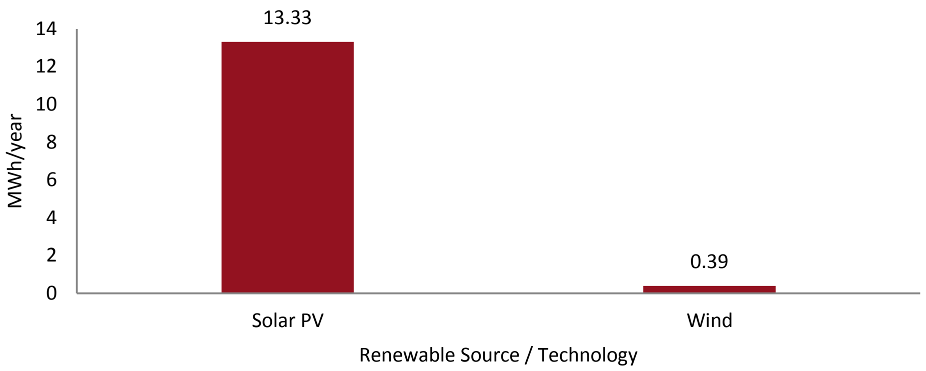
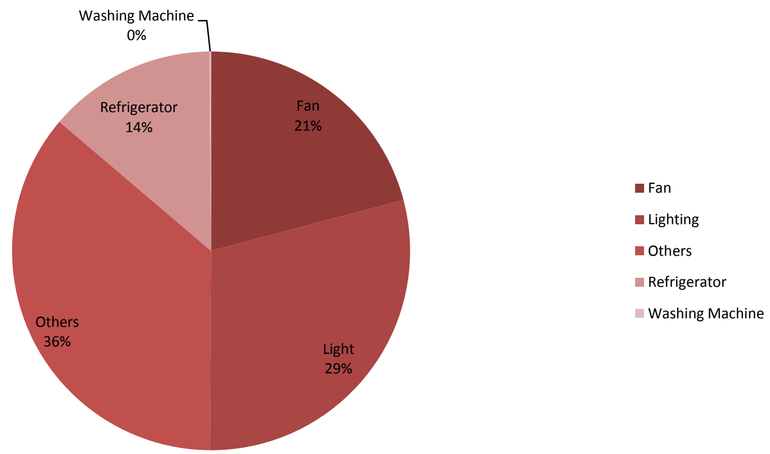



*Figure 87 Education Sector Renewable Energy by Type, Auroville 2014*




The appliances in the segment Others constitute the highest electricity consuming segment of the Education sector, accounting for 36% or 43,462 kWh of the sector's electricity demand in 2014. Lights with 29% (43,212 kWh) and fans with 21% (30,931 kWh) are other significant electricity consuming devices in this sector. For a detailed distribution of electricity consumption by type of fixture/application for this sector, refer to Figure 88.

*Figure 88 Education Sector Electricity Consumption by Type of Fixture/Application, Auroville 2014*




## SAVING POTENTIAL

Figure 89 indicates the electricity saving potential by type of fixture/application for the Education sector. The total saving potential for the Education sector amounts to 50,360 kWh or 1.08% of Auroville's total electricity consumption. The highest saving potential is found for fans with 19.705 kWh or 0.42% of total Auroville electricity consumption. The light segment indicates a saving potential of 0.42% or 19,511 kWh per year.

The most cost efficient energy efficiency intervention is for lights with a capital investment requirement of INR 19 per kWh electricity saving and a payback period of 3.0 years. Energy efficiency interventions for refrigerators will result in a payback period of 5.5 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 90.

*Figure 89 Education Sector Electricity Saving Potential by Type of Fixture/Application of Total Consumption, Auroville 2014*

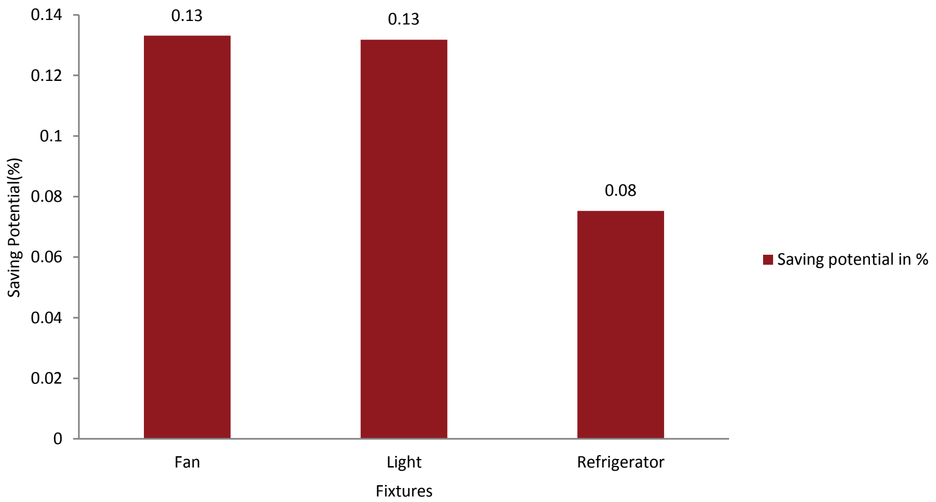



*Figure 90 Education Sector Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

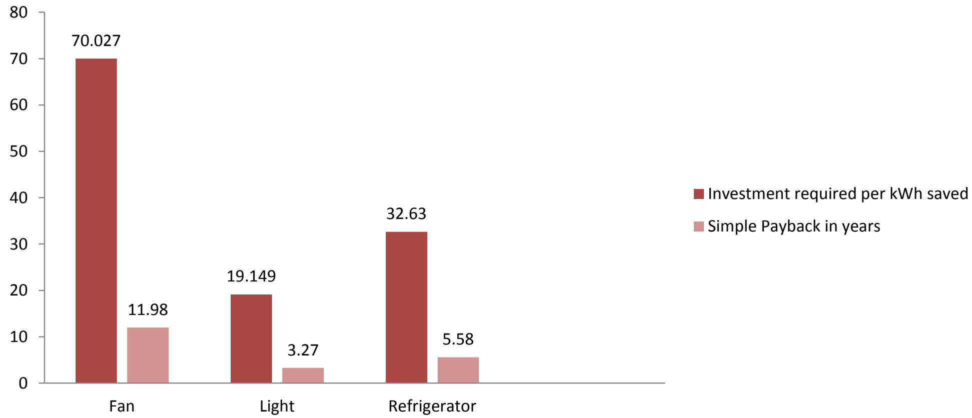



Table 51 summarizes the findings with regard to the electricity saving potential through energy efficiency interventions in the Education sector of Auroville. It lists the electricity and financial saving potential, the investment requirement and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*Table 51 Education Sector Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Fan | 30,931 | 21% | 1,80,649 | 0.42% | 19,706 | 1,15,089 | 13,79,816 | 11.99 |
| Light | 43,212 | 29% | 2,52,380 | 0.42% | 19,511 | 1,13,954 | 3,73,514 | 3.28 |
| Others | 53,462 | 36% | 3,12,246 | 0.00% | - | - | - | - |
| Refrigerator | 20,224 | 14% | 1,18,115 | 0.24% | 11,142 | 65,077 | 3,63,676 | 5.59 |
| Washing Machine | 188 | 0% | 1,098 | 0.00% | - | - | - | - |
| **Total** | **1,48,017** | **100%** | **8,64,488** | **1.08%** | **50,359** | **2,94,121** | **21,17,006** | **7.20** |

## 4.9 ADMINISTRATION

### METHODOLOGY

The electricity baseline for the Administration sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Administration sector.

### BASELINE

Figure 91 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Administration sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with 171 MWh/year, followed by electric energy from the utility grid with 98 MWh/year.

The total electricity consumption is estimated at 158 MWh per annum. 62% of this demand is sourced from the utility grid, 33% is supplied by decentralized renewable technologies and 5% by stand-by diesel generators (see Table 52). Most of the renewable electricity is supplied by solar PV systems with 53

MWh per annum. Mini wind turbines contribute 0.3 MWh of annual electricity supply (see Figure 91).

*FIGURE 91 ADMINISTRATION SECTOR ENERGY CONSUMPTION AND $CO_2$ BASELINE BY SOURCE, AUROVILLE 2014*

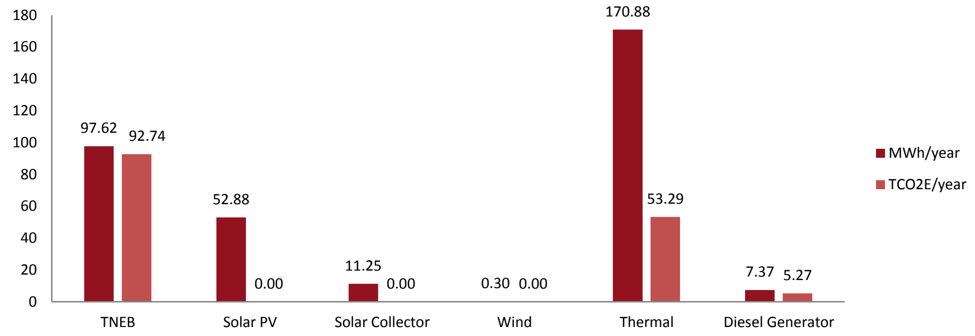
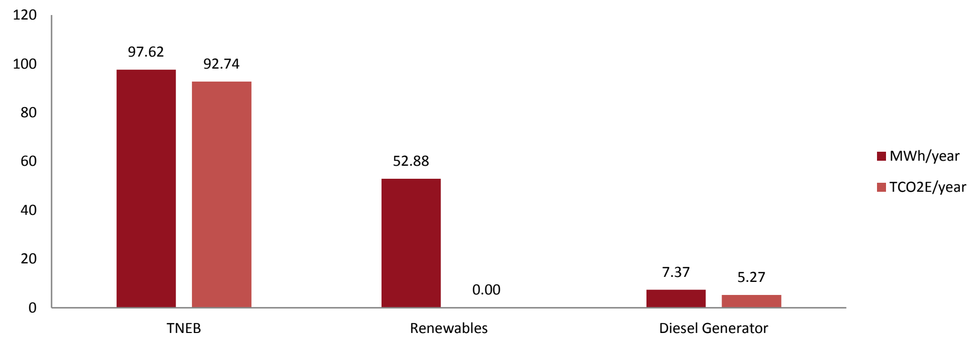



*TABLE 52 ADMINISTRATION SECTOR ELECTRICITY BASELINE BY SOURCE AND PER CAPITA ELECTRICITY CONSUMPTION, AUROVILLE 2014*

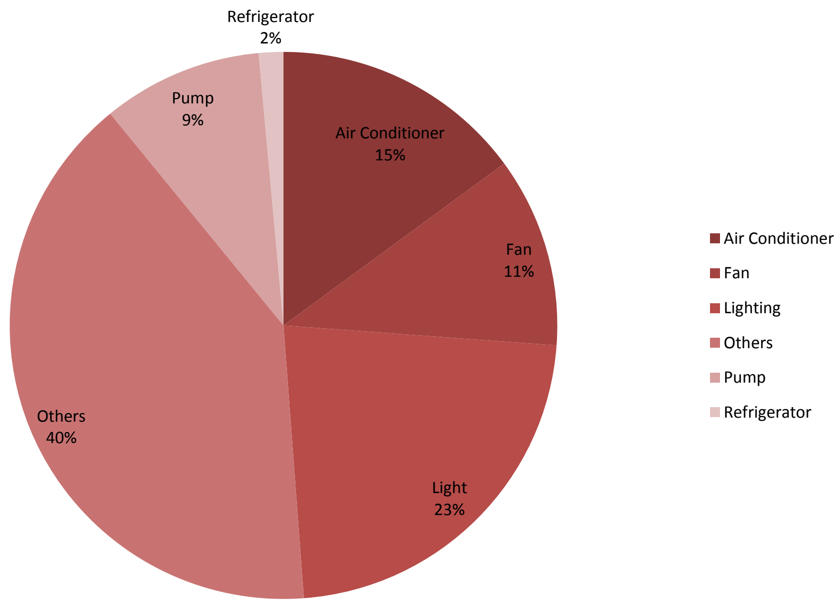
| | | |
|---|---|---|
| TNEB | 97,622 kWh | 62% |
| Renewables | 52,884 kWh | 33% |
| Diesel Generator | 7,373 kWh | 5% |
| **Total Electric Energy Demand** | **1,57,879 kWh** | **100%** |

*FIGURE 92 ADMINISTRATION SECTOR ELECTRICITY CONSUMPTION AND $CO_2$ FOR ELECTRICITY BY SOURCE, AUROVILLE 2014*




An analysis of overall energy consumption by type of electric fixture/application indicates that 40% or 63,597 kWh of the sector's electricity demand is accounted for by the segment Others. This includes scanners, printers, copy machines, servers, computers and other IT equipment. The lights segment is the second largest consumer and accounts for 35,757 kWh or 23%, followed by air conditioners with 15% and fans with 11%. Refer to Figure 93 for a detailed distribution of electricity consumption by type of fixture/application for the Administration sector.

*FIGURE 93 ADMINISTRATION SECTOR ELECTRICITY CONSUMPTION BY TYPE OF FIXTURE/APPLICATION, AUROVILLE 2014*




## SAVING POTENTIAL

Figure 94 indicates the electricity saving potential by type of fixture/application for the Administration sector. The total saving potential for the Administration sector amounts to 11,747 kWh or 0.25% of Auroville's total electricity consumption. The highest saving potential was identified for fans with 9,085 kWh or 0.19% of total Auroville electricity consumption. The light segment indicates a saving potential of 0.04% or 1883 kWh per year.

The most cost efficient energy efficiency intervention is for fans with a capital investment requirement of INR 27.96 per kWh electricity saving and a payback period of 5.2 years. Energy efficiency interventions for lights will result in a payback period of 6.3 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 95.

*Figure 94 Administration Sector Electricity Saving Potential by Type of Fixture/ Application of Total Consumption, Auroville 2014*

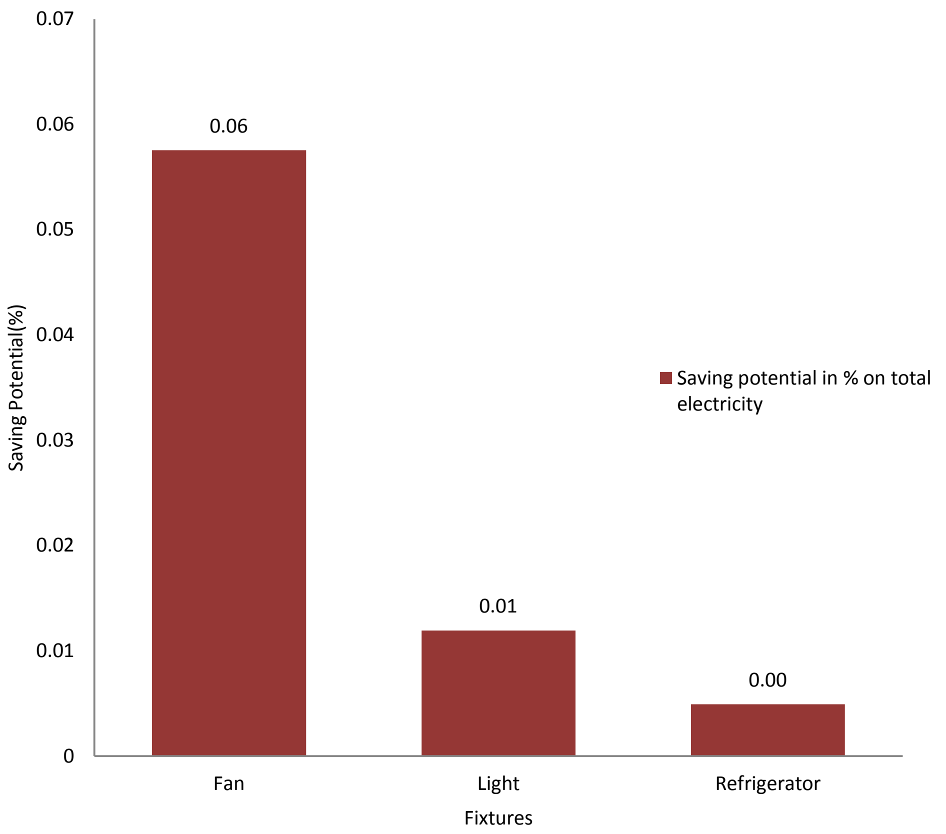



*Figure 95 Administration Sector Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

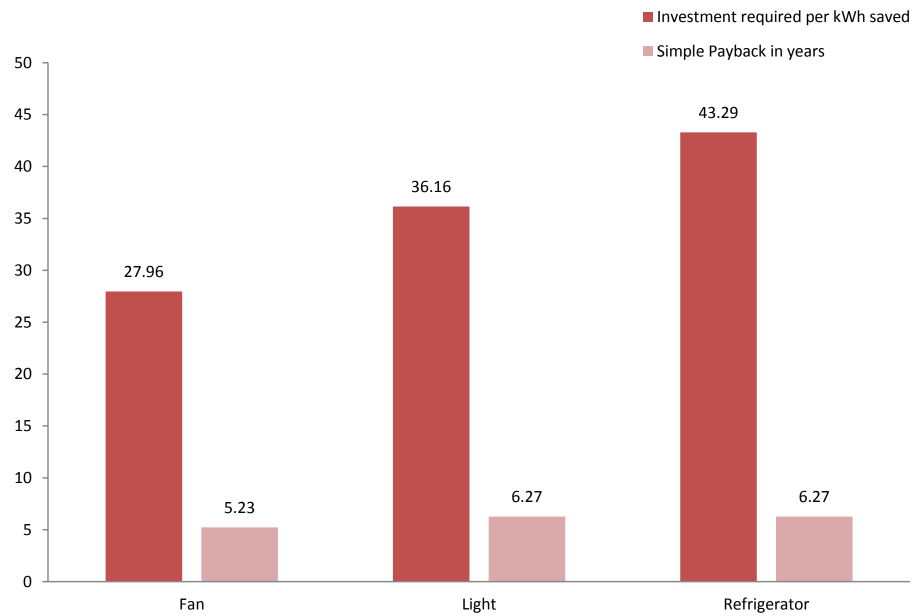



Table 53 summarizes the findings with regard to the electricity saving potential through energy efficiency interventions in the Administration sector of Auroville. It lists the electricity and financial saving potential, the investment required and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*Table 53 Administration Sector Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner* | 23,562 | 15% | 1,62,621 | 0.00% | - | - | - | - |
| Fan | 17,746 | 11% | 1,22,483 | 0.19% | 9,085 | 62,704 | 3,28,479 | 5.2 |
| Light | 35,757 | 23% | 2,46,794 | 0.04% | 1,884 | 13,001 | 81,547 | 6.3 |
| Others | 63,597 | 40% | 4,38,942 | 0.00% | - | - | - | - |
| Pump | 14,923 | 9% | 1,02,999 | 0.00% | - | - | - | - |
| Refrigerator | 2,295 | 1% | 15,837 | 0.02% | 778 | 5,369 | 33,677 | 6.3 |
| **Total** | **1,57,879** | **100%** | **10,89,676** | **0.25%** | **11,747** | **81,075** | **4,43,703** | **5.5** |

** no recommendation for Air Conditioner, as the existing models are energy efficient.*

## 4.10 HEALTH SERVICES

### METHODOLOGY

The electricity baseline for the Health Services sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Health Services sector.

### BASELINE

Figure 96 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Health Services sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with 171 MWh/year, followed by diesel generator with 35 MWh/year, and lastly the electric energy from the utility grid with 31 MWh/year.

The total electricity consumption is estimated at 66 MWh per annum. 47% of this demand is sourced from the utility grid and 53% is supplied by stand-by diesel generators (see Table 54).

*Figure 96 Health Services Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

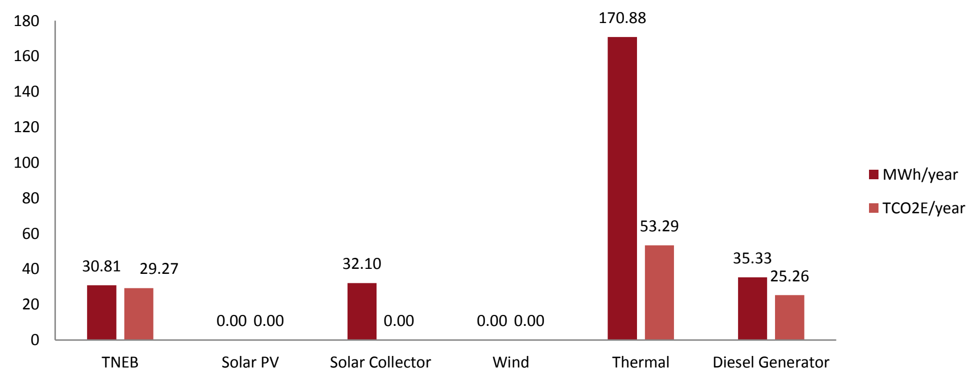
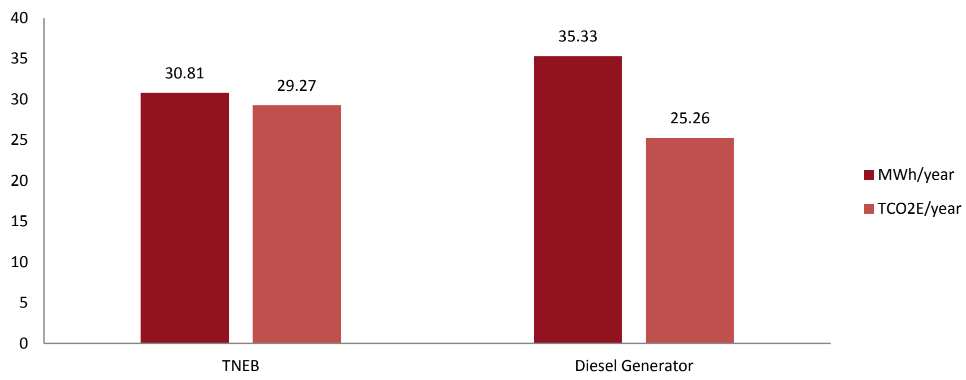



*Table 54 Health Services Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 30,809 kWh | 47% |
| Renewables | 0 kWh | 0% |
| Diesel Generator | 35,328 kWh | 53% |
| **Total Electric Energy Demand** | **66,137 kWh** | **100%** |

*Figure 97 Health Services Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*




The analysis of overall energy consumption by type of electric fixture/application indicates that 52% or 34,040 kWh of the sector's electricity demand is accounted for by the segment Others. This includes primarily water heaters, medical and dental equipment, computers and other IT equipment. The light segment is the second largest consumer and accounts for 10,629 kWh or 16%, followed by refrigerators with 15% and fans with 13% of the sector's electricity consumption. Refer to Figure 98 for a detailed distribution of electricity consumption by type of fixture/application for the Health Services sector.

*Figure 98 Health Services Sector Electricity Consumption by Type of Fixture/Application, Auroville 2014*

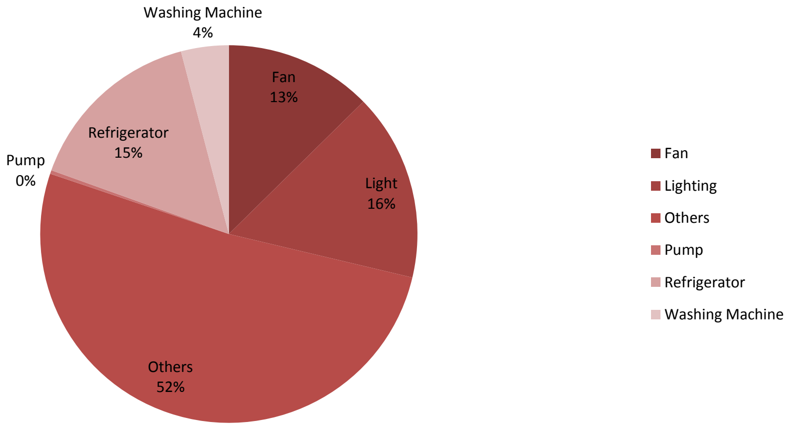
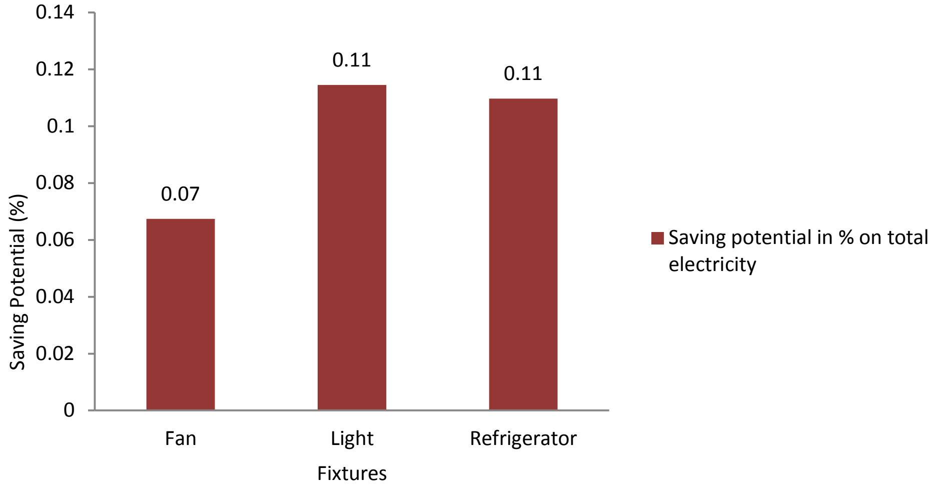



*Figure 99 Electricity Saving Potential by Type of Fixture/Application of Total Consumption, Auroville 2014*




## SAVING POTENTIAL

Figure 99 indicates the electricity saving potential by type of fixture/application for the Health Services sector. The total saving potential for the Health Services sector amounts to 19,285 kWh or 0.41 % of Auroville's total electricity consumption. The highest saving potential was identified for lights with 7,572 kWh or 0.16% of total Auroville electricity consumption. The refrigerator segment indicates a saving potential of 0.16 % or 7,257 kWh per year.

The most cost efficient energy efficiency intervention is for lights with a capital investment requirement of INR 13.71 per kWh electricity saving and a payback period of 1.2 years. Energy efficiency interventions for refrigerators will result in a payback period of 4.3 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 100.

*Figure 100 Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

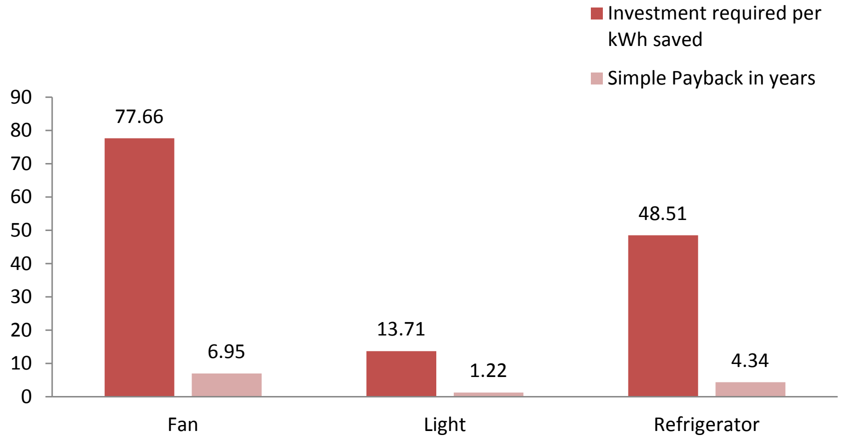



Table 55 summarizes the findings with regard to the electricity saving potential through energy efficiency interventions in the Health Services sector of Auroville. It lists the electricity and financial saving potential, the investment requirement and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*Table 55 Health Services Sector Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Fan | 8,356 | 13% | 93,290 | 0.10% | 4,456 | 49,755 | 3,46,091 | 6.96 |
| Light | 10,629 | 16% | 1,18,668 | 0.16% | 7,572 | 84,540 | 1,03,844 | 1.23 |
| Others | 34,040 | 51% | 3,80,045 | 0.00% | - | - | - | - |
| Pump | 203 | 0% | 2,264 | 0.00% | - | - | - | - |
| Refrigerator | 10,204 | 15% | 1,13,924 | 0.16% | 7,257 | 81,019 | 3,52,016 | 4.34 |
| Washing Machine | 2,705 | 4% | 30,202 | 0.00% | - | - | - | - |
| **Total** | **66,137** | **100%** | **7,38,395** | **0.41%** | **19,285** | **2,15,313** | **8,01,951** | **3.72** |

## 4.11 FOOD PROCESSING

### METHODOLOGY

The electricity baseline for the Food Processing sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of the sector and was then extrapolated on the electricity baseline for the Food Processing sector.

### BASELINE

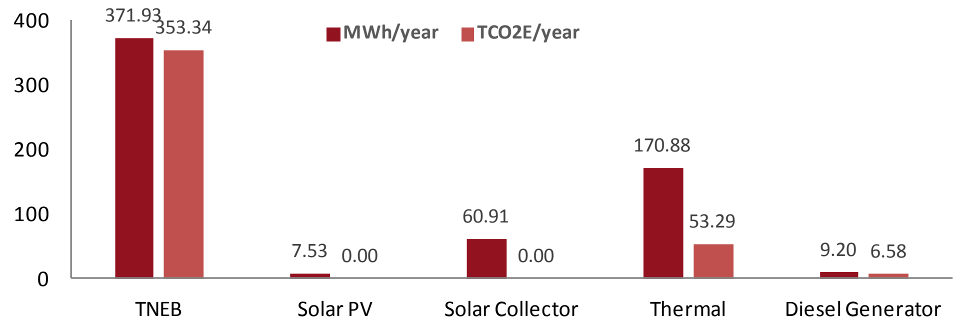
Figure 101 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Food Processing sector. Electric energy from the utility grid accounts for the majority of this sector's energy consumption with 372 MWh/year, followed by thermal energy (LPG) with 171 MWh/year.

The total electricity consumption is estimated at 339 MWh per annum. 96% of this demand is sourced from the utility grid, 2% is supplied by decentralized renewable technologies and 2% by stand-by diesel generators (see Table 56). Most of the renewable electricity is supplied by solar PV systems with 8 MWh per annum (see Figure 101).

*Table 56 Food Processing Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 3,71,932 kWh | 96% |
| Renewables | 7,529 kWh | 2% |
| Diesel Generator | 9,197 kWh | 2% |
| **Total Electric Energy Demand** | **3,88,658 kWh** | **100%** |

*Figure 101 Food Processing Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*




55% or 2, 12,209 kWh of the Food Processing Units sector's electricity consumption is accounted for by the appliances in the Others segment. This includes processing tools for food processing, stoves, baking ovens etc. Lighting accounts for 16% of this sector's electricity demand, followed by refrigerators with 14%. Refer to Figure 102 for a detailed distribution of electricity consumption by type of fixture/application for the Food Processing sector.

*Figure 102 Food Processing Sector Electricity Consumption by Type of Fixture/ Application, Auroville 2014*

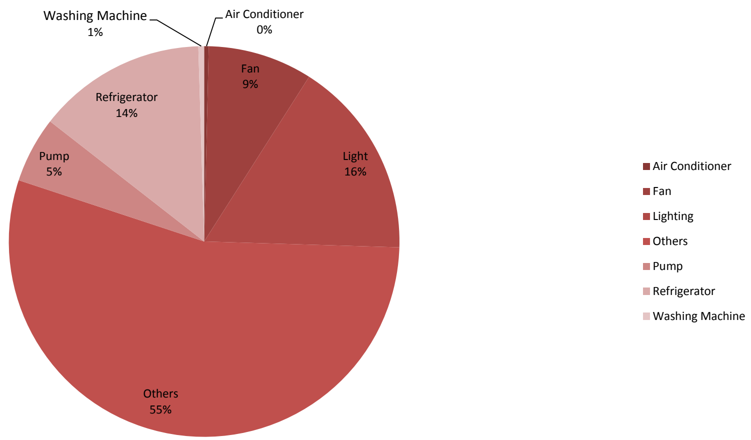
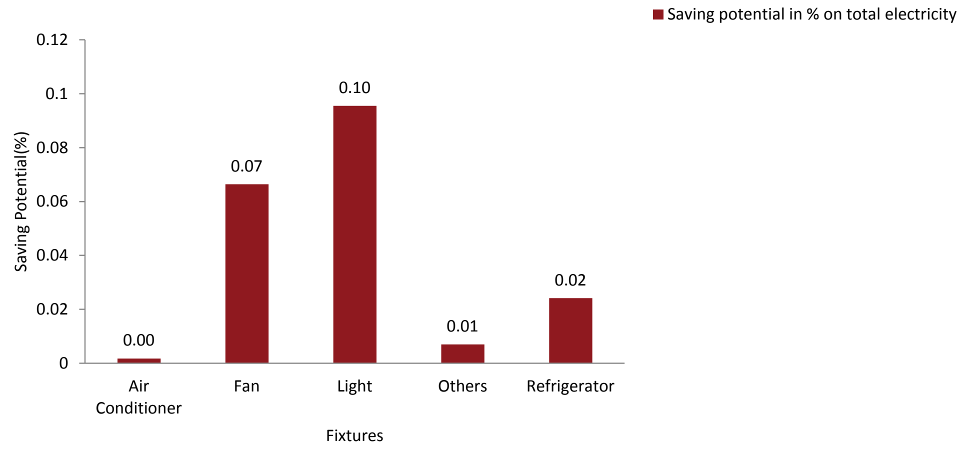



*Figure 103 Food Processing Sector Electricity Saving Potential by Type of Fixture/Application of Total Consumption, Auroville 2014*




## SAVING POTENTIAL

Figure 103 indicates the electricity saving potential by type of fixture/application for the Food Processing sector. The total saving potential for the Food Processing sector amounts to 75,678 kWh or 1.62% of Auroville's total electricity consumption. The highest saving potential was identified for lights with 37,137 kWh or 0.79% of total electricity consumption in Auroville. The refrigerator segment indicates a saving potential of 0.55% or 25,799 kWh per year.

The most cost efficient energy efficiency intervention is for lights with a capital investment requirement of INR 9.15 per kWh electricity saving and a payback period of 1.5 years. Energy efficiency interventions for the segment Others will result in a payback period of 3.5 years. For a detailed analysis of capital investment required per kWh of electricity saving and the estimated payback period, refer to Figure 103.

*Figure 104 Food Processing Sector Payback and Investment Required per kWh Saving by Fixture/Application in INR, Auroville 2014*

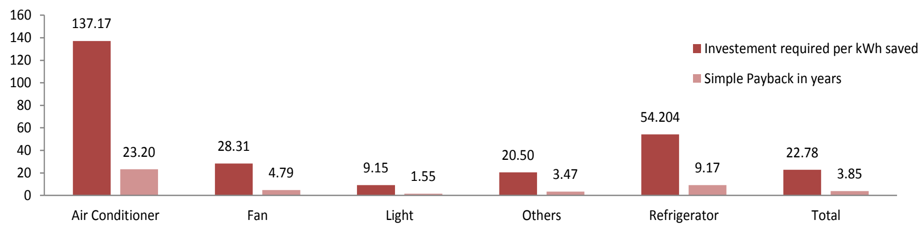



Table 57 summarizes the findings with regard to the electricity saving potential through energy efficiency interventions in the Food Processing sector of Auroville. It lists the electricity and financial saving potential, the investment requirement and the payback period. The most promising intervention in terms of payback period and achievable electricity saving is highlighted in colour.

*Table 57 Food Processing Sector Electricity Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Air Conditioner | 1,453 | 0% | 8,593 | 0.01% | 661 | 3,906 | 90,627 | 23.20 |
| Fan | 33,645 | 9% | 1,98,898 | 0.55% | 25,799 | 1,52,518 | 7,30,450 | 4.79 |
| Light | 63,919 | 16% | 3,77,873 | 0.79% | 37,138 | 2,19,549 | 3,39,818 | 1.55 |
| Others | 2,12,209 | 55% | 12,54,520 | 0.06% | 2,711 | 16,025 | 55,562 | 3.47 |
| Pump | 21,218 | 5% | 1,25,436 | 0.00% | - | - | - | - |
| Refrigerator | 54,362 | 14% | 3,21,373 | 0.20% | 9,371 | 55,398 | 5,07,908 | 9.17 |
| Washing Machine | 1,852 | 0% | 10,951 | 0.00% | - | - | - | - |
| **Total** | **3,88,658** | **100%** | **22,97,642** | **1.62%** | **75,679** | **4,47,396** | **17,24,364** | **3.85** |

## 4.12 AGRICULTURE

### METHODOLOGY

The electricity baseline for the Agriculture sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Agriculture sector.

### BASELINE

Figure 105 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Agriculture sector. Thermal energy (LPG) accounts for the majority of this sector's energy consumption with 171 MWh/year, followed by electric energy from the utility grid with 34 MWh/year.

The total electricity consumption is estimated at 436 MWh per annum. 78% of this demand is sourced from the utility grid and 22% is supplied by decentralized renewable technologies (see Table 58). Most of the renewable electricity is supplied by mini wind turbines with 8 MWh per annum. Solar PV systems contribute 3 MWh of annual electricity supply (see Figure 107).

*Figure 105 Agriculture Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

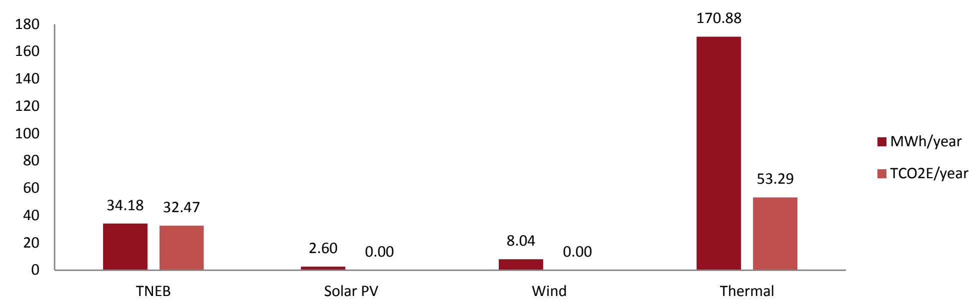



*Table 58 Agriculture Sector Electricity Baseline by Source and per Capita Electricity Consumption, Auroville 2014*

| | | |
|---|---|---|
| TNEB | 34,180 kWh | 78% |
| Renewables | 9,442 kWh | 22% |
| Diesel Generator | 0 kWh | 0% |
| **Total Electric Energy Demand** | **43,622 kWh** | **100%** |

*Figure 106 Agriculture Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*

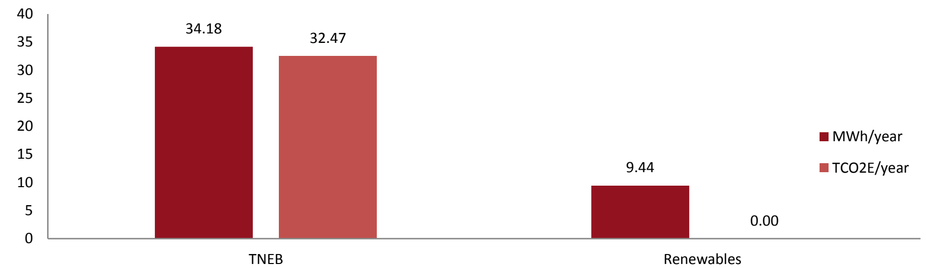
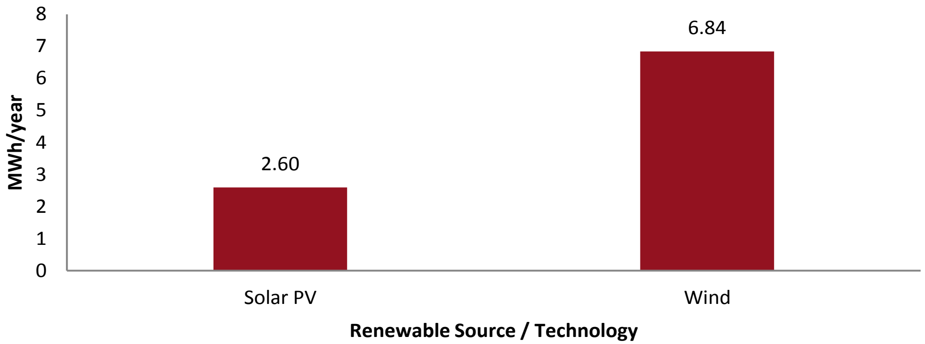


*FIGURE 107 AGRICULTURE SECTOR RENEWABLE ENERGY BY TYPE, AUROVILLE 2014*




## SAVING POTENTIAL

Water efficiency interventions for the agricultural sector have been simultaneously considered as energy efficiency interventions, assuming that for each percent of water saving the electricity consumption for pumping of water will reduce to the same extent. Water efficiency programmes, such as the installation of micro irrigation technologies, are estimated to reduce the Agriculture sector's electricity demand by 6,980 kWh per year. For details on water savings, please refer to Table 32 in Chapter 3.11 of this document.

*TABLE 59 AGRICULTURE SECTOR ELECTRICITY SAVING OPPORTUNITIES, AUROVILLE 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Water Efficiency Farms | 43,622 | 1% | 2,81,637 | 0.15% | 6,980 | 45,062 | 7,37,000 | 16.36 |

## 4.13 MUNICIPAL PUMPS

### METHODOLOGY

The electricity baseline for the Municipal Pumps sector was established using available data of electricity meter readings and the cumulative electricity consumption from renewable energy technologies and diesel generators. The saving potential per type of fixture/application was identified through energy audits conducted in units of this sector and was then extrapolated on the electricity baseline for the Municipal Pumps sector.

### BASELINE

Figure 108 indicates the total annual energy consumption by source of energy and the related $CO_2$ footprint ($TCO_2E$) for the Municipal Pumps sector. Electric energy from the utility grid solely accounts for the majority of this sector's energy consumption with 281 MWh/year.

The total electricity consumption is estimated at 281 MWh per annum, fully sourced from the utility grid (see Table 60 and Figure 108).

*TABLE 60 MUNICIPAL PUMPS SECTOR ELECTRICITY BASELINE BY SOURCE AND PER CAPITA ELECTRICITY CONSUMPTION, AUROVILLE 2014*

| | | |
|---|---|---|
| TNEB | 2,81,074 kWh | 100% |
| Renewables | 0 kWh | 0% |
| Diesel Generator | 0 kWh | 0% |
| **Total Electric Energy Demand** | **2,81,074 kWh** | **100%** |

*Figure 108 Municipal Pumps Sector Energy Consumption and $CO_2$ Baseline by Source, Auroville 2014*

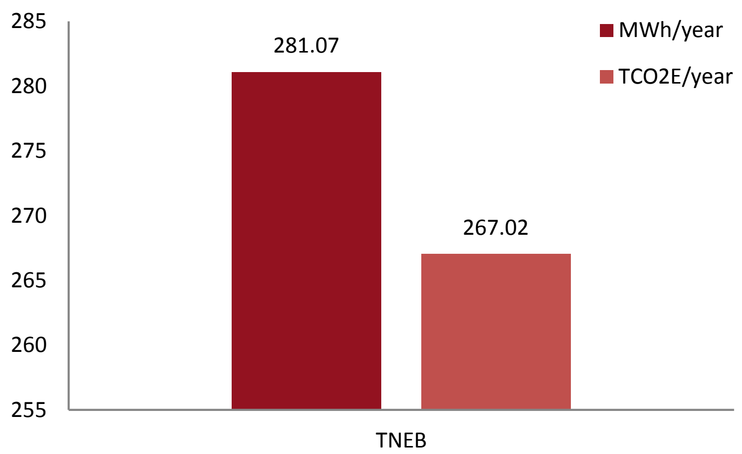
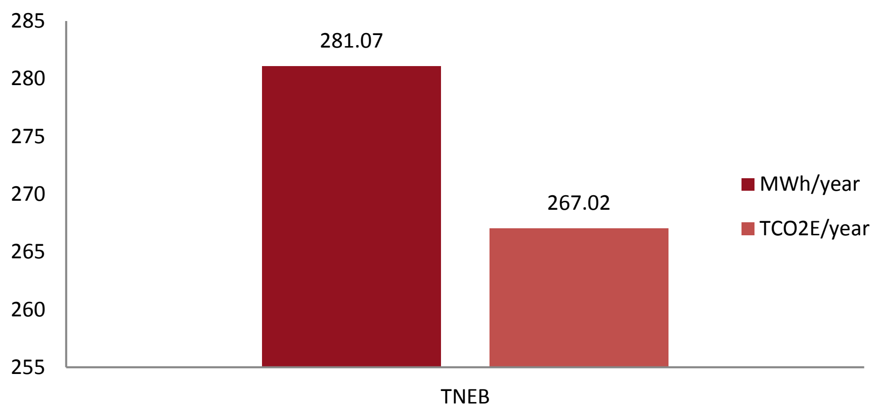



*Figure 109 Municipal Pumps Sector Electricity Consumption and $CO_2$ for Electricity by Source, Auroville 2014*




## SAVING POTENTIAL

The electricity saving potential identified for the Municipal Pump sector amounts to 2, 24,606 kWh per year or 2.95% of Auroville's total electricity demand 2014. Water efficiency for the building sector, as identified in Chapter 3, was taken into account as an energy efficiency intervention as well. Table 61 list details of the saving potential and investment required.

*Table 61 Municipal Pumps Sector Saving Opportunities, Auroville 2014*

| Appliances | Baseline Consumption 2014 in kWh/yr. | % of Total | Annual Electricity Cost 2014 in INR | Saving Potential in % of Total | Saving Potential in kWh/yr. | Saving Potential in INR/yr. | Investment Required in INR | Simple Payback in yr. |
|---|---|---|---|---|---|---|---|---|
| Energy Efficiency | 2,81,074 | 6% | 18,14,697 | 2.95% | 1,37,979 | 8,90,833 | 2,85,000 | 0.20 |
| Water Efficiency | - | 0% | - | 1.85% | 86,627 | - | - | - |
| **Total** | **2,81,074** | **6%** | **18,14,697** | **2.95%** | **2,24,606** | **14,50,12** | **2,85,000** | **0.20** |

## 4.14 TRANSPORT

### METHODOLOGY

The energy baseline for transport in Auroville was established on the basis of data from the Auroville Transport Service and verified assumptions from online research and TDC. Transportation in Auroville is mainly based on two wheelers (scooters, mopeds, geared and gearless bikes) and four wheelers (cars and heavy duty vehicles, like buses and load carriers). For this study, battery-operated vehicles have not been taken into account, as they do not contribute to the overall $CO_2$ emissions. Also taxis and guest/volunteer related transportation were not taken into consideration.

The total number of two wheelers in Auroville was assumed to be around 1,419 (see Table 62). This value is based on the assumption that 80% of the baseline population in Auroville above the age of 18 own a two wheeler. The average distance travelled by an individual in Auroville for personal and work-related activities per day is 9.6 km and the average mileage is 50 km/L, as per the report published by TDC (Council, 2014). The related $CO_2$ emissions per litre of consumption amount to 2.4 kg (EIA, 2014).

For four wheelers, the total number of cars in Auroville was challenging to identify, as only 18 vehicles were registered with the Auroville Transport Service. TDC, however, approximated the number to be on the higher side, at currently about 200. Additionally, there are 30 load carriers and buses in Auroville. The average distance travelled per day by a car is the same as that covered by two wheelers, namely 9.6 km. For load carriers and buses, however, the estimated value had to be doubled (20 km). The average mileage for a car is 16 km/L of petrol (Society of Indian Automobile Manufacturers (SIAM), 2011), and 6 km/L of diesel for buses and load-carriers. The corresponding $CO_2$ emissions amount to 2.4 kg/L and 2.74 kg/L, respectively (EIA, 2014). Based on the above parameters, the total energy consumption for transport and its related $CO_2$ emissions was established (see Figure 110).

The average per capita/year fuel consumption for transportation in Auroville is estimated at 64 L/year. This seems less compared with the equivalent value for Tamil Nadu at 198 L/year. Before comparisons are made, it must be highlighted that the baseline for transport in Auroville does not include the Auroville taxi services and petrol consumption of tractors, as there were no data recordings. Therefore, the average per capita/year fuel consumption for Auroville must be actually higher than the estimated value.

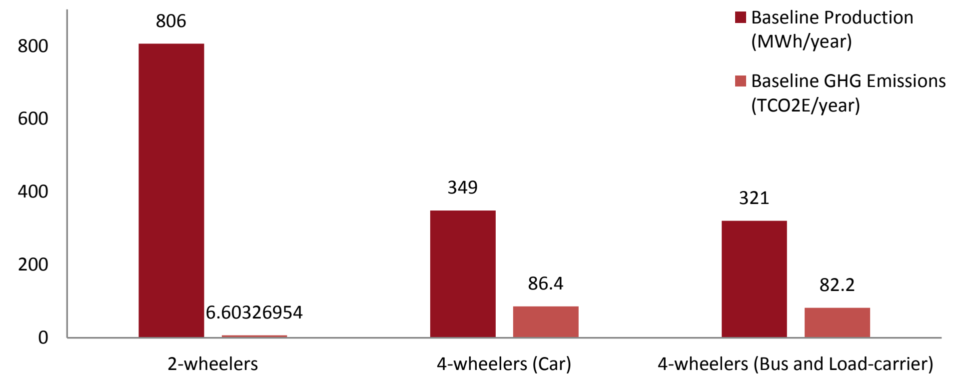
However, no recommendations were made on efficiency interventions for the transport sector in Auroville, as this was beyond the scope of the project.

## BASELINE

*Table 62 Transport Sector Data for Baseline Year, Auroville 2014*

| Item | Value |
|---|---|
| No. of Two Wheelers | 1,419 |
| No. of Four Wheelers (Cars) | 200 |
| No. of Four Wheelers (Buses and Load Carriers) | 30 |
| Annual Two Wheeler Petrol Consumed | 83,128 L |
| Annual Four Wheeler Petrol Consumed | 36,000 L |
| Annual Four Wheeler Diesel Consumed | 30,000 L |

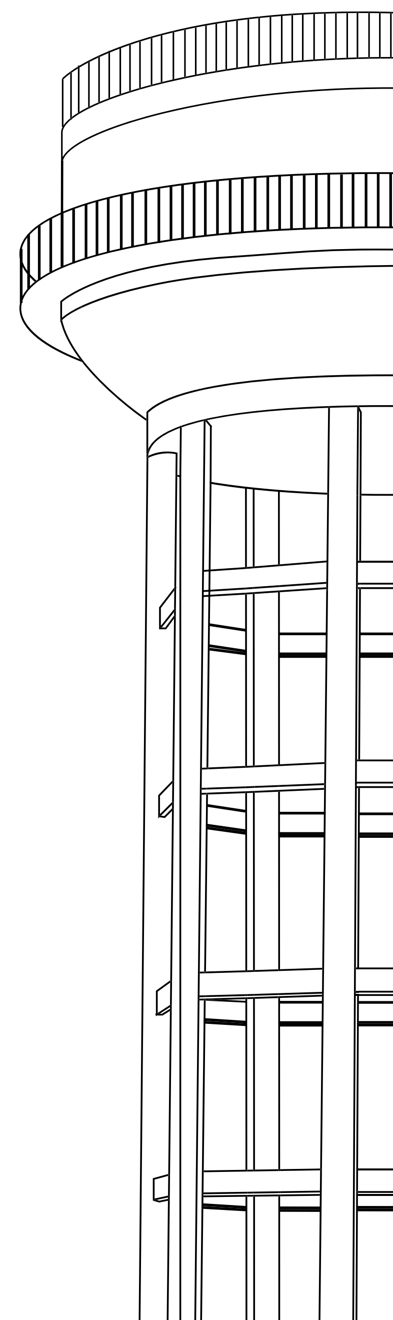
*Figure 110 Transport Sector Energy Consumption and $CO_2$ Baseline by Vehicle Type, Auroville 2014*

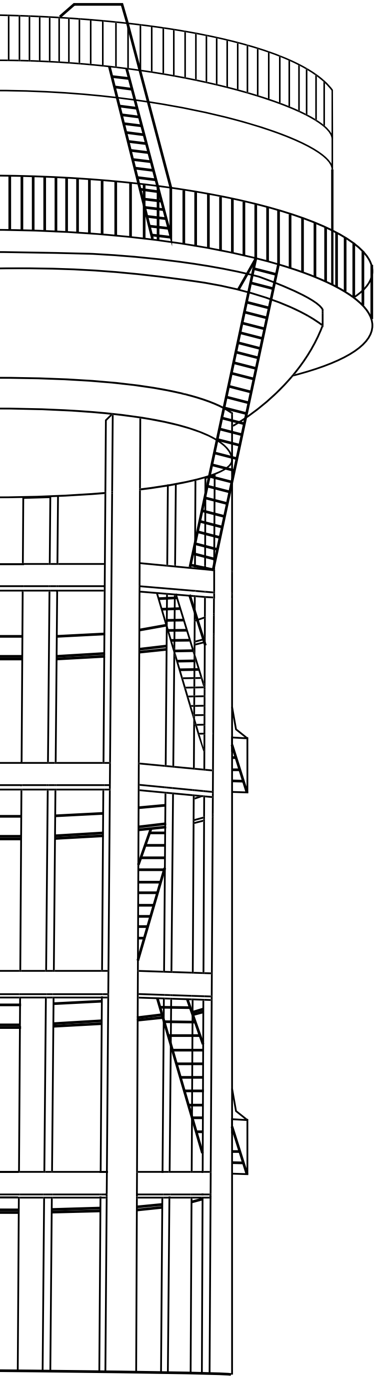



## 4.15 GOOD ENERGY SAVING PRACTICES AUROVILLE

In 2014, Auroville started an initiative named Sustainable Energy Prosperity Auroville, with the aim to increase Auroville's energy efficiency and renewable energy production. Demonstration projects for energy efficiency were implemented in four buildings:

- **PITANGA COMMUNITY CENTRE:** All T12 and T8 tubes were replaced by T5 tubes, Tungsten filament lamps were replaced by LED lights, and super efficient fans replaced all inefficient fans. A total reduction of 47% of baseline load was achieved.
- **UNITY PAVILION:** All T12 tubes were replaced by T5 tubes, Tungsten filament lamps were replaced by LED lights, and all fans were replaced by super efficient fans. A total reduction of 62% of baseline load was achieved.
- **DEEPANAM SCHOOL:** Refrigerator, T12, T8 tubes, fans and CFL lights were replaced by more efficient fixtures. A total reduction of 33% of baseline load was achieved.
- **NANDANAM KINDERGARTEN:** Refrigerator, T8 tubes and fans were replaced by more efficient fixtures. A total reduction of 42% of baseline load was achieved.





# 3. WATER DEMAND FORECASTING

# 5. WATER DEMAND FORECASTING

## METHODOLOGY

Water forecasting is based on the baseline calculated for the year 2014. Key criteria, such as population growth and the achievable target saving potential, are assumed. Based on this, the demand forecast is projected for the different scenarios. In the Business as Usual (BAU) case, no water saving interventions are taken up, and population growth projections are taken into account, based on baseline water consumption. In Case 1, all the suggested interventions are implemented to achieve overall water savings of 34% of baseline consumption. In Case 2, only selected interventions are implemented to achieve the set target saving potential. In Case 3, only selected interventions with low investment and high savings are implemented, along with a policy for water efficiency interventions in new buildings.

## FORECASTING

Figure 111 depicts the forecast of Auroville water consumption by sector from the baseline year to the year 2020. This forecasting is based on the assumption of a yearly population growth of 7%. The overall water consumption for Auroville will increase by 50.07% or an additional 7, 84,185 KL by the year 2020 (see Table 63).

*TABLE 63 WATER FORECASTING FOR BAU ON PUMPED WATER*

| | |
|---|---|
| Water Baseline 2014 | 15,66,082 KL |
| Forecasting BAU 2020 | 23,50,267 KL |
| Increase in KL | 7,84,185 KL |
| Increase in % | 50.07% |

*FIGURE 111 WATER FORECASTING BY SECTOR 2014 TO 2020*

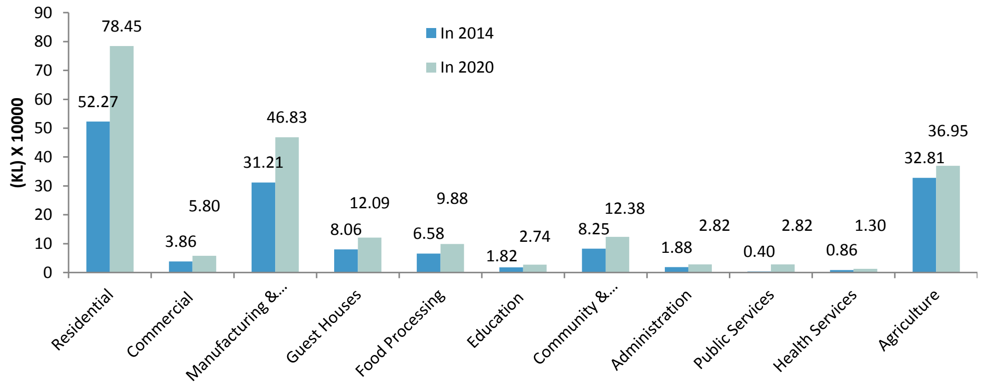



Figure 112 compares the water forecast for the Business as Usual scenario with 3 different scenarios of future water consumption in Auroville, when water efficiency programmes are implemented.

Case 1 estimates that 34.38% or 5, 35,222 KL of water consumption can be saved by 2020, if all recommended measures to achieve the water saving potential identified for the baseline year 2014 are being implemented.

Case 2 estimates that 16% or 2, 56,357 KL of water savings can be achieved compared with the baseline year, if the measures related to this scenario are implemented.

Case 3 estimates that a total saving potential of 33% or 5, 24,360 KL compared with baseline year water consumption can be achieved, if only the existing least efficient water fixtures are replaced by superior water efficient fixtures (16% water saving of baseline) and a mandatory water efficiency policy or building code for upcoming buildings or sites is implemented.

## FORECASTING DIFFERENT SCENARIOS

*Figure 112 Water forecast by different scenarios*

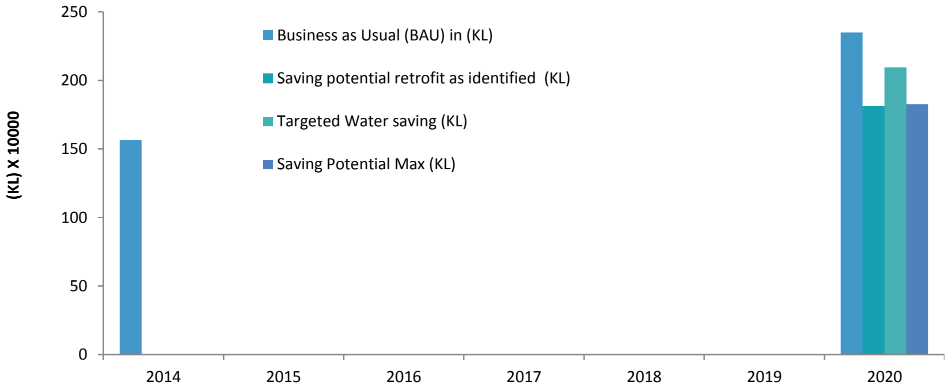
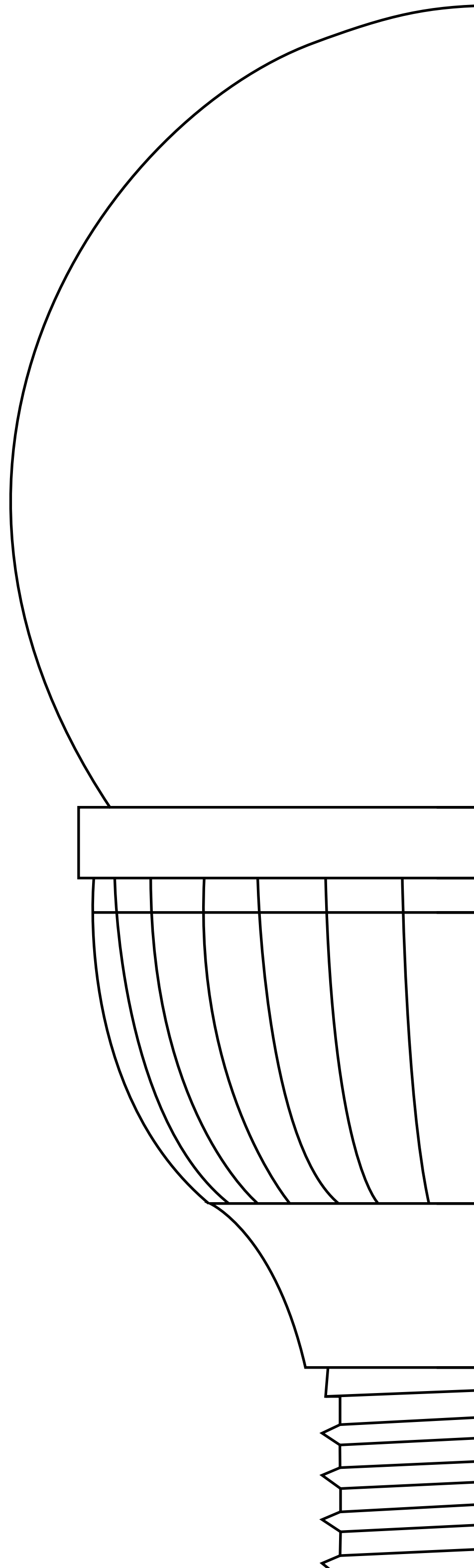


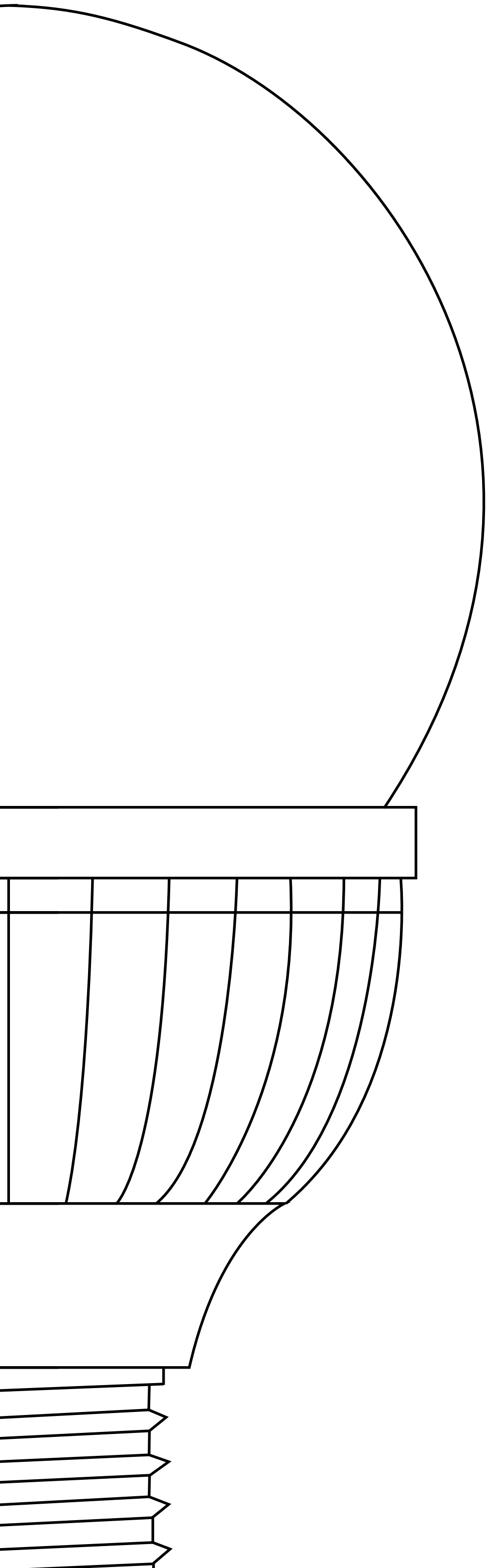

Table 64 gives a summary of the forecast figures for the three water efficiency scenarios and also lists the investment required for each of them. It indicates that the combination of a water efficiency programme for the low hanging fruits (fixtures with a high water saving potential and comparatively low capital investment) and a mandatory water efficiency building code will achieve high water savings with comparatively moderate capital investment, if compared to Case 1.

*Table 64 Water Saving Forecasting by Three Scenarios*

| | Case 1: 34.38% Water Saving | Case 2: 16% Water Saving | Case 3: 33% Water Saving |
|---|---|---|---|
| Water Saving in KL | 5,35,222 | 2,56,357 | 5,24,360 |
| Water Saving in % of Baseline | 34.18% | 16.37% | 33.48% |
| Investment in INR | 356,42,793 | 60,43,755 | 64,43,755* |

** The cost for developing the water efficiency building codes included in Case 3 has been estimated to be INR 4 lakhs.*





# 4. ENERGY DEMAND FORECASTING

# 6. ENERGY DEMAND FORECASTING

## METHODOLOGY

The energy demand forecast is calculated based on the energy baseline for the year 2014 (see Figure 113). Historical data of the population in Auroville and the corresponding electricity consumption from TNEB are used from 2005 until the baseline year 2014 (see Figure 114). This helps in estimating the annual percentage of population growth in Auroville and the percentage of increase in electricity consumption, owing to changes in lifestyle. These two factors are key in determining and projecting the energy forecast until the target year 2020. Similarly, the percentage of increase in electricity consumption over various sectors is calculated (see Figure 115). A similar methodology applies to the related $CO_2$ emissions. The three major contributors to the electricity generation in Auroville are the TNEB power grid, energy from renewable energy sources and back-up diesel generators. The forecast of electricity from these sources is calculated assuming that they will annually increase along with population growth and change in lifestyle.

*Figure 113 Historical Data on Electricity Consumption from TNEB, Auroville 2005 – 2014*

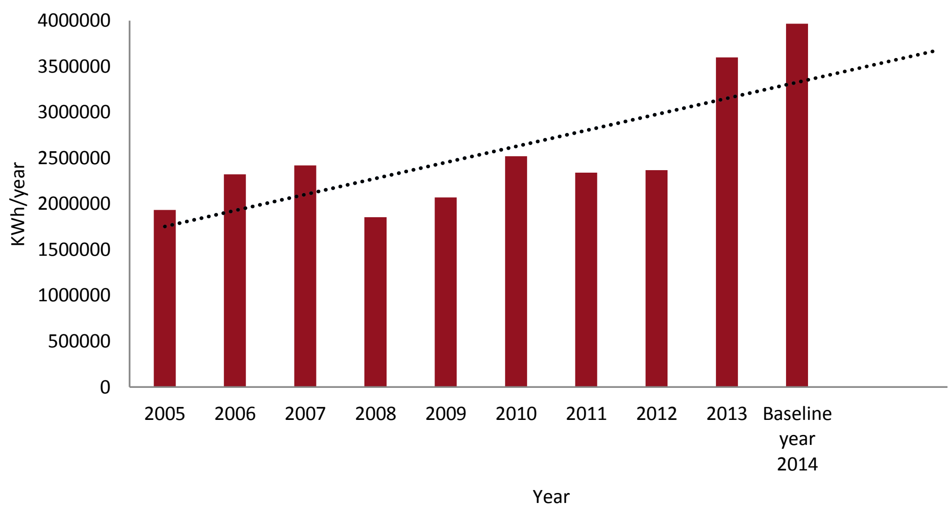



Figure 114 indicates the electricity consumption per capita/year from the TNEB utility grid. In the span of five years, the per capita electricity consumption has increased by 725 kWh. This is attributed to the changes in lifestyle encountered in Auroville, as residents install high energy consuming fixtures with the intention of seeking additional comfort during the summers in Auroville.

*Figure 114 Electricity Consumption per Capita from TNEB each Year of Total, Auroville 2009 – 2014*

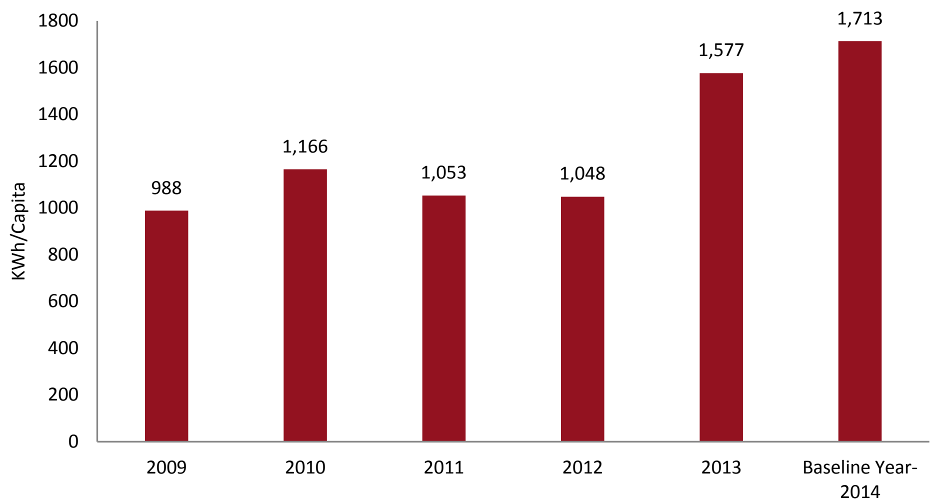



Figure 115 indicates the increase in percentage of electricity consumption from TNEB since 2009. The Agriculture sector shows the highest percentage of increase in electricity consumption. This may be due to the fact that the agricultural units in Auroville were connected to the TNEB power grid only recently. Earlier, these units were off-grid, relying purely on renewable resources for their electricity. The Administration sector shows the least percentage of increase in electricity consumption. This may be attributed to the fact that no new administration units were constructed since 2009, and consumption increased only slightly. The figures for the Health Services and Education sectors constitute the second largest percentage of increase in electricity consumption after the Community & Culture sector.

*Figure 115 Percentage of Increase in Electricity Consumption from TNEB due to Lifestyle Changes, Auroville 2009 - 2014*

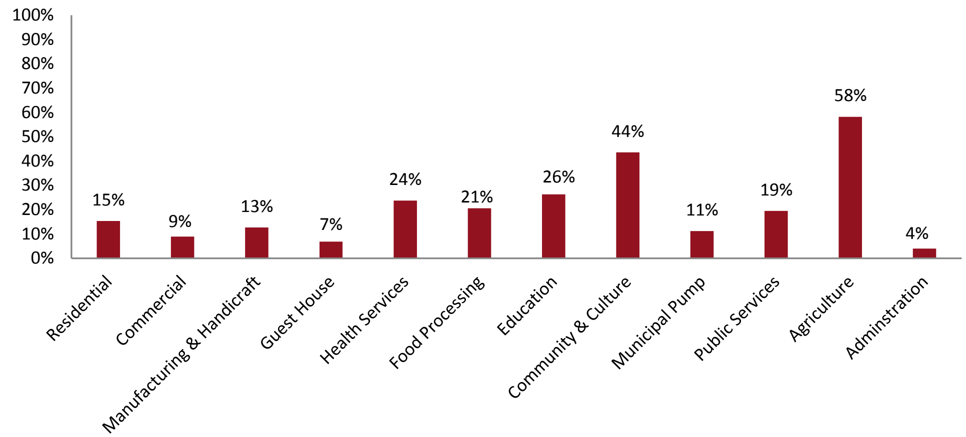



Figure 116 indicates the increase in electricity consumption per capita per sector. The Residential sector mainly contributes to the increase, with consumption almost doubled since 2009. The Agriculture sector shows the least increase in per capita consumption, followed by Public Service and Health Services sectors. There has also been a proportionate increase in the per capita energy demand from the Food Processing and Manufacturing & Handicraft sectors.

*Figure 116 Electricity Consumption per Capita Increase per Sector from TNEB, Auroville 2009 - 2014*

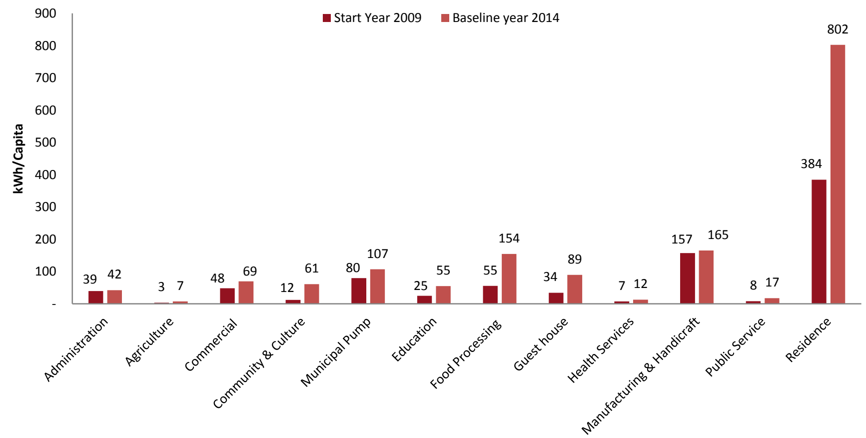



*Figure 117 Energy Demand Forecast by Source, Auroville 2020*

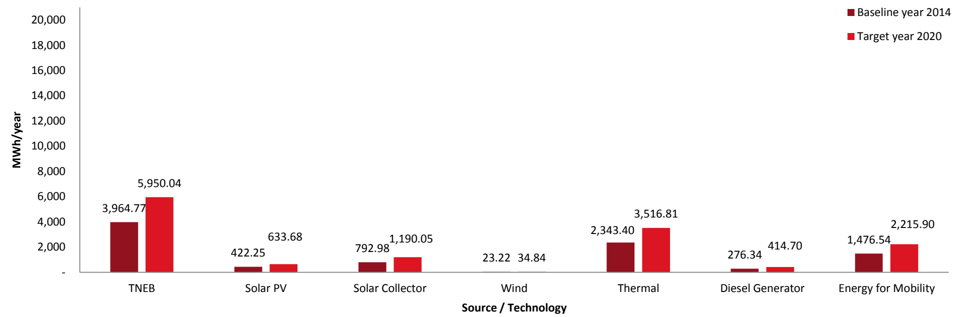


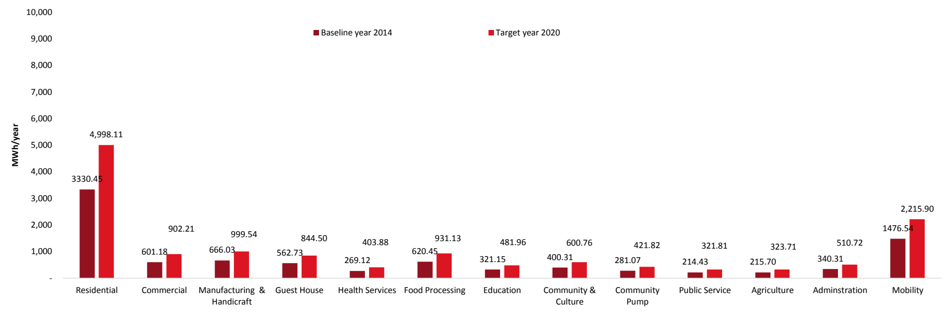

Figure 118 indicates the energy demand forecast by sector in Auroville. The Residential sector makes up the majority of future energy demand, almost half of the total energy demand in Auroville in 2020, followed by the Transport sector. The Commercial, Food Processing, Guest Houses and Manufacturing sectors all share almost an equal figure.

## FORECASTING

The energy demand forecast for Auroville was calculated after a detailed study of the historical trend of energy demand, based on which figures were estimated which validate the growing population and change in lifestyle choices of individuals in Auroville. The three sources for electrical energy generation in Auroville are the TNEB power grid, renewable sources (solar PV and mini wind turbines) and back-up diesel generators. For the energy produced by the above three sources, the percentage of population growth and percentage of change in lifestyle choices were factored in to project the energy required by 2020. For the remaining energy sources, like thermal, mobility and solar collector, the baseline energy for 2014 was multiplied with the percentage of increase in population.

As shown in Figure 117, the overall demand for energy in Auroville is forecasted to almost double by 2020. The energy demand forecast from TNEB is predicted to almost quadruple compared with the baseline scenario. This is followed by the energy demand from thermal energy (firewood and cooking gas) and the energy demand for transport. The forecasted energy demand from the solar PV and wind energy installations is meagre in comparison to the other sources. This strongly contradicts the sustainable lifestyle that Auroville abides by. Hence, more emphasis must be given to the development of renewable energy sources for generating electricity.

*FIGURE 118 ENERGY DEMAND FORECAST BY SECTOR, AUROVILLE 2020*




The forecast of $CO_2$ emissions by sector is depicted in Figure 119. Similar to the energy consumption forecast, energy consumption from the TNEB power grid almost contributes one third of the total 7,221 tonnes of $CO_2$ emissions in the year 2020. About 1,000 tonnes of $CO_2$ are emitted by thermal sources. $CO_2$ emissions from diesel generators and transport amount to about 250 to 300 tonnes in the year 2020, respectively.

*FIGURE 119 $CO_2$ EMISSION FORECAST BY SOURCE, AUROVILLE 2020*

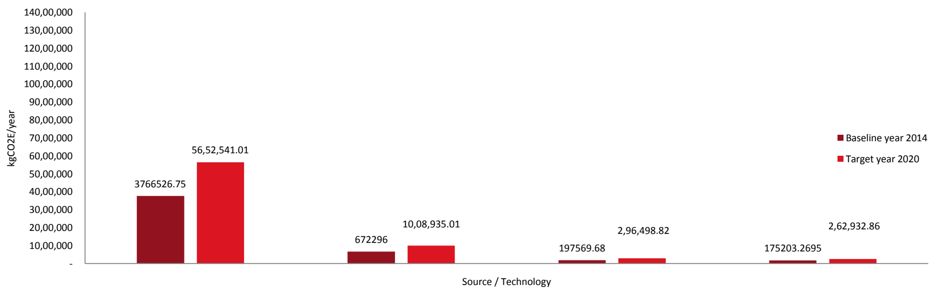



Figure 120 shows the forecast of $CO_2$ emissions by sector for Auroville by 2020. The energy consumption related $CO_2$ emissions in the Residential sector make up almost half of the total $CO_2$ emissions for the year 2020. The Manufacturing and Food Processing sectors are the next major contributors to $CO_2$ emissions in Auroville in 2020. Agriculture units are the least emitters of $CO_2$ as most of the energy is generated from renewable sources.

*FIGURE 120 $CO_2$ EMISSION FORECAST BY SECTOR, AUROVILLE 2020*

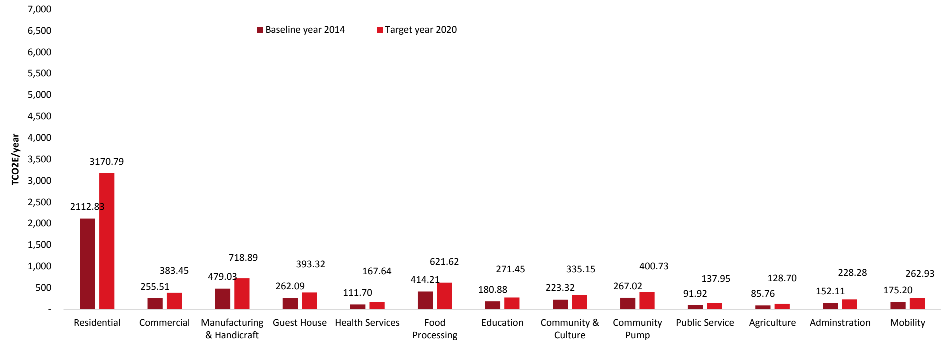



Figure 121 shows the electricity demand forecast by sector in Auroville by 2020. The electricity demand is forecasted to be highest in the Residential sector, consuming nearly half of all electricity required in 2020. Accordingly, the energy saving potential is highest in this sector. The Community & Culture and the Food Processing sectors are the next major consumers of electricity. The forecast of electricity demand in these sectors has exponentially increased.

*FIGURE 121 ELECTRICITY DEMAND FORECAST BY SECTOR, AUROVILLE 2020*

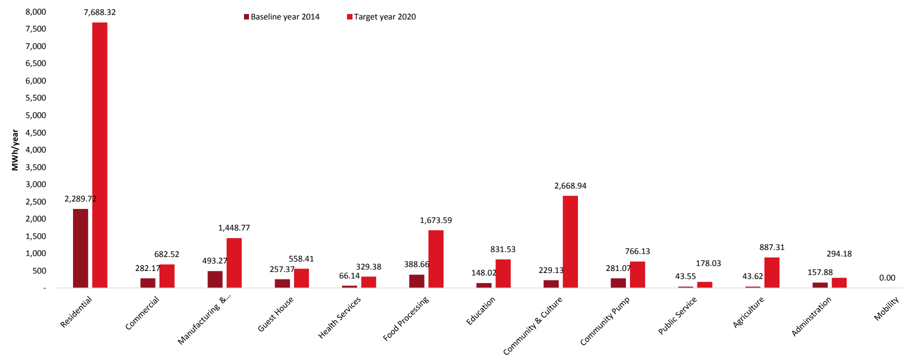
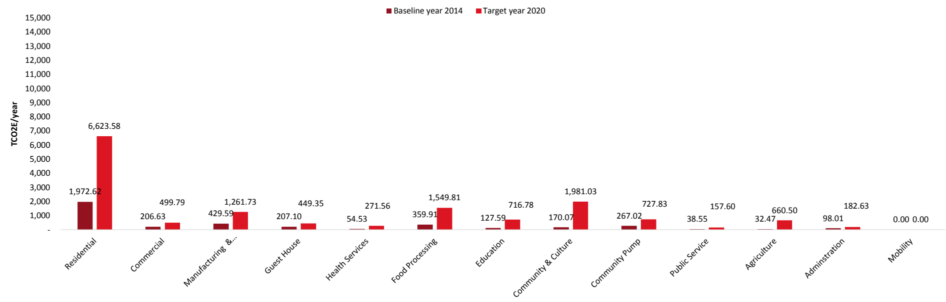


Figure 122 shows the forecast of electricity consumption related $CO_2$ emission by sector in Auroville in 2020. The $CO_2$ emissions in the Residential sector are highest. As in the case for electricity consumption by sector, the Community & Culture and the Food Processing sectors are the next main emitters of $CO_2$. The forecast of $CO_2$ emissions in these sectors has exponentially increased, owing to the forecast of higher electricity consumption.

*FIGURE 122 FORECAST OF ELECTRICITY RELATED $CO_2$ EMISSIONS PER SECTOR, AUROVILLE 2020*




## FORECASTING BY SCENARIO

Figure 123 and Figure 124 compare the electricity and $CO_2$ forecasting for the Business as Usual scenario, with a simulation of three different cases for future electricity consumption if energy efficiency programmes are implemented.

Case 1 estimates the electricity consumption by 2020 if all of the interventions for the identified energy saving potential in the baseline year 2014 are implemented. This can result in 26.91% electricity saving compared with the baseline.

Case 2 simulates the electricity consumption with a target of 22% electricity savings of the baseline year, resulting in 14,436 kWh of electricity savings.

Case 3 estimates the electricity saving potential of Case 2 in combination with a building energy code for operational energy (main fixtures such as fans, lights, refrigerators, air conditioners and geysers etc.), which will be made mandatory for any new building development. In this case, a saving potential of 27.28% of the baseline year can be expected.

*FIGURE 123 FORECAST OF $CO_2$ EMISSION REDUCTION IN DIFFERENT SCENARIOS, AUROVILLE 2020*

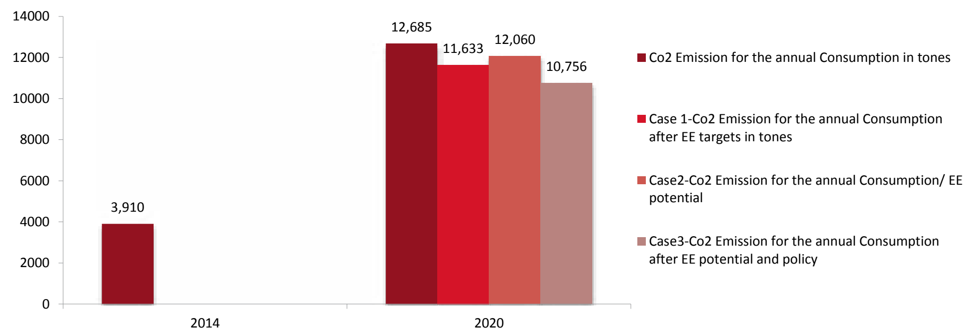



*FIGURE 124 FORECAST OF ELECTRICITY REDUCTION IN DIFFERENT SCENARIOS, AUROVILLE 2020*

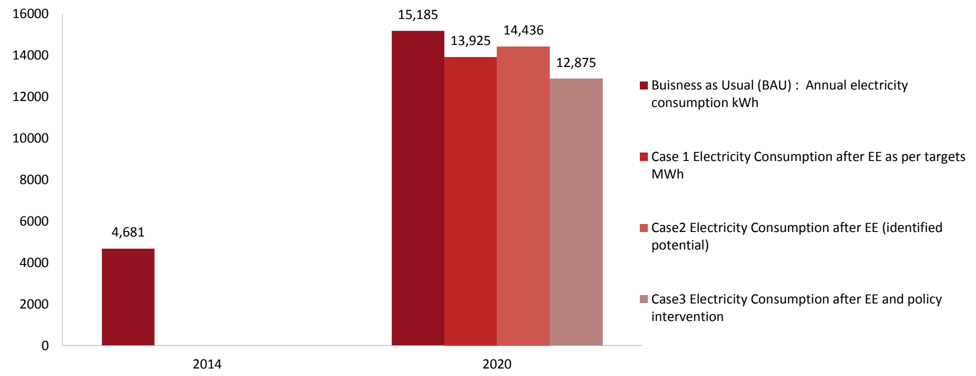
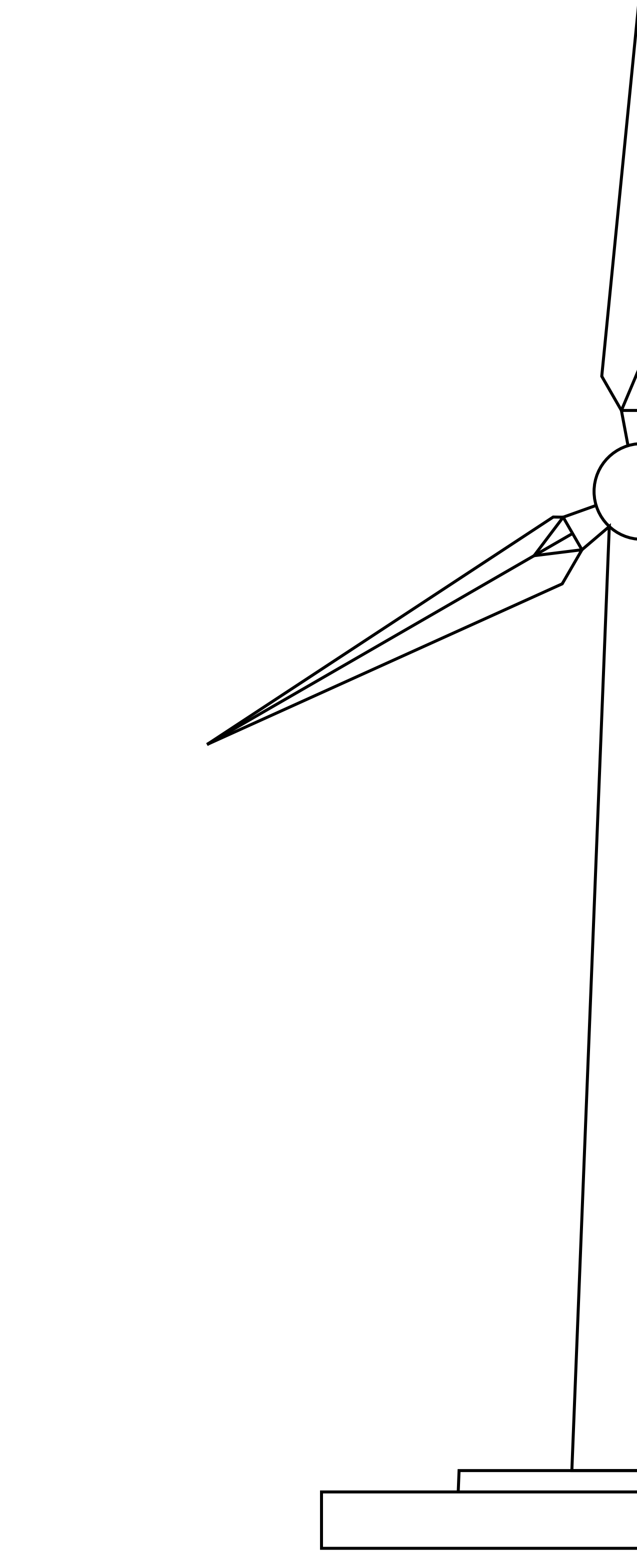


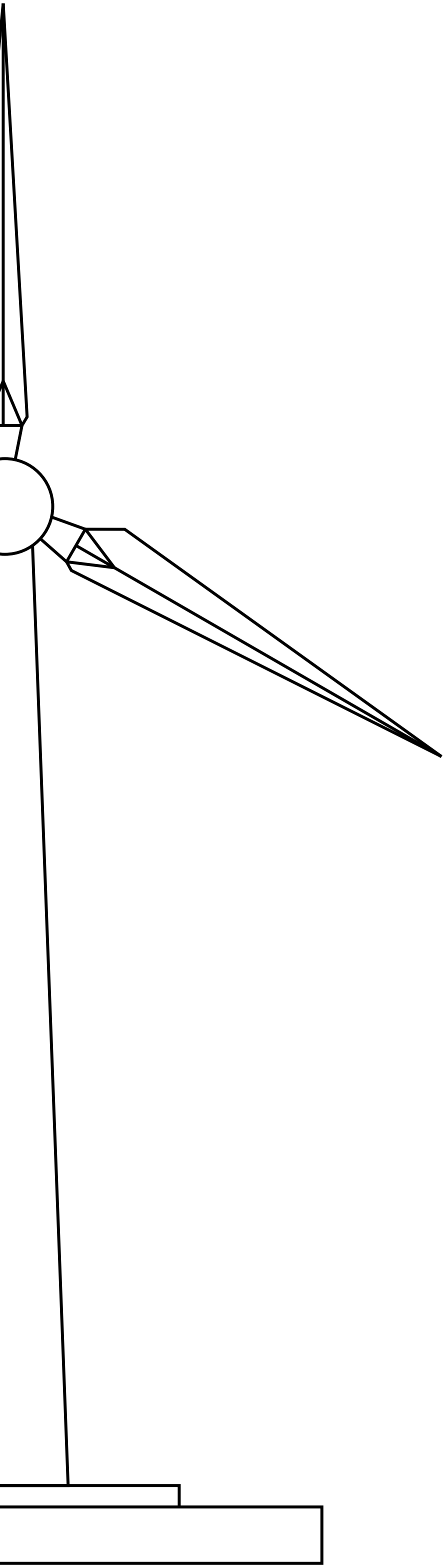

Table 65 indicates the $CO_2$ saving potential in percentage of the total Auroville $CO_2$ baseline 2014 for different energy efficiency cases. It highlights the respective investment requirements. Case 3 has the highest impact in terms of $CO_2$ reduction and, in comparison to case 2, it may achieve a similar $CO_2$ saving with greater cost effectiveness. The combination of a widespread energy efficiency programme for the main electrical fixtures and appliances (fans, lights, refrigerators) with an energy building code is recommended for implementation.

*Table 65 Comparison of $CO_2$ Saving Potential for Three Energy Efficiency Scenarios*

| | | | |
|---|---|---|---|
| Baseline $CO_2$ Emission 2014 in kg $CO_2E$/yr. * | 48,11,000 | | |
| $CO_2$ Reduction Target (25% of Total) | 12,02,750 | | |
| | **Case 1** | **Case 2** | **Case 3** |
| Energy Efficiency $CO_2$ Savings in kg$CO_2E$ | 10,52,279 | 8,61,337 | 11,19,358 |
| Energy Efficiency % of $CO_2$ Savings of Total in kg$CO_2E$ | 22% | 18% | 23% |
| Energy Efficiency Investment in INR | 3,44,70,440 | 1,97,08,494 | 2,01,78,494 |

** Total Auroville $CO_2$ Baseline (includes all energy sources)*





# 5. RENEWABLE ENERGY ASSESSMENT

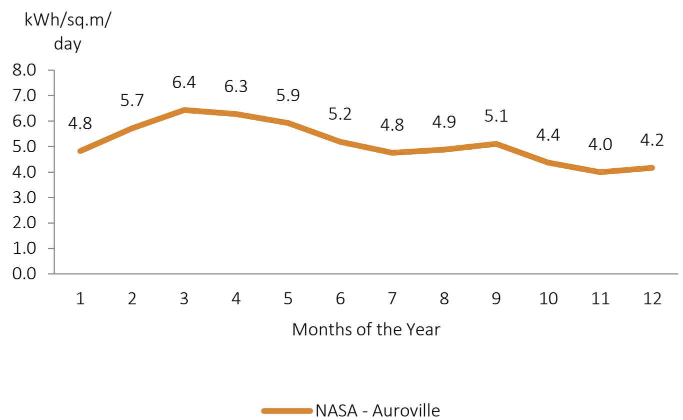
# 7. RENEWABLE ENERGY ASSESSMENT

This chapter explores the capacity potential and suitability of selected renewable energy technologies for Auroville. The suitability was explored in financial terms (capital cost, operation and maintenance, levelised cost). Other parameters such as water demand, land requirement, speed of deployment, infrastructure requirement and local employment generation were also taken into account.

## 7.1 SOLAR

Auroville is located at 12.01 N latitude and 79.81 E longitude, at an elevation of 64 AMSL. Data from NASA SSE Satellite, MNRE Solar Radiation Handbook and the National Renewable Energy Laboratory have been used to assess the solar radiation present in the general area (NASA data was taken for Auroville, while MNRE and NREL data was sourced in Chennai). From this data we can see that Auroville receives a good amount of solar radiation, with the average daily horizontal solar radiation amounting to 5.14 kWh/sq.m/day. We used this data to approximate a monthly average horizontal radiation for the location of the project, which is shown in the table below (see Figure 125).

*Figure 125 Mean Monthly Insulation Incident on a Horizontal Surface (kWh/sq.m/day)*




### AREA AVAILABLE FOR SPV

Medium and large-scale ground mounted solar systems require large land areas and infrastructure availability. Therefore, not many land parcels in Auroville are fit for large-scale solar PV development. Existing rooftop spaces are an attractive way to make Auroville more energy sufficient in a sustainable manner. The potential area available for solar PV rooftop installations was estimated to be 1,10,044 sq.m. This translates into a solar PV potential of 9.17 MW of installed capacity (see Table 66).

*Table 66 Potential Rooftop Area Available for Solar Technologies, Auroville 2014*

| | |
|---|---|
| Total Estimated Rooftop Area * | 2,20,089 sq.m |
| Estimated Rooftop Area Fit for SPV Installation (50% of Total) ** | 1,10,044 sq.m |
| SPV Rooftop Potential (12 sq.m per kW) | 9.17 MW |

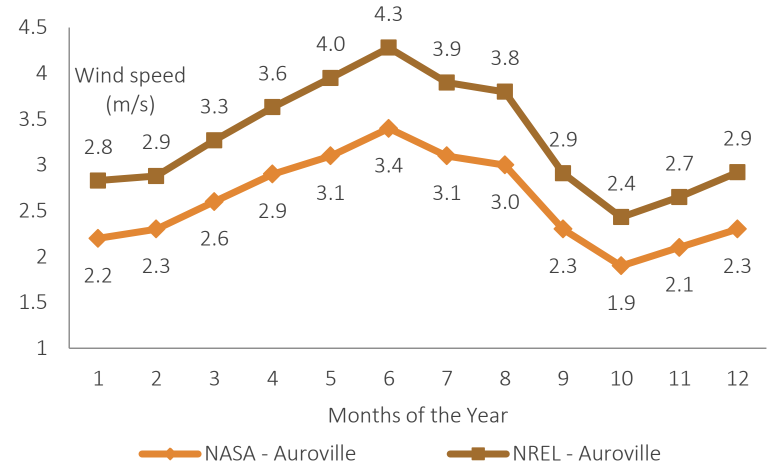
** The rooftop area has been calculated from data on building dimensions provided by Auroville Town Development Council. This value of rooftop area may be on the higher side as it has been assumed that the building footprint and the building rooftop area are the same size. The latter has been calculated from data on building dimensions, provided by Auroville Town Development Council (TDC).*

*** Not all of the rooftop area will be fit for Solar PV installation due to structural limitations, existing water tanks, shading by trees or structures etc. Therefore the utilizable space for SPV is estimated at 50% of the total rooftop area.*

## 7.2 WIND

Wind data for Auroville is presented in Figure 126. As average annual speeds of 4.0-4.5 m/s are needed to make a wind turbine cost-effective, wind potential seems to be less in Auroville. However, locally developed mini wind turbines are currently installed in Auroville, operating at a wind speed between 3 to 6 m/s, delivering 350 to 800 W at 10 m/s (MinVayu).

*Figure 126 Mean Monthly Wind Speed in Auroville (m/s)*




## 7.3 BIOGAS

In order to evaluate the biogas-to-energy generation potential for Auroville, existing decentralized waste water treatment systems and their potential biogas output and electricity equivalent were analysed. Auroville has about 40 decentralised waste water treatment systems installed as of the baseline year 2014. For a listing of all waste water treatment systems installed at Auroville refer to Annexure 4.

*Table 67 Waste Water Treatment Plants in Auroville and Potential Electricity Generation*

| Location | Volume of Waste Water in cu.m/day | Energy Content in Biogas in kWh/cu.m | Potential Energy Production* in kWh/yr. | Proposed System Size** in kW |
|---|---|---|---|---|
| Visitors Centre's Public Toilet | 162.5 | 330.4 | 32,711 | 42 |
| Udyogam | 39.0 | 79.3 | 7,851 | 10 |
| Solar Kitchen | 28.9 | 58.7 | 5,810 | 8 |
| Invocation-Arati-Surrender | 19.5 | 39.7 | 3,925 | 5 |
| AIAT | 19.5 | 39.7 | 3,925 | 5 |
| Auromode | 16.9 | 34.4 | 3,402 | 5 |
| Visitors Centre | 15.6 | 31.7 | 3,140 | 4 |
| **Total Capacity** | **301.9** | **613.8** | **67,209** | **79** |

** An electrical conversion efficiency of 30% is assumed. The system runs for 330 days per year (accounting for 35 days per year for maintenance).*

*** It is assumed that the system does not run more than 8 hours a day and extracts the full potential energy from the volume of waste water available.*

Table 67 includes all waste water systems which have a potential biogas production superior to 5 cubic meters per day, assuming that they run on their full capacity. It was found that the considered waste water treatment systems have a maximum annual electric energy production of 67,209 kWh.

## 7.4 BIOMASS

Data from The Auroville Biomass Study Report has been used to analyse the amount of biomass available in Auroville and the surrounding area in order to make recommendations on the potential for the development of biomass-based energy resources. The study concludes that biomass should be used only in so far as biodiversity and principles of conservation are respected so the reforested areas can be preserved. Of the various types of biomass available for the use as fuel, the principal source consists of fallen leaves and twigs (see Table 68). Seasonal availability of these leaves and twigs, as well as agricultural residues and industrial biomass, is relatively uniform throughout the year, which indicates that the input for power generation would be consistent.

*Table 68 Surplus Biomass Availability - Category Wise Biomass Type Surplus Available in Tonnes per Year*

| Biomass Type | Surplus Available in tonnes/yr. |
|---|---|
| Paddy Hay | 5.915 |
| Sugarcane Tops and Trash | 94.604 |
| Ground Nut | 3.283 |
| Coconut | 1,906.000 |
| Leaf/Twigs Available on Ground | 11,155.300 |
| Agroindustries | 90.250 |
| **Total** | **13,225.570** |

The findings suggest that the total biomass available in and around Auroville amounts to about 15,000 tonnes per year, out of which 13,225 tonnes are suitable for power generation. From this amount of biomass, 1.3 MW of power can be generated per year.

## RECOMMENDATIONS

In the short term, it would be advisable to use a decentralized approach with several plants ranging from 20-200 kWe. Though this may be more costly than building a large MWe-scale plant from the onset, it is more likely to succeed considering the distribution of biomass resources across Auroville. Transportation costs (not to mention the associated fuel emissions) of getting the biomass from forested areas to the plant, as well as storage and handling costs would discourage the use of biomass resources in Auroville. There is also the compelling argument that the twigs and leaves which have fallen to the ground contribute to the regeneration of the soil, and therefore removal of this residue for use in energy production would have a detrimental effect on the overall health of the forest. Thus, the study states, "harvesting of biomass from the reforested areas is not desirable."

## ALTERNATIVES

To ensure biomass is harvested sustainably in the long term, growing crops specifically for energy production has significant potential. Since energy crops typically require several years of growth before the harvest, it would be beneficial to co-produce with non-energy crops. Degraded lands should be used for energy plantations to minimise competition for land use with agriculture. One concern raised with energy plantations is the amount of water required. If properly managed, however, they can provide a regular source of woody biomass for energy production in the long term. As shown in the following table, hundreds of hectares of land are available in Auroville on which energy crops could be grown.

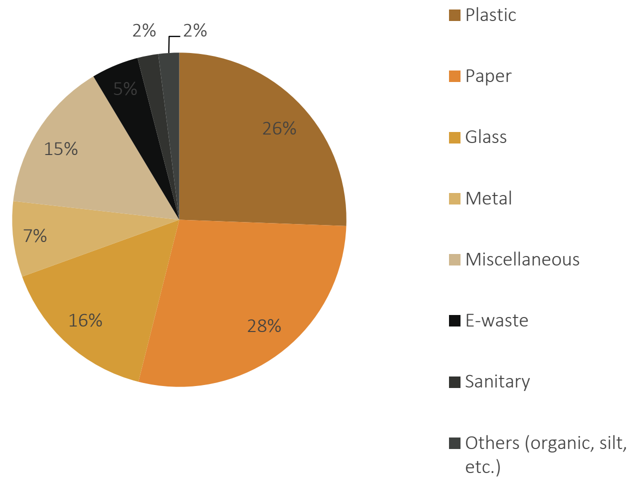
*Table 69: Land for Possible Energy Plantations (from Mukherjee, 2008: p. 25)*

| Land Type | Area in Hectares |
|---|---|
| Barren and Uncultivable Land | 361 |
| Land Under Miscellaneous Tree Crops & Groves | 8 |
| Fallow Land Other Than Current Fallow | 90 |
| **Total** | **459** |

## 7.5 WASTE-TO-ENERGY

The municipal solid waste (MSW) generated in Auroville is estimated to amount to 0.18 kg per capita per day. This does not include biodegradable waste, as most of the communities currently either compost their kitchen waste or collaborate with local farmers for the pick-up of the same. MSW generation rates in small towns are usually lower than those of metro cities. The per capita generation rate of MSW in India ranges from 0.2 to 0.5 kg/day (Kaushal 2012). Per capita MSW for Tamil Nadu is 0.467 kg per capita/day and 0.295 per capita/day for Pondicherry.

*Figure 127: Composition of MSW in %*



Assuming an annual increase of 1.33% in consumption patterns (EAI, 2012) and continuity in the composition of waste due to the raise of disposable income, the total generated waste per day in 2020 will amount to 1,015 kg, out of which 254 kg would be for landfill. MSW going to landfill has a calorific value of 35.7 MJ/kg (Nickolas J. Themelis, 2014). The minimum feedstock required to operate a waste-to-energy plant is one ton per day, and economies of scale favour big scale plants (van der Walt); therefore, this possibility is recommended to be left aside until the city grows to provide sufficient feedstock.

Considering biodegradable waste, the quantity and distribution per sector of food waste is shown in Figure 128. Nonresidential sectors contribute 163 kg of food waste per day. The food waste of Aurovilians might be reflected in 20% of the food waste collected by restaurants, as they have a good proportion of their meals outside home. Therefore, the contribution of the Residential sector has been estimated to be 80% of the food waste generated by each individual resident; this is estimated to be the difference between MSW per capita per day in Tamil Nadu and MSW generated per Aurovilian per day. This makes an individual contribution to organic waste of 0.230 kg per day, leading to a total of 538 kg per day in Auroville.

*Figure 128: Distribution of Food Waste in kg per Day per Sector, Auroville 2014*

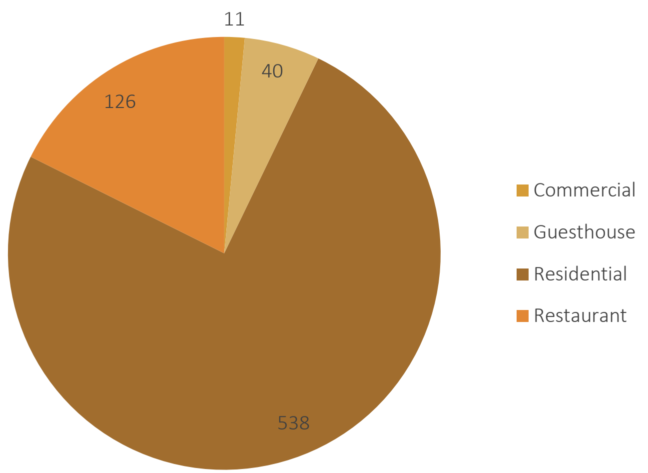



*Table 70 Food Waste, Energy Potential, Auroville 2014*

| | |
|---|---|
| Food Waste per Day | 716 kg |
| Estimated Biogas Production per Day | 358 cu.m |
| Electricity Potential per Day | 766 kWh |

Based on the available food waste, the potential biogas production amounts to 358 cubic meters, which equals 190 kWh per day for the contribution of the nonresidential sectors and 576 kWh for the Residential sector. Details on the biodegradable waste available for biogas digestion are available in Annexure 8.

## 7.6 RENEWABLE ENERGY TECHNOLOGIES

### SOLAR PHOTOVOLTAIC (PV)

Solar PV panels capture sunlight using semi-conducting material in an electric circuit. The solar radiation excites electrons in the PV cells, causing electrons to flow and electricity to be generated as direct current (DC). This DC travels through the inverter where it is converted to alternating current (AC), which can be used for electricity. Although PV panels work better in direct sunlight, they are not reliant on it and can produce electricity as long as there is daylight.

Solar PV systems can either be connected to a battery, which will store the solar energy to be consumed when there is no sunlight, or they can be grid-connected. If there is an excess of electricity produced by solar irradiance and a battery bank is used, a diversion load controller may be needed to divert electricity from the battery bank once it has been fully charged. If the PV system is grid-connected, however, this excess electricity can be sold back to the grid. Conversely, energy from the grid can be used to supplement solar energy when it does not provide enough electricity.

### SOLAR THERMAL

Solar thermal electric systems use mirrors to concentrate solar irradiance and heat a reserve of water. This turns the fluid into steam, which can be used to turn a turbine and generate electricity. There are several common types of concentrating solar thermal systems, including linear Fresnel reflectors, parabolic dishes and solar towers. Most technologies either use steam turbines, Stirling engines, organic rankine turbines or some combination of these to generate both electricity and heat.

### SOLAR HOT WATER

Solar hot water systems use a flat plate or an evacuated tube collector technology to convert solar energy into heat. In flat plate collectors, the sun heats copper pipes running through a glass-covered collector. In evacuated tube systems, two glass tubes are fused at the top and bottom, and the space between forms a vacuum. A copper pipe running through the centre is connected to a slow flow circulation pump that siphons off the heated water. Both collector systems are linked to an insulated storage tank, so the hot water can be used day or night.

Evacuation tube systems are more efficient because they are able to extract heat out of the air on a humid day when there is not direct sunlight, or when the light is not at an optimum angle (such as early morning or late afternoon).

### MINI WIND TURBINES

The mass of air moving in wind is a source of kinetic energy that can be harnessed by wind turbines. The wind rotates the blades, and this rotational motion is transferred to harmonic motion of the shaft. This can either be used to pump water or connected to a generator to make electricity. The amount of energy that wind carries increases as its speed increases and is proportional to the mass of air that passes over the rotors of the wind turbine. Modern wind turbines convert up to 50% of energy in wind into electricity, which comes close to the theoretical limit of 59% (calculated by Albert Betz in 1920).

### BIOGAS DIGESTER

Biogas digester systems break down organic matter such as kitchen waste and manure from livestock to produce biogas, which is mainly composed of methane and carbon dioxide. This biogas can be combusted and used as a fuel source for cooking, lighting, and other energy needs. It is called a "digester" because the tank contains anaerobic bacteria that eat the organic waste and give off biogas as a by-product. Once the waste has been fully digested, the remaining organic material exits the system as another by-product that can be used as fertilizer.

### BIOMASS GASIFICATION

Biomass gasification involves exposing biomass to high temperatures without sufficient air for full combustion to take place. Using a controlled amount of oxygen in the reaction converts the solid organic material into a gaseous mixture called syngas that is composed of carbon monoxide, hydrogen, and carbon dioxide. Use of syngas as a fuel can be cleaner than simply combusting the original biomass, because the high temperature of the gasification process refines out corrosive elements. Syngas can also be more efficient than directly combusting biomass because it can be burned at higher temperatures. Another benefit is that it makes use of the energy embedded in carbonaceous organic material which would otherwise have been disposed of or lie fallow.

## 7.7 EMERGING TECHNOLOGIES

### BUILDING INTEGRATED AND INFRASTRUCTURE INTEGRATED SOLAR PV

Building roofs and facades offer a large potential for harvesting solar energy. Building-integrated photovoltaic consists in using photovoltaic materials to replace conventional building materials in surfaces of the building envelope such as the roof, skylights or facades. Although they are mainly incorporated to the construction of new buildings, existing buildings can be retrofitted with the same technology. It allows solar to be the primary or secondary source of energy of the building, or to be exported to another utility through grid interconnection.

### STORAGE SOLUTIONS

Deployable for long-duration stationary applications, Aqueous sodium-ion based batteries show an interesting perspective for ecological storage technologies: "The Pittsburgh, Penn.-based Aquion says its technology can deliver round-trip energy efficiency of 85 percent; a ten-year, 5,000-plus-cycle life span; energy storage capacity optimised to charge and discharge for multi-hour applications; and perhaps most notably, a price point of $250 per kilowatt-hour" (Greentechmedia, 2014). Aqueous Hybrid Ion chemistry is composed of a saltwater electrolyte, manganese oxide cathode, carbon composite anode, and synthetic cotton separator. The battery utilizes non-corrosive reactions at the anode and cathode to prevent deterioration of the materials. The water-based chemistry results in a nontoxic and non-combustible product that is safe to handle and environmentally friendly (Aquion Energy, 2014).

## MICRO GRID, SMART GRID

Micro grid generates, distributes, and regulates the flow of electricity locally, on a small-scale version of the bulk power grid. The micro grid can function autonomously from the macro grid. It achieves specific local goals such as reliability, carbon emission reduction, and diversification of energy sources, decided by the community served. In areas such as Auroville, suffering from lack of power quality, voltage stability, reliability, protection and control, implementing a micro grid structure is a way to palliate those issues and implement renewable energies as a primary source of energy. Micro grids rely on the combination of distributed energy generation and diversified energy sources, already found in Auroville.

## DISTRIBUTED GENERATION

"Distributed generation from renewable energy sources will be an essential part of Auroville's electrical energy plans. This will include grid-connected solar PV systems, mostly on rooftops in the Auroville Township, small wind turbines and biogas plants. Distributed generation of electrical energy from renewable energy sources and rooftop solar PV in particular has the following advantages:

- Power is generated at the consumption centre resulting in reduction in transmission and distribution losses for the distribution licensee;
- In the case of solar energy, the daytime grid demand-supply gap gets reduced;
- The systems do not require land as is the case with utility-scale ground mounted systems;
- The systems can be connected to the existing (building) electrical infrastructure and do not require a dedicated electrical network to be developed and maintained;
- The distributed nature of small-scale (rooftop) solar PV systems reduces grid outage risks."

"The electrical distribution system as proposed in this electrical master plan will allow for extensive distributed generation and bidirectional energy flow in LT and HT feeders. While it is expected that the surplus renewable energy produced, if any, in a building or facility will be used by Auroville, if there is a net surplus at township level, that surplus will be exported to the Tamil Nadu electricity grid and accounted for through net-metering or other suitable mechanisms as applicable in the State. Bidirectional energy flow therefore will happen in most electrical feeders envisaged in this electrical master plan." (Development Consultants, 2014)

## SMART STREET LIGHTING

"Most streetlights in Auroville are solar street lights with individual solar panels and batteries for each luminaire. This has caused some maintenance challenges and there are plans to switch over to a cluster system whereby groups of street lights are connected to common solar energy systems that in most cases will be integrated with buildings along the roads to be lit."

"Each alternative street lighting fixture shall be fed from solar power and hence, balance intermediate street lighting fixtures shall be fed from grid power. This concept of road lighting by using combination of different power sources (grid power as well as solar power) adds the following advantages:

- Reduction of grid energy consumption
- Utilization of renewable energy
- Failure of one grid-fed lighting fixture, complete darkness avoided
- Failure of one solar-fed lighting fixture, complete darkness avoided
- Use of lower cross-sectional cable size" (Development Consultants, 2014)

Intelligent lighting can also integrate a daylight dependent control system. It involves a sensor which detects the amount of natural light and adapts to it using dimmable lamps.

## 7.8 COMPARISON OF RENEWABLE ENERGY TECHNOLOGIES

In order to support an informed decision making on the choice of the renewable energy to be deployed, different renewable energy technologies for electric energy generation were compared along a set of 12 parameters. Parameters include:

- Capital Cost (Rs/kW)
- LCOE (Rs/kWh)
- Point of Generation
- LCOP (Rs/kWh)
- Point of Consumption
- Year of Parity (LCOE)
- Year of Parity (LCOP)
- O&M (INR/yr.) Average
- Land Requirement (sq.m/kW)
- Water Usage (L/day)
- Speed of Deployment
- Infrastructure Requirement
- Employment Generation
- Social Acceptance
- Capital Cost and Operation & Maintenance Cost

*FIGURE 129 COMPARING CAPITAL COST AND OPERATION & MAINTENANCE COST OF RENEWABLE ENERGY TECHNOLOGIES*

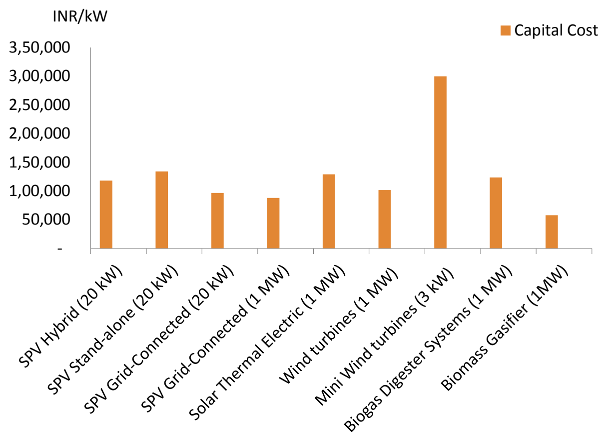


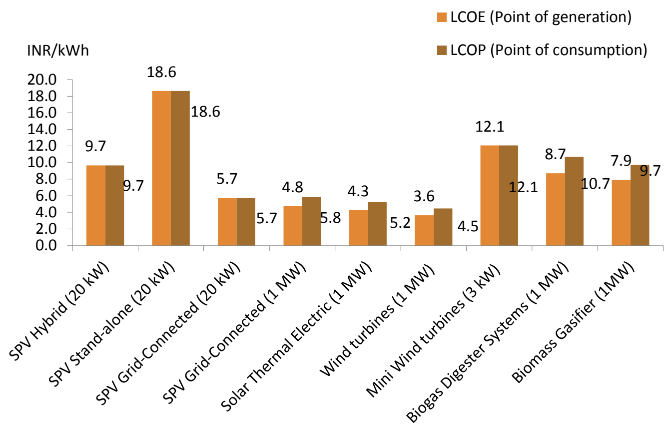

*TABLE 71: CAPITAL COST AND OPERATION & MAINTENANCE COSTS FOR DIFFERENT RENEWABLE ENERGY TECHNOLOGIES*

| System Type | Capital Cost in INR | O&M Avg. Costs in INR/yr. |
|---|---|---|
| SPV Hybrid (20 kW) | 1,18,343 | 13,758 |
| SPV Stand-Alone (20 kW) | 1,33,976 | 5,763 |
| SPV Grid-Connected (20 kW) | 96,776 | 12,673 |
| SPV Grid-Connected (1 MW) | 88,151 | 5,03,926 |
| Solar Thermal Electric (1 MW) | 1,29,040 | 30,84,472 |
| Wind Turbines (1 MW) | 1,01,612 | 17,93,680 |
| Mini Wind Turbines (3 kW) | 3,00,000 | 23,175 |
| Biogas Digester Systems (1 MW) | 1,23,465 | 82,79,886 |
| Biomass Gasifier (1MW) | 57,718 | 79,84,287 |

### LEVELISED COST ANALYSIS AND YEAR OF PARITY

A Levelised Cost Analysis is an economic tool that indicates the average price per kWh of electricity produced by a technology over the lifetime of the technology (20-25 years). A Levelised Cost Analysis accounts for capital costs, O&M, fuel costs, electricity generated, inflation rates etc. over the lifetime of the technology. Two different Levelised Cost Analyses were used in this report: Levelised Cost at the Point of Generation (LCOE) and Levelised Cost at the Point of Consumption (LCOP). Compared with LCOE, LCOP takes into account transmission and distribution losses of 18.5% (TEGI WRI, 2014) in the evacuation of electric power via the state utility grid. Therefore, LCOP per kWh is usually higher than LCOE. For small and medium sized renewable energy technologies such as grid connected solar rooftop systems or mini wind turbines, distribution losses were not considered as power consumption largely happens at the point of production itself. In this case the results for LCOP and LCOE will be the same.

*Figure 130 Levelised Cost of Point of Generation and of Point of Consumption, Auroville 2014*




Levelised Cost Analysis allows us to calculate the year of parity. The year of parity is the first year where the unit of renewable energy is equal or lower in price than the unit of electricity from the state utility grid (TNEB). For calculating the year of parity, an annual increase of 6% in price of electricity from the utility grid and the average price per kWh of electricity for Auroville of currently 5.62 INR were considered.

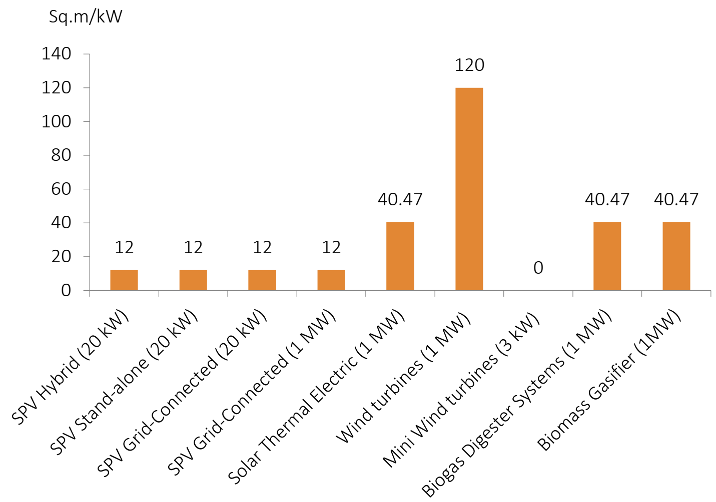
*Table 72 Year of Parity for Selected Renewable Energy Technologies, Auroville 2014*

| Renewable Technology | Year of Parity (LCOE) | Year of Parity (LCOP) |
|---|---|---|
| SPV Hybrid (20 kW) | 13 | 13 |
| SPV Stand-Alone (20 kW) | no parity | no parity |
| SPV Grid-Connected (20 kW) | 1 | 1 |
| SPV Grid-Connected (1 MW) | 1 | 1 |
| Solar Thermal Electric (1 MW) | 1 | 7 |
| Wind Turbines (1 MW) | 1 | 1 |
| Mini Wind Turbines (3 kW) | 13 | 13 |
| Biogas Digester Systems (1 MW) | 6 | no parity |
| Biomass Gasifier (1MW) | 1 | no parity |

## LAND REQUIREMENT

Land requirements vary for each renewable energy technology. Sometimes land acquisition is not necessary, as the technologies can be deployed in rooftops (such as for rooftop solar PV or mini wind turbines). Figure 131 indicates the land requirement per installed kWp for the selected technologies. The highest land requirement is accounted for big scale wind turbines due to the space requirement between two turbines. The land in between large wind turbines can be used productively for agriculture or the deployment of other renewables such as solar energy.

*Figure 131: Land Requirement for Renewable Energy Technologies (sq.m/kW), Auroville 2014*




## WATER USAGE

As Auroville is largely dependent on monsoon rains and water extraction for its water supply, water security and scarcity are two important issues for its further development. Highly water intensive renewable energy technologies may therefore not be prioritised, or alternatively the use of recycled water from local waste water treatment systems may be considered. Solar PV, wind and biomass gasifiers are renewable energy systems which are low in water consumption. Solar thermal electronic systems (e.g. Fresnel technology) are the most water intensive renewable technology in this comparison (see Table 73).

*Table 73: Water Usage of Selected Renewable Energy Technologies*

| Renewable Technology | Water Usage in L/day |
|---|---|
| SPV Hybrid (20 kW) | 0.040 |
| SPV Stand-Alone (20 kW) | 0.040 |
| SPV Grid-Connected (20 kW) | 0.040 |
| SPV Grid-Connected (1 MW) | 0.040 |
| Solar Thermal Electric (1 MW) | 54,000 |
| Wind Turbines (1 MW) | 0 |
| Mini Wind Turbines (3 kW) | 0 |
| Biogas Digester Systems (1 MW) | 20 |
| Biomass Gasifier (1MW) | 0 |

## OTHER PARAMETERS

Additional parameters in assessing the most appropriate renewable energy solution for Auroville were social acceptance, local employment generation, speed of deployment and infrastructure requirements. Social acceptance varies according to the type of renewable energy technology deployed. Actual or perceived disturbances such as noise, aesthetics, smell or associations play a role in whether or not a certain technology is accepted by the residents. Employment generation, speed of deployment, infrastructure requirement can be qualified based on a multi-criteria analysis (see Annexure 9).

*Table 74: Comparison of Renewable Energy Technologies Along Various Parameters*

| Renewable Technology | Speed of Deployment | Infrastructure Requirement | Employment Generation | Social Acceptance |
|---|---|---|---|---|
| SPV Hybrid (20 kW) | High | Low | Medium | High |
| SPV Stand-Alone (20 kW) | High | Low | Medium | High |
| SPV Grid-Connected (20 kW) | High | Low | Medium | High |
| SPV Grid-Connected (1 MW) | Medium | High | High | High |
| Solar Thermal Electric (1 MW) | Medium | High | Medium | Medium |
| Wind Turbines (1 MW) | Low | Medium | Low | High |
| Mini Wind Turbines (3 kW) | High | Low | High | Medium |
| Biogas Digester Systems (1 MW) | Low | High | High | Medium |
| Biomass Gasifier (1MW) | Low | High | Medium | Low |

## SUMMARY

| Renewable Technology | Capital Cost in INR/kW | LCOE in INR/kWh Point of Generation | LCOP in INR/kWh Point of Consumption | Year of Parity (LCOE) | O&M in INR/yr. Average | Land Requirement in sq.m/kW | Water Usage in L/day | Speed of Deployment | Infrastructure Requirement | Employment Generation | Social Acceptance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SPV Hybrid (20 kW) | 1,18,343 | 9.7 | 9.7 | 13 | 13,758 | 12.00 | 0.040 | High | Low | Medium | High |
| SPV Stand-Alone (20 kW) | 1,33,976 | 18.6 | 18.6 | No | 5,763 | 12.00 | 0.040 | High | Low | Medium | High |
| SPV Grid-Connected (20 kW) | 96,776 | 5.7 | 5.7 | 1 | 12,673 | 12.00 | 0.040 | High | Low | Medium | High |
| SPV Grid-Connected (1 MW) | 88,151 | 4.8 | 5.8 | 1 | 5,03,926 | 12.00 | 0.040 | Medium | High | High | High |
| Solar Thermal Electric (1 MW) | 1,29,040 | 5.4 | 6.6 | 1 | 36,80,311 | 40.47 | 54,000 | Medium | High | Medium | Medium |
| Wind Turbines (1 MW) | 1,01,612 | 3.6 | 4.5 | 1 | 17,93,680 | 120.00 | 0 | Low | Medium | Low | High |
| Mini Wind Turbines (3 kW) | 3,00,000 | 12.1 | 12.1 | 13 | 23,175 | 0.00 | 0 | High | Low | High | Medium |
| Biogas Digester Systems (1 MW) | 1,23,465 | 8.7 | 10.7 | 6 | 82,79,886 | 40.47 | 20 | Low | High | High | Medium |
| Biomass Gasifier (1MW) | 57,718 | 7.9 | 9.7 | 1 | 79,84,287 | 40.47 | 0 | Low | High | Medium | Low |

## 7.9 GOOD RENEWABLE ENERGY PRACTICES IN AUROVILLE

**SOLAR KITCHEN:** Use of a solar concentrated system producing steam for cooking purposes. It directly converts water pumped into its receiver into steam. Working together with a diesel fired boiler, the solar bowl produces a quarter of the steam required during the morning, and 100% of the steam necessary from 11 a.m., on sunny days. The remaining energy requirements for cooking and the production of hot water necessary to clean the kitchen vessels are covered by the solar bowl steam.

**EXAMPLE RESIDENTIAL HOME:** Installation of 16 solar panels on the rooftop. It represents an installed PV capacity of 1.7 kW. Surplus energy is exported into the grid and the system does not comprise batteries. The system is fully utilized and annually exports 1470 kWh to the grid, whereas it imports only 1210 kWh for internal consumption, which makes it energy positive. A stand-alone PV system completes the setup, producing 2240 kWh per year. It allows the installation to be independent from grid power cuts.

**FUTURE SCHOOL:** Use of a grid-connected solar PV system, producing 4,760 kWh per year. Solar PV production accounts for 65% of the building's total electricity consumption.

**TOWN HALL:** Use of a grid-connected solar PV system, producing 11,680 kWh a year. Solar PV production accounts for 11% of the building's total electricity consumption. A stand-by generator is used as backup when solar power is not sufficient.

**AUROVILLE FOUNDATION OFFICE:** Use of a grid-connected solar PV system, producing 25,000 kWh a year, of which 2,400 are annually exported to the state utility grid. Solar PV production accounts for 60% of the total building electricity consumption.

**AFSANAH GUEST HOUSE:** Use of a grid-connected solar PV system, producing 25,200 kWh a year, of which 1,200 are annually exported to the state utility grid. Solar PV production accounts for 57% of the total building electricity consumption; power imported from the grid represents 37% of the electricity consumption. A diesel generator is used as a back-up power source and accounts for 9% of the annual electricity consumption.

**MAROMA:** Use of a grid-connected solar PV system, producing 15,000 kWh a year. It is used as a hybrid system, in combination with a diesel generator in case of power cuts.

**AUROVILLE VISITORS' CENTRE CAFETERIA:** Use of two portable biogas digesters, amounting to an estimated 4.8 kg of gas per day.

**WATER PUMPING WIND TURBINES:** 20 mechanical wind turbines produce the energy necessary to pump water from the bore well to tanks, or directly to the houses.

**SOLAR PUMPS:** 16 solar pumps are used for supplying some of the water requirements of Auroville farms.

# 10. TARGETS ANNUAL GOALSETTING

# 8. TARGETS ANNUAL GOAL SETTING

Based on the findings of the water and energy saving potential and the potential for installing renewable energy systems, annual targets for each of these areas were defined in order to achieve a 25% reduction of $CO_2E$ by 2020. Table 75 details the targets per type and sector of interventions and indicates the capital cost required for the procurement of fixtures, appliances and systems. It may be noted that installation costs for water and energy efficiency fixtures are not reflected in this table, but only the capital investment required for purchase.

*Table 75 Water Saving Target and Annual Goal Setting*

| Sector | Interventions | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Saved Water in KL | % Saved | Investment in INR |
|---|---|---|---|---|---|---|---|---|---|
| Residential | Garden Pimple | - | 5,667 | 5,667 | 5,667 | - | 17,000 | 1.55% | 3,06,000 |
| | Showers | - | 20,000 | 20,000 | 20,000 | - | 60,000 | 5.47% | 27,00,000 |
| Commercial | Tap | - | - | | 4,500 | 4,500 | 9,000 | 0.82% | 36,000 |
| Manufacturing & Handicraft | Garden Pipe | - | - | 4,500 | 4,500 | - | 9,000 | 0.82% | 45,000 |
| | Cisterns | - | - | 2,000 | 2,000 | - | 4,000 | 0.36% | 3,28,000 |
| Guest Houses | Garden Pipe | - | - | 575 | 575 | - | 1,150 | 0.10% | 4,600 |
| | Kitchen Sink | - | - | 6,650 | 6,650 | - | 13,300 | 1.21% | 53,200 |
| Food Processing | Kitchen Sink | - | - | 3,333.3 | 3,333 | 3,333 | 10,000 | 0.91% | 2,10,000 |
| Education | Kitchen Sink | - | 500 | - | - | - | 500 | 0.05% | 40,000 |
| Community & Culture | Garden Pimple | - | 4,500 | 4,500 | - | - | 9,000 | 0.82% | 36,000 |
| Administration | Tap | - | 1,500 | 1,500 | - | - | 3,000 | 0.27% | 3,000 |
| | Garden Pimple | - | 1,600 | 1,600 | - | - | 3,200 | 0.29% | 3,200 |
| Public Service | | - | - | - | - | - | - | - | - |
| Health Services | | - | - | - | - | - | - | - | - |
| Matrimandir | | - | - | - | - | - | - | - | - |
| Agriculture | Micro Irrigation | - | 18,250 | 18,250 | | | 36,500 | 3.33% | 14,60,000 |
| | **Total** | **-** | **52,017** | **68,575** | **47,225** | **7,833** | **1,75,650** | **16.02%** | **52,25,000** |

*Table 76 Electricity Annual Goal Setting and Target*

| Sector | Energy Efficiency Electricity | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | kWh Saved | % Saved on Electricity Baseline | $CO_2E$/ Reduction in tonnes | Investment in INR |
|---|---|---|---|---|---|---|---|---|---|---|
| Residential | Fan | - | - | 18,189 | 18,189 | 18,189 | 54,567 | 1.17% | 45.59 | 20,03,829 |
| | Light | - | - | 70,462 | 70,462 | 70,462 | 2,11,387 | 4.52% | 176.60 | 34,32,120 |
| | Refrigerator | - | - | 32,067 | 32,067 | 32,067 | 96,202 | 2.06% | 80.37 | 31,66,230 |
| Commercial | Fan | - | - | 2,412 | 2,412 | - | 4,825 | 0.10% | 4.03 | 2,21,701 |
| | Light | - | - | 2,188 | 2,188 | - | 4,376 | 0.09% | 3.66 | 1,92,918 |
| | Refrigerator | - | - | 710 | 710 | - | 1,419 | 0.03% | 1.19 | 49,099 |
| Manufacturing & | Fan | - | - | 24,389 | 24,389 | - | 48,778 | 1.04% | 40.75 | 24,40,973 |
| Handicraft | Light | - | - | 20,414 | 20,414 | - | 40,829 | 0.87% | 34.11 | 16,04,796 |
| | Refrigerator | - | - | 1,239 | 1,239 | - | 2,477 | 0.05% | 2.07 | 1,10,591 |
| Guest Houses | Fan | - | - | 3,261 | 3,261 | - | 6,521 | 0.14% | 5.45 | 4,04,786 |
| | Light | - | - | 2,791 | 2,791 | - | 5,583 | 0.12% | 4.66 | 2,05,007 |
| | Refrigerator | - | - | 3,611 | 3,611 | - | 7,222 | 0.15% | 6.03 | 3,84,231 |
| Food Processing | Fan | - | - | 12,900 | 12,900 | - | 25,799 | 0.55% | 21.55 | 7,30,450 |
| | Light | - | - | 18,569 | 18,569 | - | 37,138 | 0.79% | 31.03 | 3,39,818 |
| | Refrigerator | - | - | 4,685 | 4,685 | - | 9,371 | 0.20% | 7.83 | 5,07,908 |
| Education | Fan | - | 19,706 | - | - | - | 19,706 | 0.42% | 16.46 | 13,79,816 |
| | Light | - | 19,511 | - | - | - | 19,511 | 0.42% | 16.30 | 3,73,514 |
| | Refrigerator | - | 11,142 | - | - | - | 11,142 | 0.24% | 9.31 | 3,63,676 |
| Culture & | Fan | - | 43,161 | - | - | - | 43,161 | 0.92% | 36.06 | 30,04,993 |

*Table 77 Renewables Annual Goal Setting and Target*

| Sector | Solar PV Installed Capacity in kWp | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | kWh Produced | $CO_2E$/ Reduction in tonnes | Investment in INR |
|---|---|---|---|---|---|---|---|---|---|
| Education | 50 | | 25 | 25 | | | 73,440 | 69.77 | 44,00,000 |
| Culture & Community | 70 | | 30 | 30 | 10 | | 1,02,816 | 97.68 | 61,60,000 |
| Administration | 30 | | 10 | 10 | 10 | | 44,064 | 41.86 | 26,40,000 |
| Public Service | 25 | | | 10 | 5 | 5 | 36,720 | 34.88 | 22,00,000 |
| Health Services | 20 | | 10 | 10 | | | 29,376 | 27.91 | 17,60,000 |
| Municipal Pumps | 50 | | 25 | 10 | 10 | | 73,440 | 69.77 | 44,00,000 |
| **Total** | **245** | **0** | **100** | **95** | **35** | **5** | **3,59,856** | **341.86** | **2,15,60,000** |

*TABLE 78 SUMMARY GOALS SETTING $CO_2$ REDUCTION*

| | |
|---|---|
| Baseline $CO_2$ Emission 2014 in $kgCO_2E/yr$. | 48,11,000 |
| $CO_2$ Reduction Targets (25% of Total) | 12,02,750 |
| Energy Efficiency $CO_2$ Savings in $kgCO_2E$ | 8,61,337 |
| Energy Efficiency of $CO_2$ Savings of Total ($kgCO_2E$) in % | 18% |
| Energy Efficiency Investment in INR | 1,97,08,494 |
| Solar PV $CO_2$ Savings in $kgCO_2E$ | 3,41,413 |
| Solar PV kWh to be Produced for $CO_2$ Offset | 3,59,382 |
| Solar PV Installed Capacity Requirement in kW | 245 |
| Solar PV Investment in INR | 2,15,31,620.18 |
| Total $CO_2$ Savings Energy Efficiency and Solar PV in $kgCO_2E$ | 12,02,750 |
| Total $CO_2$ Savings Energy Efficiency and Solar PV in % | 25% |
| Total Investment for each Case in INR | 4,12,40,114 |

## 8.1 GENERAL RECOMMENDATIONS

Some general recommendations for Auroville in regard to improved water and energy efficiency are listed below.

### DATA MANAGEMENT

- Introduce sound data management practices: standardise categories, nomenclatura, introduce smart data bases for data management related to water and energy.

### PLANNING & POLICIES

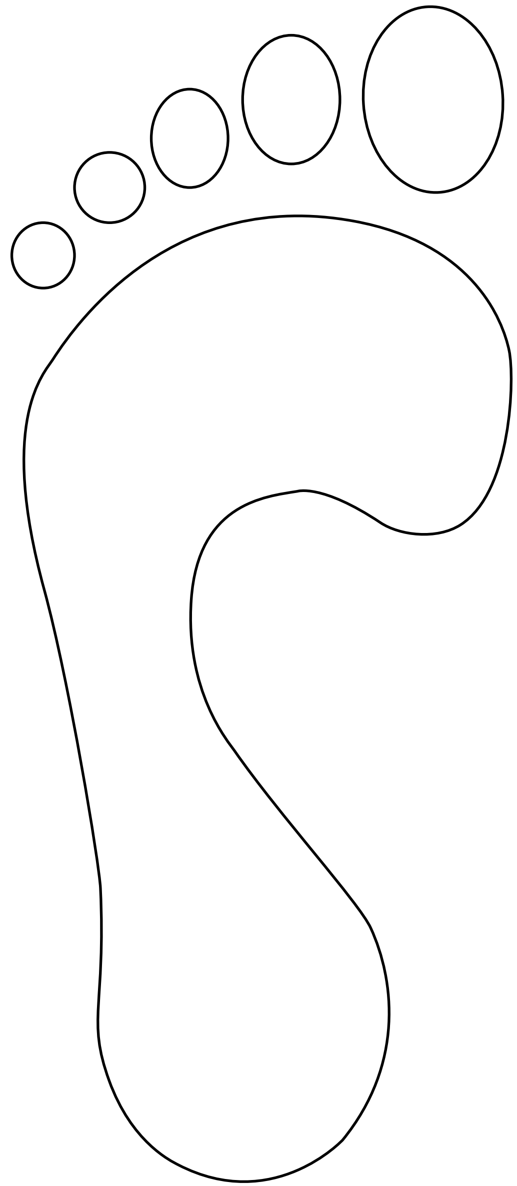
- Plan for services such as bakeries, grocery shops, petrol stations in the city centre as this will reduce the transport requirement for two and four wheelers and will help in reducing transport related $C0_2$ emissions.
- Encourage care and taxi sharing practices via IT tools and work with local taxi companies on implementing a taxi-sharing scheme.
- Incentivise nonpolluting transport solutions.
- Provide public charging stations for electric two wheelers.
- Introduce energy and water efficiency codes for all upcoming buildings.

### PROCUREMENT

- Introduce a bulk procurement initiative for energy and water efficient fixtures and make them available with service providers such as the Auroville Water Service and the Auroville Electrical Service. Bulk procurement will reduce the cost per fixture and will induce building stewards to install more energy and water efficient fixtures.

### COMMUNICATION & AWARENESS

- Enhance communication efforts on Auroville's water and energy consumption. Using technologies in the form of a dashboard that informs each resident about their respective water and electric energy consumption and allows to celebrate best performers.
- Introduce water and energy conservation in the curriculums of



# 9. IMPLEMENTATION STRATEGY

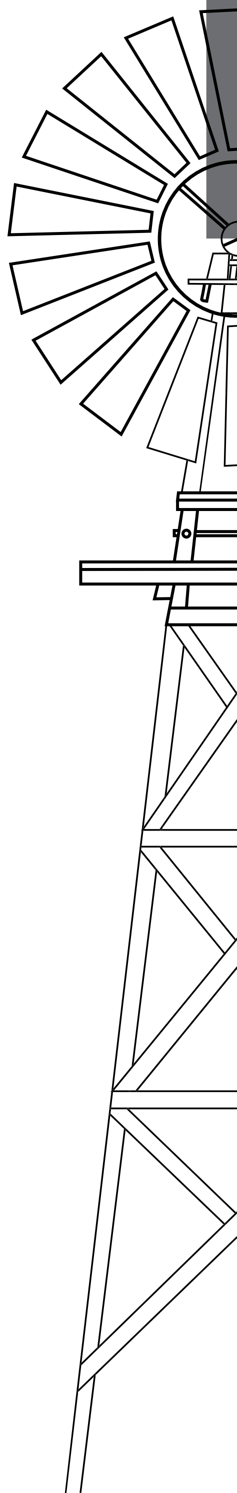
The following implementing strategy for achieving the set targets is recommended:

• Set--up a resource management cell for energy and water efficiency under the Auroville Town Development Council with the following roles and responsibilities:
- Prepare annual implementation plans for energy and water efficiency
- Monitor the implementation progress
- Prepare and publish the progress report
- Create and manage a revolving fund in the range of between INR 2.5 -.- 3 cores to finance water and energy efficiency initiatives. Financial savings achieved through water and energy efficiency initiatives will replenish the revolving fund.

• Support continuous capacity building of local service providers (water services, electrical services etc.) to develop water and energy efficiency expertise at Auroville.

• Develop and implement building energy and water codes.

• Develop water and energy monitoring tools and a communication system to share achievements with Auroville residents.



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# 11. ANNEXURES

## ANNEXURE 1 LISTING OF SITES PER SECTOR

### ADMINISTRATION

1. Auroville Foundation
2. Av Fund Secretariat
3. L.R.M.
4. Matrimandir HT
5. SAIIER - Field Activity Bldg.
6. SAIIER Office
7. Town Hall
8. Village Action Group
9. Village Action Group II

### FARMS (WITH TNEB CONNECTIONS)

1. Annapurna
2. Auro Orchard - Lighting
3. Auro Orchard - Poultry
4. Auro Orchard - Pump
5. Discipline Farm
6. Kottakarai Farm
7. New Farm Community
8. Pazhamudircholai
9. Pazhamudircholai Farm
10. Siddhartha Forest
11. Solitude Farm
12. Windara

### COMMERCIAL SECTOR

1. ABC Building
2. ADPS Watchman Quarters
3. Aurobrindavan
4. Aurosarjan
5. Auroville Design Consultants
6. Auroville Language Lab
7. Auroville Today
8. AV design
9. Buildaur Office
10. C&M Architects
11. Capability Landscape
12. Centre for Scientific Research
13. CSR
14. Ecoteco Pools
15. H.E.R.S.
16. Inside India
17. Luisa
18. New Creation Transport Service
19. Palmyra - ICEF
20. Progress Landscape
21. PT Purchasing Service
22. Revelation - Office
23. Riding School
24. SaraCon
25. Shakti - Office
26. Sumark Construction
27. Swayam Project
28. Unity Transport Service
29. UnLimited Tamil Nadu
30. Varuna Project
31. Visitors Centre - Water Fountain
32. Water Project
33. Yantra Studio c/o Mona

### COMMUNITY & CULTURE

1. African Pavilion
2. Arka
3. AV Sports Resource Centre
4. Basketball Court
5. Bharat Nivas Auditorium
6. Bharat Nivas Pavilion
7. Centre for Indian Culture
8. Certitude Sports Ground
9. Cultural Centre
10. Drama Project
11. Kala Kendra
12. La Piscine
13. Matrimandir
14. New Creation Gym

15. New Creation Sports
16. Pavilion of Tibetan Culture
17. Pitanga Hall
18. Public Building
19. Riding School
20. Savitri Bhavan
21. Savitri Bhavan - Hostel
22. Tamil Heritage Centre
23. Tennis Court
24. Unity Pavilion c/o Jaya
25. Youth Centre

**MUNICIPAL/MUNICIPAL PUMPS**

1. Acceptance Community
2. Ami Community
3. Angira's Garden - Pump
4. Aspiration - Pump II
5. Aurodam Community
6. Auromics
7. Av Fund Secretariat - Pump
8. Centre Field Bore well
9. Centre Field Bore well Storeroom
10. Certitude Community Pump
11. Courage: Pump + 3
12. Dana Community
13. Djaima-Agrl. Pump/0121
14. Fraternity Water Supply
15. Grace Community
16. Gratitude Community
17. Kalabhumi - Water
18. Kamal Singh
19. Madhuka Pump
20. Mango Garden
21. MM-Nursery
22. Pony Farm - Pump
23. Prarthna
24. Prayatna - Booster Pump
25. Prayatna - Bore well
26. Recueillement
27. Repos Community
28. Reve - Pump
29. Revelation
30. SAIIER - Pump
31. Samasti Community
32. Shakti community - Pump
33. Sharnga - New Pump
34. Sharnga Community
35. Sharnga Guest House
36. Sharnga Pump
37. Silence - Bore well
38. Udavi School - New Block Pump
39. Udavi School - Pump
40. Vikas Community
41. Water Team, Auromodele

**EDUCATION**

1. A.I.A.T.
2. Arul Vazhi School
3. Aurospirul - Night School
4. Auroville Food Lab
5. Auroville Industrial School
6. Auroville Language Lab
7. Av Language Lab
8. Av. Technical Training Centre
9. Creche
10. Cripa Project
11. Deepam
12. Deepanam School
13. Dehashakti - Sports Storeroom
14. Future School
15. Illaignargal Education Centre
16. Integral Learning Centre
17. Isaiambalam School
18. Kindergarten
19. Last School - New Building
20. Life Education Centre
21. Lila Loka Project c/o Anand
22. Lilamayi Creche
23. Nandanam School
24. New Creation Bilingual School

25. New Creation Child Development
26. New Creation Community - Badminton Court
27. New Creation Community - Creche
28. New Era Secondary School
29. Oli School
30. Pre Creche c/o Vinayagam
31. SAIIER - Art & Craft Workshop
32. SAIIER - Transition School
33. Sarasu
34. Sirpam
35. Tamarai Healing Centre
36. Tamil Ulagam
37. Transition - Computer Section
38. Trust School
39. Udavi School - Akila Class
40. Udavi School - Art Room
41. Udavi School - Chandresh
42. Udavi School - Dance Class
43. Udavi School - Guest Kitchen
44. Udavi School - Guest Room 1
45. Udavi School - Guest Room 2
46. Udavi School - Kinder Garden
47. Udavi School - Play of Painting
48. Udavi School - Siva Kumar
49. Udavi School - Surendar
50. Udavi School Office & Classroom
51. Udhayam Educational & Cultural
52. White Peacock

**FOOD PROCESSING**

1. Auro Spirul
2. Aurosoya
3. Aurospirul
4. Auroville Bakery
5. G.P. Cafe
6. Ganesh Bakery
7. KOFPU
8. La Ferme Cheese
9. Naturellement
10. Roma's Kitchen
11. Solar Kitchen & PTDC
12. Tanto
13. Tanto - ECR
14. Tanto Italian Restaurant
15. Visitors Centre

**GUEST HOUSES**

1. Afsanah Guest House
2. American Pavilion
3. Arka Guest Room
4. Atithi Griha Guest House
5. Centre Guest House
6. Creativity Guest House
7. Daniel - Swimming Pool
8. Fraternity Guest House
9. Fraternity Guest House & Kitchen
10. Gaia's Garden
11. Hope Guest House
12. Mitra Hostel
13. NC Guest House
14. Needam Guest House
15. New Creation Guest House
16. Quiet - Pump, Kitchen & Laundry
17. Quiet H.C. - Accommodation
18. Quiet Therapy Cent, Pool, Recept
19. Samarpana Guest House
20. Samasti Guest House
21. Sharnga Guest House
22. Swagatham Guest House
23. Transformation Guest House
24. Udavi School - Mitra Hostel
25. Youth Camp

**HEALTH SERVICES**

1. Auroville Health Centre
2. Dental Centre
3. Dental Clinic
4. Dental Clinic & Linda

**MANUFACTURING & HANDICRAFT**

1. Aqua Dyn Research
2. Aureka
3. Auro Rachana
4. Auro Sunshine
5. Aurocreation
6. Auromics
7. Auromics - Bijou Building
8. Auromode
9. Aurospirul
10. Auroville Bamboo Centre
11. Auroville Energy Products (AEP)
12. Auroville Press
13. Auroville Printers
14. Auroville Wind Systems
15. Auzolan
16. CSR Ferrocement Technology
17. Cuppa Chai
18. Discovery
19. Earth Institute
20. Edition AV Press - AV Papers
21. EVFuture
22. Flame
23. Freeland
24. Ganesh Beads
25. Imagination
26. Jesus Workshop
27. Kenji
28. Lively Boutique
29. Lumiere
30. Magica
31. Mantra Pottery
32. Maroma
33. Merville Trust
34. Nagappan
35. New Dawn Carpentry
36. New School Crafts
37. Papyrus
38. Radiance
39. Rolf - Cosmic
40. Shradhanjali
41. Soap manufacture (Bon AVA)
42. Sumark Construction
43. Sunlit Future
44. Svaram
45. Upasana
46. Well Paper
47. Wood Workshop

**PUBLIC SERVICE**

1. Animal Care
2. Archives
3. Auro Orchard - Ganesh Temple
4. Auroville Electrical Service
5. Auroville Library
6. Auroville Telephone Service
7. Auroville Water Service
8. Eco Service
9. Gas Bottle Service
10. Housing Service
11. Laboratory of Evolution
12. Post Office
13. Puncture Service
14. Road Service
15. SAIIER Transport Service
16. Security Service

## ANNEXURE 2 ASSUMPTION FOR WATER BASELINE

To establish the water baseline, the following assumptions are taken into account.

*TABLE 79 DATA FROM AUROVILLE RESIDENT SERVICE, AUROVILLE GUEST SERVICE AND FARM GROUP*

| | |
|---|---|
| Total Population of Auroville | 2,314 |
| Number of Aurovilians in Commercial Sector | 149 |
| Number of Aurovilians in Manufacturing & Handicraft Sector | 216 |
| Total Number of Beds Available for Guests | 733 |
| Number of Aurovilians Working in Food Processing Sector | 91 |
| Number of Students in Auroville | 722 |
| Number of Aurovilians in Culture & Community Sector | 395 |
| Number of Aurovilians in Administration Sector | 113 |
| Number of Aurovilians in Public Service Sector | 111 |
| Number of Aurovilians in Health Services Sector | 47 |
| Total Area (in acres) Under Cultivation in Auroville | 147.4 |

Average % taken from last 4 years' records of AM and AWS, which is assumed to be the % of non-revenue water in all the sectors.

| | |
|---|---|
| Non-Revenue Water % or Water Lost in Distribution | 30% |
| Projected Increase in Population | 7% |
| Water Saving Target to be Achieved | 16% |

- The sample size from water audits allowed us to extrapolate on water consumption (indoor/outdoor) and saving potential per fixture.
- Data from Auroville Water Service and Auromodel water team is representative for the domestic sector (per capita consumption, non-revenue water etc.)
- Data regarding number of students, AV in sectors etc. is precise enough.
- Assumptions for Agriculture sector: number of acres cultivated, percentage of cultivated land under micro irrigation, number of rainy days etc.
- It is assumed that the ratio of total number of Non-Aurovilian to Aurovilian workers obtained from the sample data remains constant within the same sector.

## ANNEXURE 3 METHODOLOGY FOR WATER BASELINE

**STEP 1:** Data from water audit or any secondary source is collected.

**STEP 2:** From the sample data, the following indicators are calculated.

**No. of Days** = Date (start) - Date (end)
**Revenue Water (KL)** = Indoor Water (KL) + Outdoor Water (KL)
**Non-Revenue Water (KL)** =
Total Water Pumped (KL) - Revenue Water (KL)
**Indoor Water (KL)** = Revenue Water (KL) - Outdoor Water (KL)
**Outdoor Water (KL)** =
Revenue Water (KL) * (1/Ratio of Indoor: Outdoor Water)
**Per Unit Type per Day (L) of Revenue Water** =
[(Total Revenue Water (KL)/ (No. of Days * No. of Units)] * 1000
**Per Unit Type per Day (L) of Water Pumped** =
[(Total Water Pumped (KL)/ (No. of Days * No. of Units)] * 1000
**Max No. of People Working in Auroville Present Sector** =
No. of Aurovilian in Present Sector * Ratio of Non-Aurovilians to Aurovilians

**STEP 3:** Based on the calculated data above, the following final calculations were made:

**Revenue Water (KL)** =
(Per Unit Type per Day (L) * No. of Unit * No. of days) / 1000
**Non-Revenue Water (KL)** =
Total Water Pumped (KL) - Revenue Water (KL)
**Total Water Pumped (KL)** =
(Revenue Water (KL) * 100%) / (100% - Non-Revenue Water %)
**Indoor Water (KL)** =
Revenue Water (KL) * % of Indoor to the Total Revenue Water
**Outdoor Water (KL)** =
Revenue Water (KL) * % of Outdoor to the Total Revenue Water

**No.** – Number
**Unit Type** – refers to the total number of Aurovilians in case of Residential; to the number of workers in case of Commercial, Manufacturing & Handicraft, Guest Houses, Food Processing, Education, Community & Culture, Administration, Public Service, Health Services sectors; to number of beds in case of

Guest Houses sector; to number of students in case of Education sector; to number of acres in case of Agriculture sector.

## ANNEXURE 4 METHODOLOGY FOR WATER SAVINGS

From the data collected from sample audits, a pivot table is formed to calculate the following indicators:

**Water Consumption per Fixture (% of Total Consumption)** =
(Sum of Overall Consumption of Changeable Fixture (L) / Total of Overall Consumption of Changeable Fixture (L) * 100

**Number of Fixtures Needing Replacement (% of Total No. of Fixtures)** =
(Sum of No. of Fixtures to be Changed / Sum of Original No. of Fixtures)*100

**Saving per Type of Fixture (% of Total Consumption)** =
[(Sum of Overall Consumption of Changeable Fixture (L) - Sum of New Fixture Consumption (L) / (Sum of Overall Consumption of Changeable Fixture (L)] * 100

**Water Savings (KL)** =
(Sum of Overall Consumption of Changeable Fixture (L) - Sum of New Fixture Consumption (L) / 1000

**Capital Investment Required per KL Saved (INR/KL)** =
Sum of Cost (INR) / Water Savings (KL)

## ANNEXURE 5 METHODOLOGY FOR ENERGY BASELINE

The data of the annual electricity consumption from the start year 2009 to the baseline year 2014 is gathered from the Varuna Web Portal and sorted by sectors.

The annual electricity consumption from renewables was calculated by adding the total units produced from solar and wind installations in Auroville.

**Solar Energy Baseline $_{2014}$ (kWh)** = [Total Units Produced from Off-Grid SPV Systems + Grid Connected SPV Systems + Solar Water Heaters + Solar Street Lights]

**Wind Energy Baseline $_{2014}$ (kWh)** = [Total Units Produced from Mini-Wind Turbines + Mechanical Wind Pumps]

<u>Calculation of the Total Units of Electricity Produced from Off-Grid SPV Systems in Auroville:</u>
**Total Produced Units $_{\text{Off-Grid SPV}}$ (kWh)** = [Capacity of System * 24 * 365 * CUF $_{\text{Off-Grid}}$]

<u>Calculation of the Total Units of Electricity Produced from Grid Connected SPV Systems in Auroville:</u>
**Total Produced Units $_{\text{Grid Connected SPV}}$ (kWh)** = [Capacity of System * 24 * 365 * CUF $_{\text{Grid-Connected}}$]

<u>Calculation of the Total Units of Electricity Produced from Solar Street Lights in Auroville:</u>
**Total Produced Units $_{\text{Solar Street Lights}}$ (kWh)** = [Qty. of Street Lights * Wattage of each SPV Panel * 24 * 365 * CUF $_{\text{Solar Street Light}}$]

<u>Calculation of the Total Units of Electricity Produced from Solar Water Heaters in Auroville:</u>
**Total Produced Units $_{\text{Solar Water Heaters}}$ (kWh)** = [Savings in Electrical Units per Litre of Installation * Capacity of the Solar Water Heater Installation]

<u>Calculation of the Total Units of Electricity Produced from Mini-Wind Turbines in Auroville:</u>
**Total Produced Units $_{\text{Mini Wind Turbine}}$ (kWh)** = [Capacity of System * 24 * 365 * CUF $_{\text{Mini Wind}}$]

<u>Calculation of the Total Units of Electricity Produced from Mechanical Wind Pumps in Auroville:</u>
The number of units of electricity produced from mechanical wind pumps is calculated by converting the potential energy (Joules) required to pump the water to the height of the water tank, and then converting the work done in Joules to electrical units (kWh). The total units of electricity produced by

mechanical wind pumps is thus calculated by converting the potential energy to mechanical energy:

**Potential Energy (or) Work Done $_{\text{Mech. Wind Pump}}$ (J)** = [Litres of Water Pumped to the Tank * g * Height of the Water Tank]

**Equivalent Electrical Energy $_{\text{Mech. Wind Pump}}$ (kWh)** = [Potential Energy (or) Work Done $_{\text{Mech. Wind Pump}}$ (J)] * 365 / (60*60*1000)

Calculation of the Total Units of Electricity Produced from Diesel Generators:
**Total Produced Units $_{\text{Diesel Generator}}$ (kWh)** = [Litre Consumption of the Diesel Generator * Electrical Energy Produced per Litre of Diesel]

Calculation of the Total Annual Energy (Steam) Produced by the Solar Bowl (Solar Kitchen):
**Total Energy Production by Solar Bowl (kg/year)** = [Peak Steam Production of the Solar Bowl * Peak Hour Efficiency * No. of Hours of Operation per Day * 365]

Calculation of the Total Annual Energy Produced by the Solar Water Heaters:
**Total Energy Production by Solar Water Heaters (kWh/year)** = LPD Capacity of the Installation * Savings Capacity per Litre of Solar Water Heater Installation

Calculation of the Total Annual Energy Produced by the Firewood:
**Total Energy Production by Solar Water Heaters (kJ/year)** = Weight of the Firewood * Heating Value of Firewood

Calculation of the Total Annual Energy Produced by the Biogas Digesters:
**Total Energy Production by Biogas Digesters (cu.m/year)** = [No. of Digesters * (Weight of Food Wastage per Year/10) * Efficiency Factor of Waste Cow Dung or Kitchen Waste]

Calculation of the Total Annual Energy Produced by the LPG Gas for Cooking:
**Total Energy Production by LPG Cooking Gas (kg/year)** = Weight of the Cylinder * No. of Cylinders

Calculation of the Total Annual Energy Consumed by Transport (Two Wheelers):
**Total Energy Consumed by Transport (L/year)** = No. of Two Wheeler Vehicles * Distance Travelled * Average Mileage of Two Wheeler

Calculation of the Total Annual Energy Consumed by Transport (Four Wheelers):
**Total Energy Consumed by Transport (L/year)** = No. of Four Wheeler Vehicles * Distance Travelled * Average Mileage of a Four Wheeler

Calculation of the Annual $CO_2$ Emission from the Start Year (2009) to the Baseline Year (2014) for the Units Produced from TNEB:
**Total $CO_2$ Emission $_{\text{TNEB}}$ ($TCO_2E$/year)** = [Annual Units Consumed from TNEB * $CO_2$ Emission per kWh from TNEB]

Calculation of the Annual $CO_2$ Emission for the Baseline Year (2014) for the Units Produced from Diesel Generators:
**Total $CO_2$ Emission $_{\text{Diesel Generator}}$ ($TCO_2E$/year)** = [Annual Units Produced from the Diesel Generator * $CO_2$ Emission per kWh from Diesel Generator]

Calculation of the Annual $CO_2$ Emission for the Baseline Year (2014) for the Energy Produced from Firewood:
**Total $CO_2$ Emission $_{\text{Firewood}}$ ($TCO_2E$/year)** = [Annual Energy Produced from the Firewood * $CO_2$ Emission per kWh from Firewood]

Calculation of the Annual $CO_2$ Emission for the Baseline Year (2014) for the Energy Produced from LPG Cooking Gas:
**Total $CO_2$ Emission $_{\text{LPG}}$ ($TCO_2E$/year)** = [Annual Energy Produced from the LPG * $CO_2$ Emission per kWh from LPG]

Calculation of the Annual $CO_2$ Emission per Capita from the Start Year (2009) to the Baseline Year (2014) for the Units Produced from TNEB:

**Total $CO_2$ Emission per Capita $_{TNEB}$ ($TCO_2E$/Capita)** = [Electricity from TNEB per Capita * $CO_2$ Emission per kWh from TNEB]

Calculation of the Annual $CO_2$ Emission per Capita from the Start Year (2009) to the Baseline Year (2014) for the Units Produced from Diesel Generator:
T**otal $CO_2$ Emission per Capita $_{Diesel\ Generator}$ ($TCO_2E$/Capita)** = [Electricity from Diesel Generator per Capita * $CO_2$ Emission per kWh from Diesel Generator]

Calculation of the Annual $CO_2$ Emission for the Baseline Year (2014) for the Energy Consumed by Transport (Two Wheelers):
**Total $CO_2$ Emission Transport $_{Two\ Wheeler}$ ($TCO_2E$/year)** = [Annual Energy Consumed by Two Wheeler Transport * $CO_2$ Emission per Litre of Fuel]

Calculation of the Annual $CO_2$ Emission for the Baseline Year (2014) for the Energy Consumed by Transport (Four Wheelers):
**Total $CO_2$ Emission Transport $_{Four\ Wheeler}$ ($TCO_2E$/year)** = [Annual Energy Consumed by Four Wheeler Transport * $CO_2$ Emission per Litre of Fuel]

## ANNEXURE 6 ASSUMPTIONS FOR ENERGY BASELINE

*Table 80 Assumptions for Energy Baseline*

| Assumption | Value | Unit | Industry Expert/Source/Citation/Web link/Publication |
|---|---|---|---|
| Off-Grid SPV Systems ($CUF_{Off\text{-}Grid}$) | 14% | - | (Toine Van Megen, 2014) |
| Grid Connected SPV Systems ($CUF_{Grid\text{-}Connected}$) | 17% | - | (Toine Van Megen, 2014) |
| LED Solar Street Lights ($CUF_{Solar\ Street\ Light}$) | 13% | - | (Martin Scherfler, 2014) |
| Solar Water Heaters (Savings in Electrical Units per Capacity/Litre of Installation) | 15 | kWh | (Bijili Bachao, 2014) |
| Mini-Wind Turbines ($CUF_{Mini\text{-}Wind\ Turbine}$) | 22% | - | (MinVayu, 2015) |
| Average Litres of Water Pumped by a Mechanical Wind Pump | 10,000 | L | (MinVayu, 2015) |
| Acceleration Due to Gravity (g) | 9.81 | $m/s^2$ | (Wikipedia, 2015) |
| Electrical Energy Produced per Litre of Diesel with Capacity < 100kW | 3.2 | kWh | (Bhoo Thirumalai, 2012) |
| Electrical Energy Produced per Litre of Diesel with Capacity > 100kW | 5 | kWh | (Bhoo Thirumalai, 2012) |
| $CO_2$ Emitted per kWh Consumption from TNEB | 0.95 | $kgCO_2E$/kWh | (cBalance, 2009) |
| $CO_2$ Emitted per Litre of Diesel Consumption | 2.64 | $kgCO_2E$/L | (ecoScore, 2015) |
| $CO_2$ Emitted per kWh Consumption from Diesel Generator | 0.71 | $kgCO_2E$/kWh | calculated value |
| $CO_2$ Emitted from Burning of 1 kg of Firewood | 2 | $kgCO_2E$/kg | (Transition Culture, 2008) |
| $CO_2$ Emitted per kg of LPG Gas Cylinder | 3.0 | $kgCO_2E$/kg | (Engineering Toolbox, 2014) |
| Biogas Production per 10 kg of Waste | 1 | cu.m | (Kaveish Bio-energy, 2014) |
| Water Requirement per kg of Waste | 2.0 | L | (Kaveish Bio-energy, 2014) |
| Methane Yield from Cow Dung | 67.9% | - | (Department of Industrial Physics, 2012) |
| Methane Yield from Domestic/Kitchen Waste | 51.4% | - | (Department of Industrial Physics, 2012) |
| Heating/Calorific Value of Firewood | 19,685 | kJ/kg | (Netherlands, 2014) |
| Average Cost of 1 Litre of Diesel (in 2014) | 55.03 | INR | (My Petrol Price, 2014) |
| Average $CO_2$ Emission per Litre of Petrol | 2.4 | kg/L | (EIA, 2014) |
| Average $CO_2$ Emission per Litre of Diesel | 2.74 | Kg/L | (EIA, 2014) |
| Percentage Rise in Consumption of Electricity and Energy in Tamil Nadu Since 2012 | 15% | - | (Times of India, 2014) |

## ANNEXURE 7 METHODOLOGY FOR ENERGY EFFICIENCY

From the data collected from sample audits, the following indicators are calculated:

**Baseline Consumption of 2014 (kWh/yr.)** = TNEB Baseline Overall Consumption * Percentage on Total
**Annual Electric Cost of 2014 (INR)** = TNEB Bill Amount * Saving Potential in Percentage
**Saving Potential (kWh/yr.)** = TNEB Baseline Overall Consumption * Saving Potential in Percentage
**Saving Potential (INR/yr.)** = TNEB Bill Amount * Saving Potential in Percentage
**Investment Required (INR)** = Saving Potential in kWh/yr. * Investment Required per kWh Saved

**Simple Payback in Years** = Investment Required in INR * Saving Potential (INR/yr.)
**Current Population of Auroville** = 2,314
T**otal Annual Electricity Consumption in 2014** = 39, 64,765 kWh
**Total Annual Diesel (Generator) Consumption in 2014** = 2, 76,335 kWh
**Total Annual Renewable Energy Consumption in 2014** = 11, 80,539 kWh
**Total Annual Energy Consumption in 2014** = 54, 21,639 kWh
**Per Capita/Year Consumption (Overall) in 2014** = 2,342.97
**Energy Efficiency Potential** = 22.40%
**Energy Efficiency Target** = 20%
**$CO_2$ Emission from TNEB** = Total Units from TNEB * 0.95
**$CO_2$ Emission from Diesel Generators** = Diesel Generator * 0.72

## ANNEXURE 8 WATER FORECASTING ASSUMPTIONS

- Water consumption does not increase due to lifestyle changes but only due to population growth.
- Water saving target to be achieved is 25%.
- Population growth is 7% per annum.
- It is assumed that 60% of currently cultivated farmland at Auroville is already under micro irrigation, thus only the remaining 40% of farmland is taken into account for intervention.

## ANNEXURE 9 WATER FORECASTING METHODOLOGY

**Per Capita per Day Distribution of Auroville Water Pumped** = Total Annual Water Pumped in 2014 / (Present Population * 365 Days)

**Business as Usual (BAU) in (KL) in 2020** = Total Population in 2020 * per Capita per Day Distribution of AV Water Pumped * 365 Days

**Water Saving after Intervention (KL) 2014** = Total Annual Water Pumped in 2014 * Water Saving Achieved After Intervention

**Water Saving After Intervention (KL) 2020** = Business as Usual (BAU) in (KL) in 2020 - Water Saving Intervention (KL) 2014

**Targeted Water Saving (KL) in 2014** = Total Annual Water Pumped in 2014 * Water Saving Target to be Achieved

**Targeted Water Saving (KL) in 2020** = Business as Usual (BAU) in (KL) in 2020 - Targeted Water Saving (KL) 2014

**Saving Potential Max (KL) in 2014** = (Difference in Baseline of 2014 & 2020 * Water Saving Achieved After Intervention) + (Water Saving Target to Achieve * BAU 2014)

**Saving Potential Max (KL) in 2020** = BAU 2020 - (Difference in Baseline of 2014 & 2020 * Water Saving Achieved After Intervention) + (Water Saving Target to Achieve * BAU 2014)

## ANNEXURE 10 ENERGY FORECASTING ASSUMPTIONS

- The population of Auroville in the year 2014 is 2314.
- The annual increase or growth in population is calculated as 7%. Based on this percentage, the population forecast until the end year 2020 is calculated.
- The annual increase in energy demand due to lifestyle changes for Overall is 14.67%.
- The annual increase in energy demand due to lifestyle changes for Commercial is 8.86%.
- The annual increase in energy demand due to lifestyle changes for Manufacturing & Handicraft is 12.67%.
- The annual increase in energy demand due to lifestyle changes for Guest Houses is 6.78%.
- The annual increase in energy demand due to lifestyle changes for Health Services is 23.68%.
- The annual increase in energy demand due to lifestyle changes for Education is 26.33%.
- The annual increase in energy demand due to lifestyle changes for Food Processing is 20.55%.
- The annual increase in energy demand due to lifestyle changes for Community & Culture is 43.56%.
- The annual increase in energy demand due to lifestyle changes for Mu-

nicipal Pumps is 11.19%.

- The annual increase in energy demand due to lifestyle changes for Public Service is 19.45%.
- The annual increase in energy demand due to lifestyle changes for Agriculture is 58.22%.
- The annual increase in energy demand due to lifestyle changes for Administration is 3.93%.

## ANNEXURE 11 ASSUMPTIONS FOR ENERGY EFFICIENCY FORECASTING

- Projected Increase in Population = 7%
- Projected Increase in Electric Energy Consumption (Appliance Ownership, Lifestyle) = 14.67%

## ANNEXURE 12 ENERGY FORECASTING METHODOLOGY

Calculation of the Required Electricity by Source of Energy (TNEB, Renewables and Diesel Generator) per Capita for the Baseline Year 2014:

**Electricity Consumption per Capita (kWh)** $_{\text{Source of Energy}}$ = Overall Source of Energy consumption 2014 (kWh) / Population in 2014

Calculation of the Percentage of Increase in Energy Demand by Source of Energy per Sector:

**% of Increase in Energy Demand** $_{\text{Source of Energy}}$ = [Sum of the Difference in Energy Demand from Base Year (2010) to Current Year (2014) / Electricity from Source of Energy per Capita for 2009] * 100

Calculation of the Forecast for Electricity Consumption by Source of Energy until the End Year 2020, Taking into Account the Lifestyle Change and Increase in Population:

**Electricity Consumption (kWh)** $_{\text{Source of Energy}}$ = [Annual Source of Energy Consumption for the Previous Year (YYYY) * % of Increase in Energy Demand $_{\text{Source of Energy}}$] + [Annual Source of Energy Consumption for the Previous Year (YYYY)] + [Annual Source of Energy Consumption for the Year (YYYY) * Percentage of Annual Population Growth]

Calculation of the Forecast for Electricity Consumption per Capita by Source of Energy until the End Year 2020, Taking into Account the Lifestyle Change and Increase in Population:

**Electricity Consumption per Capita (kWh)** $_{\text{Source of Energy}}$ = [Annual Source of Energy Consumption for the Previous Year (YYYY) * % of Increase in Energy Demand Source of Energy] + [Annual Source of Energy Consumption for the Previous Year (YYYY)] + [Annual TNEB Consumption for the Year (YYYY) * Percentage of Annual Population Growth]

## ANNEXURE 6 METHODOLOGY FOR ENERGY EFFICIENCY FORECASTING

**BAU/Capita Consumption/yr./kWh** = (Projected Increase in Lifestyle * per Capita for the Baseline Year) + per Capita for the Baseline Year + (Projected Increase in Population * per Capita for the Baseline Year)

**BAU Annual Electricity Consumption** = (Total Annual Energy Consumption * Projected Increase in Lifestyle) + Total Annual Electricity Consumption + (Total Annual Energy Consumption * Projected Increase in Population)

**Case 1 Electricity Consumption after EE** = Annual Electricity Consumption - (Annual Electricity Consumption * Energy Efficiency Potential)

**Case 2 Electricity Consumption after Set Targets** = Annual Electricity Consumption - (Annual Electricity Consumption * Energy Set Target)

**Case 3 Electricity Consumption After Policy** = Annual Electricity Consumption - (Case 1 * Energy Efficiency Potential)

# ANNEXURE 7 LIST OF ALL EXISTING WASTEWATER TREATMENT PLANTS IN AUROVILLE

| Place | Start up | PE (Person Equivalent) | Liters per Capita per Day of Wastewater (LPCD) | Wastewater Treatment Installed Capacity in cu. m/day | Biogas Generated at Installed Capacity in cu. m/day | Treatment Method | Type of Wastewater | Agency |
|---|---|---|---|---|---|---|---|---|
| Visitors Centre's Public Toilet | 2006 | 1250 | 130 | 162.5 | 54.17 | Septic tanks-Baffled reactor then connected to the existing vertical planted filter-Polishing tank | Toilets | CSR |
| Udyogam | 2004 | 300 | 130 | 39 | 13.00 | Settler-Baffled tank reactor-Anaerobic filter-Planted filter (EM technology) | Food processing units, high BOD, high TDS | CSR |
| Solar Kitchen (modified) | 2004 - 2012 | 222 | 130 | 28.86 | 9.62 | Settler-Baffled tank reactor-Planted filter-Polishing pond- 2 Vortexes | | CSR |
| Invocation – Arati – Surrender | 1998 | 150 | 130 | 19.5 | 6.50 | Imhoff tank-Horizontal planted filter-Polishing tank | Domestic wastewater. Initial overflow and clogging solved. Actual load about 100PE. Works fine | Sumark |
| AIAT – Aurobindavan | 2014 | 150 | 130 | 19.5 | 6.50 | Settler-Baffled tank reactor- Anaerobic filter- Vortex | Domestic wastewater | CSR |
| Auromode | 2000 | 130 | 130 | 16.9 | 5.63 | 3 Baffled tank reactors-Horizontal planted filter-Storage tank | Garment factory, including painting. Works fine since startup. Good biological treatment. Chemical dyes are used. | CSR |
| Visitors Centre | 1998 | 120 | 130 | 15.6 | 5.20 | Septic tanks-Vertical planted filter-Polishing tank | Domestic wastewater. Flushing system never completed. Overloaded. | CSR |
| Maitreya I | 2010 - 2012 | 100 | 130 | 13 | 4.33 | Settler-Baffled tank reactor- Vortex | Domestic wastewater | Govind-CSR |
| Aspiration | 1998 | 80 | 130 | 10.4 | 3.47 | Imhoff tank-Horizontal planted filter-Polishing tank | Domestic wastewater & public toilets - Overflow and clogging problems. | Sumark |
| Surya Nivas | 2004 | 80 | 130 | 10.4 | 3.47 | Baffled tank reactor-Polishing pond (EM technology) | Domestic wastewater | CSR |
| Aurobakthi | 2005 | 80 | 130 | 10.4 | 3.47 | Settler-Baffled tank reactor-Planted filter-Polishing pond | Handicraft units, mostly domestic wastewater. | CSR |
| Centre Guest House | 2002 - 2005 | 75 | 130 | 9.75 | 3.25 | Baffled tank reactor-Polishing pond (EM technology). Added later: Anaerobic filter, planted filter | Domestic & guest house wastewater. Experimental site. Odors problem until second phase completed. | CSR |
| Transition School Toilets + Dining Hall | 2010 | 66 | 130 | 8.58 | 2.86 | Settler-Baffled tank reactor- Anaerobic filter- Vortex - Pond | Domestic wastewater | CSR |
| Kuilapalayam Public Toilets | 2000 | 60 | 130 | 7.8 | 2.60 | Baffled tank reactor-infiltration trench | Public toilet. Blocking in inspection boxes (no screening device). | CSR |
| Citadine | 2010 | 60 | 130 | 7.8 | 2.60 | Settler-Baffled tank reactor- Anaerobic filter- Vortex - Pond | Domestic wastewater | CSR |
| Edayanchavadi Public Toilets | 1999 | 50 | 130 | 6.5 | 2.17 | Baffled tank reactor-infiltration trench | Public toilet. Initial problems with infiltration trench solved. | CSR |
| Future School | 2002 | 50 | 130 | 6.5 | 2.17 | Settler-Baffled tank Reactor (EM technology)-Storage tank | Domestic wastewater + lab sewage. | Sumark |
| Mitra Student Hostel | 2009 | 50 | 130 | 6.5 | 2.17 | Settler-Baffled tank reactor- Anaerobic filter- Vortex | Domestic wastewater | CSR |
| Vikas Community | 1992 | 45 | 130 | 5.85 | 1.95 | Open settler-Lagooning system-Polishing tank | | CSR |

| Place | Start up | PE (Per-son Equi-va-lent) | Liters per Capita per Day of Waste-water (LPCD) | Waste-water Treatment Installed Capacity in cu. m/day | Biogas Generated at Installed Capacity in cu. m/day | Treatment Method | Type of Wastewater | Agency |
|---|---|---|---|---|---|---|---|---|
| CSR | 2006 - 2009 | 40 | 130 | 5.2 | 1.73 | Settler-Baffled tank reactor- Anaerobic filter- Vortex- Pond | Toilets, showers | CSR |
| Prarthna | 1997 | 30 | 130 | 3.9 | 1.30 | Septic tank-Horizontal planted filter-Storage tank | Domestic wastewater. Slight clogging due to single inlet, changed to multiple inlets. | CSR |
| Surrender 2 | 2010 | 30 | 130 | 3.9 | 1.30 | Settler-Baffled tank reactor- Anaerobic filter- Vortex | Domestic wastewater | CSR |
| New Library | 2012 | 30 | 130 | 3.9 | 1.30 | Settler - Baffled tank reactor-Vortex | Domestic wastewater | CSR |
| Bharat Nivas / Indian Studies | 2013 | 30 | 130 | 3.9 | 1.30 | Settler - Baffled tank reactor-Vortex | Domestic wastewater | CSR |
| Prarthna II | 2000 | 25 | 130 | 3.25 | 1.08 | Septic tank-Horizontal planted filter-Storage well | Domestic Wastewater. Initial clogging problems solved. Changed to multiple outlets. | CSR |
| Samasti II (modified) | 2009 | 25 | 130 | 3.25 | 1.08 | Septic tank- baffled reactor - anaerobic filter - Horizontal planted filter - Storage tank | Domestic wastewater | CSR |
| Tibetan Pavilion | 2003 - 2010 | 23 | 130 | 2.99 | 1.00 | Settler - Baffled tank reactor-Vortex-Pond | Domestic wastewater + guest house + restaurant. | CSR |
| Pour Tous | 2004 | 21 | 130 | 2.73 | 0.91 | Settler- Baffled tank reactors- Anaerobic filters-Fast flow vertical filter (pending) | Snack bar, toilets. Not completed hence odors problems | CSR |
| Samasti (modified) | 1996 | 20 | 130 | 2.6 | 0.87 | Septic tank-Planted filter-Polishing tank | Domestic wastewater. Integrated landscape design. | CSR |
| Upasana | 2004 | 20 | 130 | 2.6 | 0.87 | Septic tank-Baffled tank reactor-Anaerobic filter-Planted filter-Polishing pond | Handicraft unit, mostly domestic waste water | CSR |
| Sukhavati II | 2004 | 15 | 130 | 1.95 | 0.65 | Settler- Baffled tank reactors- Anaerobic filters-Planted filter | Domestic wastewater | CSR |
| CSR - Earth Unit Training | 2002 - 2005 | 15 | 130 | 1.95 | 0.65 | Septic tank-Baffled Reactor-Polishing pond | Domestic wastewater | J.F. Audic |
| Promesse | 1999 | 5 | 130 | 0.65 | 0.22 | Septic tanks-Horizontal planted filter-Infiltration trench | Domestic wastewater | CSR |
| Dana (Tom's House) | 2005 | 5 | 130 | 0.65 | 0.22 | Septic tank-Baffled tank reactor | Domestic wastewater | CSR |
| Verité (Danya's House) | 2005 | 5 | 130 | 0.65 | 0.22 | Septic tank-Baffled tank reactor | Domestic wastewater | CSR |
| Centre Field (Tency Hilde House) | 1995 | 4 | 130 | 0.52 | 0.17 | Settler-Horizontal Planted Filter-Polishing tank | Domestic wastewater. Initial clogging problems solved. Change of filter material. | CSR |
| Centre Field -Tineke | 1996 | 2 | 130 | 0.26 | 0.09 | Septic tank-Planted Filter-Polishing tank | Domestic wastewater | CSR |
| Certitude (Dirk's House) | 2006 | 2 | 130 | 0.26 | 0.09 | Septic tank-Baffled tank reactor-Anaerobic filter | Domestic wastewater | CSR |
| Arati 3 | 2010 | | 130 | 0 | 0.00 | ? | Domestic wastewater | Sumark |
| La Ferme Aspiration (Cheese Unit) | 2014 | | 130 | 0 | 0.00 | Vortex system | Processed cheese waste water | CSR |

## ANNEXURE 8 LIST OF RESTAURANTS, FOOD PROCESSING UNITS GENERATING FOOD WASTE

| Unit Name | Unit Type | kg/day | Details on Food Waste |
|---|---|---|---|
| Adithi Griha GH | Guest house | 0.0 | Breakfast provided to 386 guests, dinner on request to 102 guests |
| Afsanah GH | Guest house | 3.5 | In season 5-8 kg, off season 2 kg; sometimes some food waste taken by workers |
| Aurelec | Restaurant | 9.9 | |
| AuroSoya | Food Processing | 0.0 | No waste |
| Auroville Bakery | Commercial | 5.9 | Bakery generates 3.5 kg per day, snack bar and tea shop 2.5 kg per day |
| Centre GH | Guest house | 9.9 | |
| Dreamers Café | Restaurant | 3.9 | |
| Food Link | Food Processing | 0.0 | Returned to the farmers |
| Ganesh Bakery | Restaurant | 3.9 | |
| GP Café | Restaurant | 3.0 | Open 6 days, breakfast and lunch only, own composting |
| HERS | Commercial | 2.0 | 1-2 kg compost with Ganesh Bakery per day, also give some vegetable waste to cows |
| International Pavilion | Guest house | 1.0 | |
| La Terrace | Restaurant | 0.0 | See Solar Kitchen |
| Mitra Youth Hostel | Guest house | 2.0 | |
| Naturellement | Restaurant | 14.8 | Seasonal variation, 20-200 visitors at café, 30 employees at factory. Compost of 5-30 kg used in kitchen garden. |
| Needam GH | Guest house | 1.0 | Seasonal variation |
| New Pour Tous | Restaurant | | About 1 basket per day (same baskets they have in solar kitchen at lunch time for throwing the waste) |
| Old Pour Tous | Commercial | 3.0 | |
| Quiet Healing Centre | Guest house | | 20-28 guests from mid-Dec to mid-Mar, summer is leaner with no guests at times |
| Residential | Residential | 538 | |
| Sharnga GH | Guest house | 3.0 | Off season 3 kg per day, in season over 25 liter bucket |
| Solar Kitchen | Restaurant | 39.5 | 20-40 kg per day depending on vegetables used for cooking (this does not include 2-4 kg daily of onion and lemon peel - not used for compost) |
| Swagatham GH | Guest house | 3.9 | About 1 kg at house, 3 kg for guests |
| Tanto Pizzeria | Restaurant | 30.6 | Veg and fruits peel 20 kg per day, taken by the farmers. Food waste 30 kg on the weekends, on regular days about 7 kg |
| Tibetan Pavilion | Guest house | 4.4 | ½ kg per day, 4 times a year 1 kg per day for 4 months |
| Town Hall Cafeteria | Restaurant | | Two buckets of 20-to-30 L per day |
| Verite Community | Guest house | 14.8 | Own composting for the garden |
| Visitors Center | Restaurant | 15.8 | 30-60 kg to biogas, 5-10 kg to dog sanctuary, 5-10 kg cow fodder, and 1 kg chicken bones fed to dogs. 3-5 kg to compost. |
| Well Café | Restaurant | 4.9 | |
| **Total per Day** | | **177.5** | |

## ANNEXURE 9 MULTI-CRITERIA ANALYSIS TO QUALIFY DIFFERENT RENEWABLE ENERGY TECHNOLOGIES

| | | SPV Hybrid (20 kW) | SPV Stand-Alone (20 kW) | SPV Grid-Connected (20 kW) | SPV Grid-Connected (1 MW) | Solar Thermal Electric (1 MW) | Wind Turbines (1 MW) | Mini Wind Turbines (3 kW) | Biogas Digester Systems (1 MW) | Biomass Gasifier (1MW) |
|---|---|---|---|---|---|---|---|---|---|---|
| Social Acceptance | Criteria | Solar energy is an obvious resource available 300 days throughout the year. Panels don't cause disturbances and carry a positive image of a non-polluting way of producing energy | | | | Water is not abundant as a resource in AV | The plant will not be located in AV | Makes noise, is a danger for birds | Potential smell due to production from waste | Wood is left for soil restoration / used as firewood |
| | **Final Rate** | High | High | High | High | Medium | High | Medium | Medium | Low |
| Employment Generation | Manufacture | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | Installation | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| | O&M | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| | Admin. | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| Scale: | Total Score | 2 | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 2 |
| 0-1 Low<br>2 Medium<br>3-4 High | **Final Rate** | Medium | Medium | Medium | High | Medium | Low | High | High | Medium |
| Speed of deployment | Land/Infrastr. | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| | Installation | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| | Commission | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Scale: | Total Score | 3 | 3 | 3 | 1 | 1 | 0 | 3 | 0 | 0 |
| 0 Low<br>1-2 Medium<br>3-4 High | **Final Rate** | High | High | High | Medium | Medium | Low | High | Low | Low |
| Infrastructure Requirement | Land | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| | Security | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| | Water Infrastr. | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| | Evacuation | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| Scale: | Total Score | 0 | 0 | 0 | 4 | 4 | 2 | 0 | 3 | 4 |
| 0-1 Low<br>2 Medium<br>3-4 High | **Final Rate** | Low | Low | Low | High | High | Medium | Low | High | High |

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