GA EAST MUNICIPALITY STATE OF ENERGY REPORT 2014

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SAMSET
Supporting Africa's Municipalities in Sustainable Energy Transitions

ISSER
Knowledge for Development

GA EAST MUNICIPALITY STATE OF ENERGY REPORT 2014

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SAMSET Project Information:

Supporting Sub-Saharan Municipalities with Sustainable Energy Transitions (SAMSET) is a 4-year project (2013-2017) supporting sustainable energy transitions in six urban areas in three African countries – Ghana, Uganda and South Africa. A key objective is to improve "knowledge transfer framework" so that research and capacity building efforts are more effective in supporting this challenging area.

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List of Acronyms

AFOLU	Agriculture, Forestry and Other Land Use
BOST	Bulk Oil storage and Transport Limited
BPA	Bui Power Authority
CFL	Compact Fluorescent Lamps
EC	Energy Commission of Ghana
ECG	Electricity Company of Ghana
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GEM	Ga East Municipality
GEMA	Ga East Municipal Assembly
GHG	Greenhouse Gas
GNPC	Ghana National Petroleum Corporation
GPRTU	Ghana Private Road Transport Union
GRIDCO	Ghana Grid Company
GSS	Ghana Statistical Service
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communication Technology
ISSER	Institute of Statistical, Social and Economic Research
LPG	Liquefied Petroleum Gas
MESTI	Ministry of Environment, Science, Technology and Innovation
MMT	Metro Mass Transit
MOE	Ministry of Energy
NEB	National Energy Board
NITS	The National Interconnected Transmission System
PHC	Population and Housing Census
PURC	Public Utilities Regulatory Commission
PVs	Photovoltaics
RETs	Renewable Energy Technologies
SAMSET	Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions
SEA	Sustainable Energy Africa
SoE	State of Energy
TOR	Tema Oil Refinery
VALCO	Volta Aluminium Company Limited
VRA	Volta River Authority
WSDB	Water and Sanitation Development Boards

Acknowledgement

This State of Energy Report for Ga East Municipality (GEM) is a product of a knowledge exchange collaborative project among six municipalities in three Sub Sahara African countries – Ghana, Uganda and South Africa - known as "Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions (SAMSET)''. The support all the SAMSET partners, especially SEA and ERC, whose immense contributions that have shaped the final output of this report is deeply appreciated.

The Ghana SAMSET team also appreciates the support of GEMA's top officials; the municipal Chief Executive (MCE), Hon. John Kwao Sackey, the Municipal Co-ordinating Director (MCD), Mr. Martin Dassah, the Municipal Planning Officer (MPO), Mr. Sampson Slessor Agbeve and others who exhibited keen enthusiasm in the project from the beginning and offered resources, office space and conference facilities at GEMA's premises willingly for SAMSET's activities. Special thanks also go to GEM focal persons (partners) on the SAMSET project, Mr. Felix Ameyaw-Boachie and Mr. Alex Amoah who have been very supportive since the start of the project and have played key role in the preparation of this SoE report.

Finally, the Ghana SAMSET team wishes to extend gratitude to all institutions (like GSS) and individuals who gave diverse supports towards the preparation of this SoE report.

Executive Summary

ES 1: Background Information

The state of energy report for the Ga East Municipal is the first of its kind ever produced in Ghana. The existing energy outlooks and statistics talk about national level energy situations with little being known of the holistic state of energy at the regional or metropolis/municipalities/districts. In the absence of such specific baseline information, effective planning for sustainable issues becomes highly impossible. Against this backdrop, the project "Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions (SAMSET)" has among its objectives, the building of a credible State of Energy (SoE) for all its municipal partners. The SoE reports for the six partner municipalities will provide platforms for the project team to support municipal assemblies to plan effective and sustainable energy transition pathways for the municipalities. Ga East Municipality (GEM) is one of the two municipal partners SAMSET project is collaborating with in Ghana. The SoE report has therefore been undertaken for the GEM.

ES 2: The Macro Picture: Ghana and Central Regional Energy Picture

ES 2.1: Energy Picture of Ghana

Energy used in Ghana is often supplied by three major sectors: Power/Electricity, Petroleum and Bioenergy. Electricity is generated from two main sources, hydro (Akosombo, Kpong and Bui) and thermal which together generated a total of 12,024GWh in 2012, an 18.3% increase over 2010 total generation of 12,870GWh in 2013, a 7% increase over 2012 total generation of 12,024GWh. Commercial oil production officially commenced in December 2010 and by the end of 2012, about 4, 133.8 kilotonnes of crude oil was produced in Ghana (Energy Commission 2014). This was however not consumed domestically hence Ghana still depends on crude oil importation through the Ghana National Petroleum Corporation (GNPC). Woodfuel component of bioenergy in the form of fuelwood and charcoal make up 75% or more of the national energy consumption (GSS, 2013). The biomass consumption pattern in Ghana however indicates a shift from wood for firewood source to charcoal energy for more urban households. LPG usage in Ghana has increased significantly to 18.2% in 2010 from 6.2% in 2000. This is attributed to the increasing consumption rate in the urban areas where about 42% of urban dwellers use LPG for cooking vis-à-vis only 5% of rural folks as at 2010 (GSS, 2013). Ghana is well endowed with lots of renewable energy resources that are yet to be tapped. By virtue of its location, the average duration of sunshine received in the country varies from a minimum of 5.3 hours per day at Kumasi in the Ashanti Region, which is in the cloudy semi-deciduous forest region, to 7.7 hours per day at Wa in the Upper West Region, which is in the dry savannah region with monthly average solar irradiation ranging between 4.4 and 5.6kWh/m2 /day (16-20 MJ/m /day) and

between 1,808-3,000 hours of sunshine per year (Hamlin and Ofori-Nyarko, 2005, cited in Bawakyillenuo, 2007). Currently, 2MW capacity of solar PV has been installed at Navrongo in the Upper East Region, bringing the total installed solar PV capacity to an estimated value of 2.5MW due to the failure of some previously installed PVs. Ghana has about 2,000 MW of raw potential for wind energy while there are 22 exploitable mini-hydro sites in the country with total potential between 5.6MW – 24.5MW.

The major demand sectors of the economy are the residential, non-residential and the industrial sectors. The rural and urban communities make up the residential demand side of energy. Total number of households in Ghana was about 4 million in 2000, 5,467,136 in 2010 and is expected to reach between 5 – 6 million by 2020. Utilisations of energy are usually in the form of lighting and cooking, with biomass dominating the energy types being used by most households especially in the rural communities. The non-residential sector comprises of commercial and services, agriculture, transport and industrial sub-sectors. The commercial and services sector's share of total national energy use has on average been less than 3% per annum since 2000. The informal sector comprising chop-bars (restaurants) and street vendor cooking have had the largest share (over 55%) of energy use since 2000 followed by the tourism sub-sector (10-12%) and Education sub-sector (more than 5%). The road subsector accounted for about 93% of fuel use from year 2000 to 2004. This was followed by air transport (6-7%). Energy use by the rail and the maritime subsectors is comparatively negligible, averaging 0.3% and 0.1%, respectively. The transport sector accounted for about 99.7% of gasoline consumption in the economy, with the remaining 0.3% going into industry for general use as solvent. The industrial sector without the Volta Aluminium Company Limited (VALCO) had nearly 22% of total national energy share every year since 2000. With VALCO, the industrial sector's total energy share increased slightly to about 23% per annum (Energy Commission, 2014).

ES 2.2: Energy Picture of Greater Accra Region

Various forms of energy are consumed in Greater Accra Region but the dominant three include Electricity, Petroleum and Biomass. About 95.8 percent of the regional population has access to electricity from the national grid which serves as the main source of lighting (87.1%) for households in Greater Accra Region. However, few households use kerosene lamps (5.9%), and flashlight/torch (3.9%) and generators (0.6%). The use of generators is a recent phenomenon that has ensued as a result of the frequent power outages and load shedding that have gripped the entire country. Charcoal is the main fuel used for cooking in Greater Accra (45.4%), followed by LPG (41.4%), wood (3.5%), kerosene (1.1%) and other energy sources. The sources of the charcoal and woodfuel are outside the region, mainly from the Afram Plains in the Eastern Region.

ES 3: Ga East Municipality Energy Picture and Energy Breakdown by Sectors

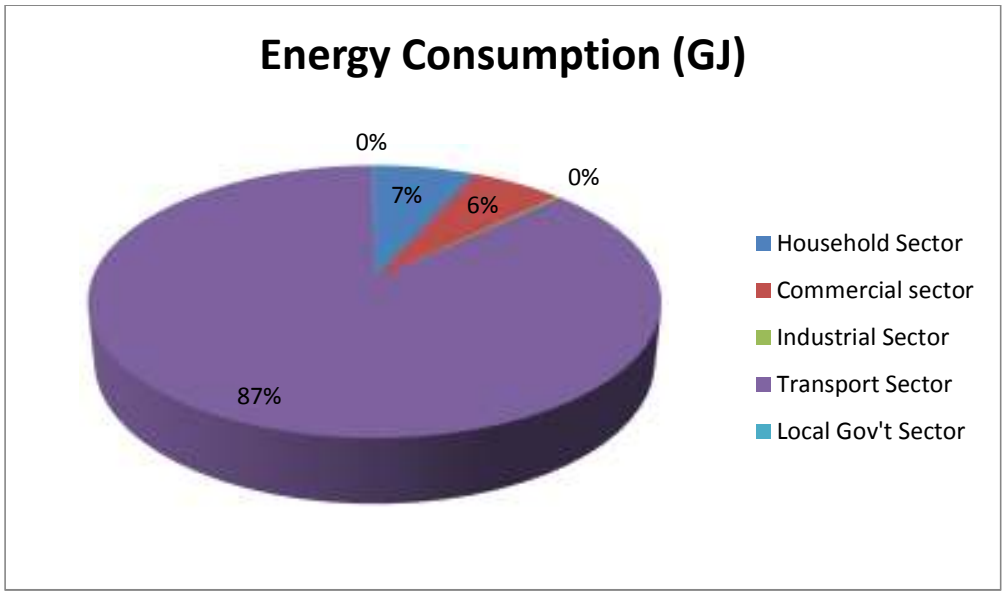
ES 3.1: GEM Energy Picture

GEM depends largely on fuels being generated from other parts of the country. Electricity that is consumed in the municipality is primarily generated by Volta River Authority (VRA) through the national hydro power source and thermal plants, which is distributed and sold to the demand sectors of the municipality by Electricity Company of Ghana (ECG). Out of about 51.2 MW of electricity available for importation into the municipality, about 36.7MW was actually imported into the municipality in 2013 and distributed among the various demand sectors including residential areas, industries and commercial activities.

All petroleum products are imported from the national stock at Bulk Oil storage and Transport Limited (BOST), which stores and transports refined petroleum products to consumers after they are either refined at Tema Oil Refinery or imported. Neither charcoal nor wood fuel is generated directly in the municipality but is imported from neighboring districts and sometimes from other regions. The quantity of wood fuel and charcoal available for importation to the GEM was 1535 ktoe and 1989 ktoe respectively. In 2013, about 105000 KG (0.0378 ktoe) of wood fuel and 182000 KG (0.16016 ktoe) of charcoal were imported to the municipality. Charcoal production areas used to be Kintampo, Wenchi, Atebubu, Mampong and Techiman. But currently, charcoal is produced and transported all the way from Bole.

With reference to the total number of households, commercial and industrial activities in the municipality, the total energy consumed in GEM is estimated around 10111293.49 Gigajoules. The transport sector constitutes the largest share (87%) of the total energy consumed in the municipality. The energy carriers mainly consumed in this sector are diesel, petrol and LPG fuels. Diesel constitutes about 75% of the fuels consumed within the transport sector, followed by petrol (23.5%) and LPG (1.5%). The household sector is the second largest energy consuming sector in GEM, constituting about 7% of the total energy consumed, followed by the commercial sector, 6%. The industrial and the local government sectors consume about 25539.2 GJ and 11909.3 GJ respectively representing less than one percent of the total energy consumed in the municipality (Figure ES 1).

Figure ES 1: Total energy consumption by sectors in GEM



Source: 2014 Energy survey

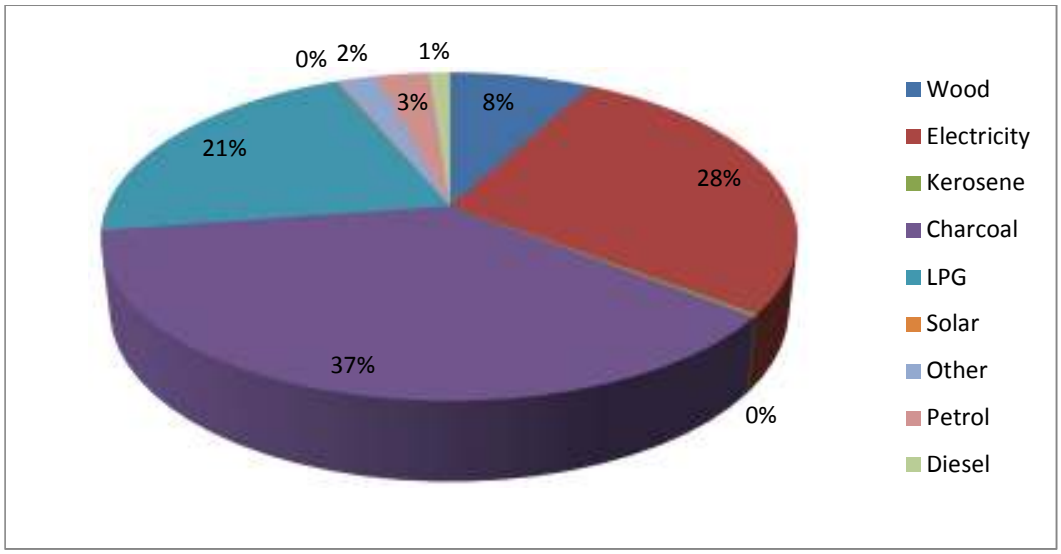
ES 3.2: Energy picture of the Household/Residential Sector in GEM

The residential sector in GEM is composed of 85% First Class households followed by Third Class (10%) and Second Class (5%). About 78% of the total households in GEM are electrified. Most electrified First Class households dwell in separate houses while most Second and Third Class households dwell in compound houses. Electrified households in GEM predominantly use louvre blade windows in their dwelling units. Majority of non-electrified First and Second Class households live in kiosks/containers while majority of Third Class non-electrified households live in uncompleted buildings. Predominantly, non-electrified households in GEM use wooden windows in their dwelling units. Majority of electrified households who use wooden windows in the municipality depend on natural air ventilation system. For households who use louvre blades, 46%, 21% and 86% of First, Second and Third class electrified households respectively use natural ventilation system while 53%, 79% and 14% of First, Second and Third class households respectively use fan as their main ventilation systems. About 0.33% of First class electrified households who have louvre blades as their window types use air conditioners (AC) as their main ventilation systems. About 26%, 52% and 23% of First class households who have sliding glazed windows use natural air, fan and AC respectively as their main ventilation systems.

The residential sector accounts for 7% of the total energy consumed within GEM and ranks, the second largest consumer of energy after the transport sector in 2013. Charcoal fuel constitutes

the largest share (37%) of the total energy consumed by the household sector in GEM followed by electricity (28%), LPG (21%), firewood (8%), petrol (3%) and diesel (2%). Dry Cell batteries and candles which make up the other fuel type constitute 2% of the total energy consumed by the residential sector in the municipality (Figure ES 2).

Figure ES 2: Percentage share of total energy consumption per energy carrier in GEM in 2013



Source: 2014 Energy Survey

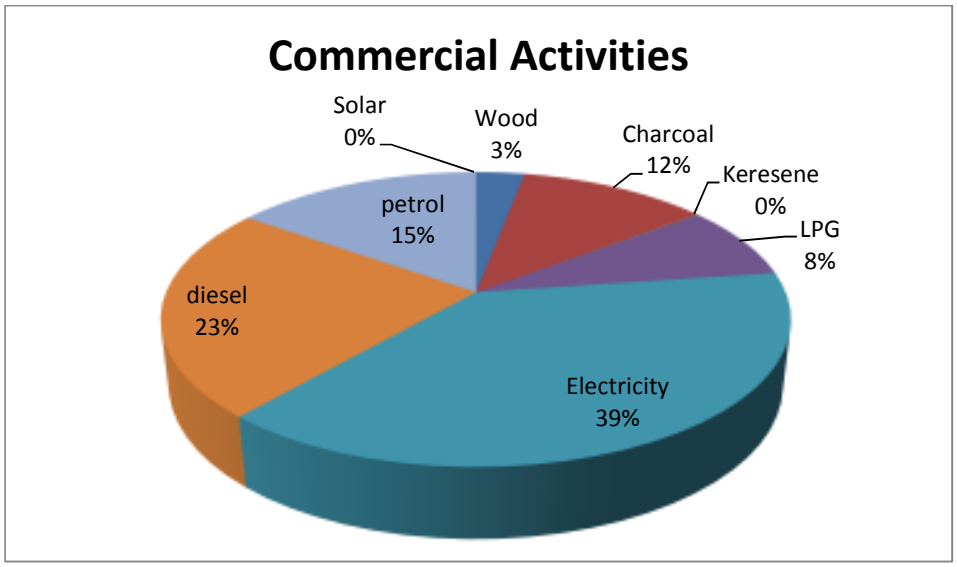
Cooking activities consume the most energy in the residential sector followed by lighting and water heating in all three classes of settlements in the municipality. LPG is the main cooking and water heating energy source in most First and Second Class electrified households while charcoal serves similar purpose in most Third electrified households and non-electrified households. Some electrified households use electricity as a supplementary source while some non-electrified households use firewood as a supplementary energy source for their cooking and water heating activities. Electricity is the main energy source for lighting in electrified households while non-electrified households depend on dry cell batteries and candles.

ES 3.3: Energy Picture of the Commercial Sector in GEM

The commercial sector accounts for about 6% of the total energy consumed in GEM. Electricity and diesel constitute the largest shares of total energy consumed in the commercial sector in GEM. About 39% of the total energy consumed by the commercial sector is electricity while

23% is diesel fuel (Figure ES 3). The remaining 38% is shared between charcoal, wood, LPG and petrol. Kerosene and solar energy are consumed in small quantities in the municipality.

Figure ES 3: Share of energy consumed by the commercial sector among energy carriers in 2013



Source: 2014 Energy Survey

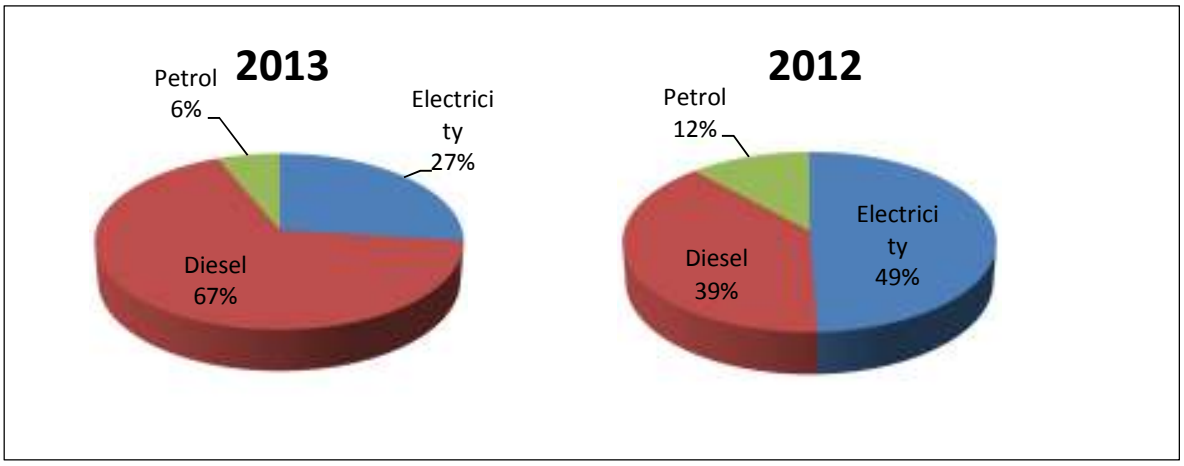
Within the formal commercial activities, electricity contributes about 40% while diesel constitutes 34% of the total energy consumed by formal commercial activities in the municipality. Petrol, LPG and charcoal fuels' shares in the total energy consumed by the formal sector are 13%, 7% and 6% respectively while solar energy, wood and kerosene fuels contribute less than 1% of the total energy consumed. Lighting consumes the most energy within formal commercial activities, accounting for 24% of the total energy consumed by the formal commercial sector followed by HVAC (20%), machine operation (19%), cooking/water heating (15%) and entertainment, refrigeration and transportation consume (7% each).

In the informal commercial sector, electricity and charcoal are the most consumed fuels. Electricity constitutes 36% of the total energy consumed by the informal commercial sector while charcoal constitutes 21%. Petrol, LPG, wood and diesel constitute 20%, 11%, 7% and 5% of the total energy consumed by the informal commercial sector respectively. Cooking/water heating is the most energy intensive activity in the informal commercial sector, consuming about 36%. This is followed by machine operation (31%), lighting (13%), entertainment (8%), refrigeration (6%) and ventilation (5%).

ES 3.4: Energy Picture of the Industrial Sector in GEM

The industrial sector accounts for less than one percent of the total energy consumed in GEM in 2013. From 2012, the consumption of petrol and diesel increased at the expense of electricity consumption when the power shortage became acute in the municipality. Electricity constitutes about 49% of the total energy consumed by the industrial sector in 2012 while petrol and diesel constitutes 39% and 12% respectively. In 2013, petrol constitutes about 67% of the total energy consumed by the industrial sector while electricity and diesel constitute 27% and 6% respectively (Figure ES 4). About 90% of the energy consumed in the industrial sector is used on machinery. Lighting accounts for about 8% of the total energy consumption in the industrial sector while the remaining 2% is consumed by cooling systems and other machine drives.

Figure ES 4: Percentage share of energy sources consumed by the industrial sector in GEM from 2010 to 2013

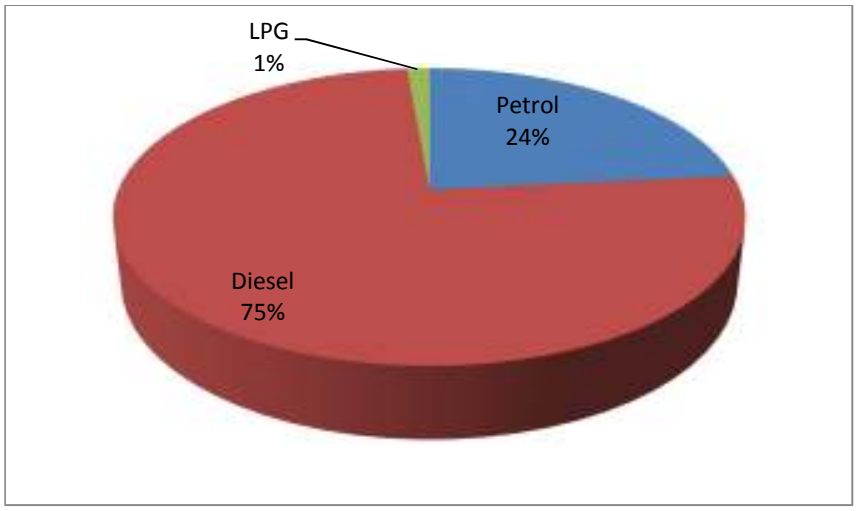


Source: 2014 Energy Survey

ES 3.5: Energy picture of the Transport Sector in GEM

The transport sector is the most energy intensive sector in the municipality. Vehicle population in the municipality as at 2013 was about 23315 consisting of 3 public vehicles (Metro Mass Transit buses), 18804 private vehicles and 4508 commercial vehicles. The MMT buses transport about 8640 people per week from various locations to and fro the municipality. Mini buses (trotro) transport about 3454800 people per week in the municipality while taxis transport about 322056 people per week. About 75% of the total energy consumed by the transport sector in the GEM is from diesel fuel (Figure ES 5). Petrol fuel constitutes about 24% of the total energy used by the transport sector while 1% of LPG is consumes in the municipality. LPG is consumed mainly by taxis, which have converted onto the LPG fuel from either petrol or diesel fuels because it is considered to be more economical than petrol and diesel.

Figure ES 5: Percentage share of fuel type consumed by the transport sector in GEM



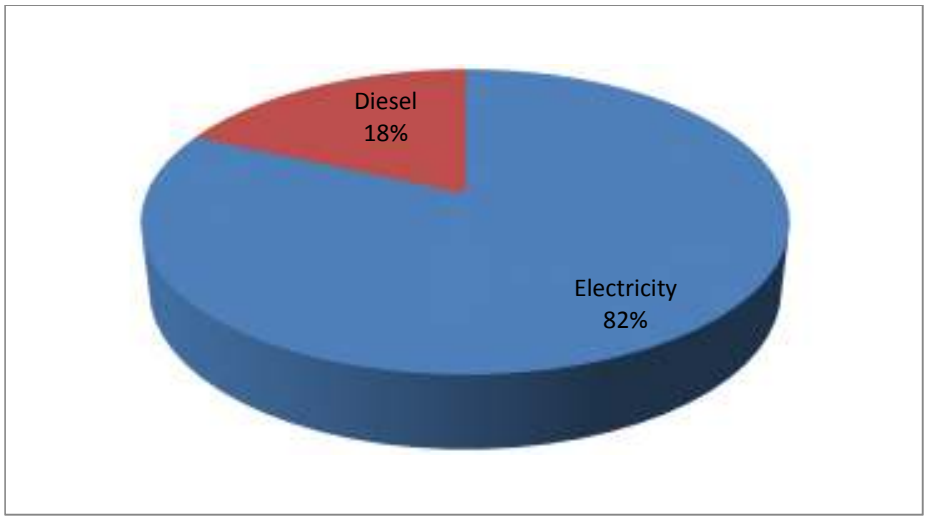
Source: 2014 Energy Survey

Medium and heavy trucks energy consumption constitutes the highest (38%) in the transport sector, followed by light passenger vehicles (30%). Light trucks consume about 15% while trotros (mini buses) consume about 13% of energy in the transport sector. Taxis' energy consumption constitute only 4% of the total fuel consumption in the transport sector while motorbikes and heavy passenger vehicles consume less than 1% of the total energy consumed in the transport sector in GEM.

ES 3.6: Energy Picture of GEMA

GEMA is the least energy consuming sector in the municipality as at 2013. The predominant energy source consumed by GEMA is electricity from the national grid. Electricity constitutes about 82% of the total energy consumed by GEMA in 2013 (Figure ES 6). The remaining 18% of the energy consumed came from diesel fuel which is used in the vehicles and also for powering the back-up generator. Ventilation and air conditioning (VAC) is the largest energy end-user, accounting for about 38% of the total energy consumed by the GEMA in 2013 (Figure 52). 18% each is consumed through refrigeration and transportation while office machines accounts for about 16% of the total energy consumed by the Assembly. 5% each is consumed through lighting and water treatment. Electricity is the main source of energy for lighting but GEMA also depends on a 60kv capacity diesel-powered generator which uses about 125.22 litres of diesel per month during periods of black-outs.

Figure ES 6: Share of total energy consumed by carriers in GEMA



Source: 2014 Energy Survey

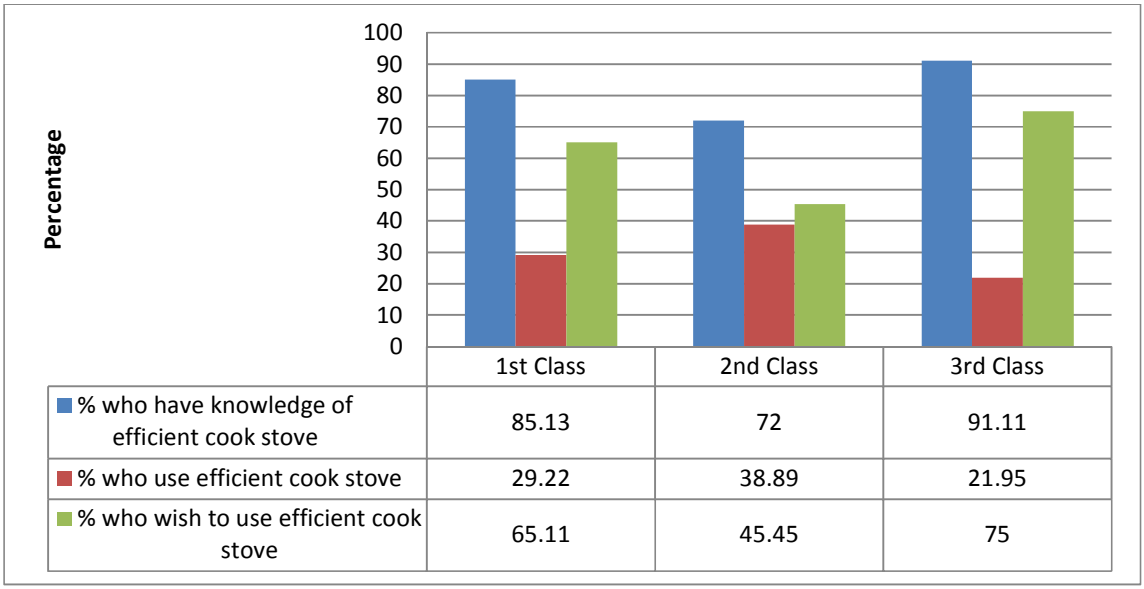
ES 4: Energy Efficiency Programmes: Knowledge-Based Evidence at the Municipal level

ES 4.1: Energy Efficient Cook stoves and light bulbs

From the survey, about 99% of First Class households strictly use energy efficient bulbs for lighting while 96% and, nearly all of Second and Third Class households respectively use efficient lighting bulbs.

Knowledge on the existence of *Gyapa* cookstoves in GEM is very high as more than 70% of electrified households across all three classes of settlements indicated their awareness of the cook stoves. Conversely, a very low percentage of these households currently use the efficient cook stoves despite the high level of awareness (Figure ES 7). Meanwhile, the percentage of electrified households who wish to use efficient cook stoves is also high, especially in First and Third Class electrified households, implying the possibility of increase in use of the technology in the municipality in future. Among non-electrified households, more than 75% of households noted their awareness of energy efficient cook stoves. However, less than 50% of such households with highly perceived awareness rate have used these efficient cook stoves. Over 75% expressed willingness to use these energy efficient cook stoves (Figure ES 8).

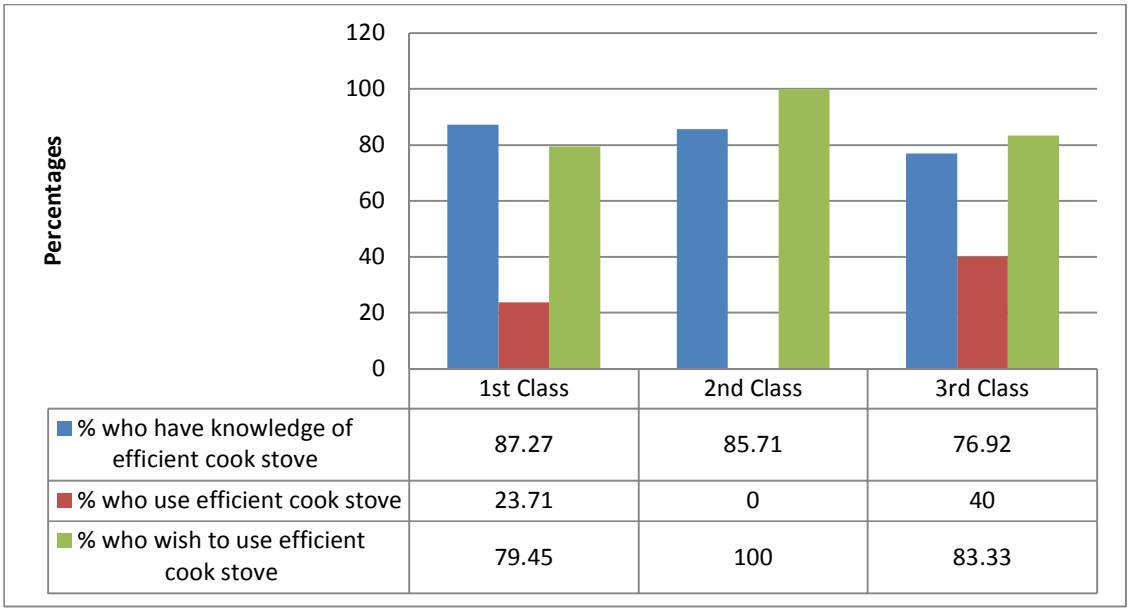
Figure ES 7: Percentage of electrified households who have knowledge, are using or wish to use efficient cook stoves in GEM



	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	85.13	72	91.11
% who use efficient cook stove	29.22	38.89	21.95
% who wish to use efficient cook stove	65.11	45.45	75

Source: 2014 Energy Survey

Figure ES 8: Percentage of non-electrified households who have knowledge, are using or wish to use efficient cook stoves in GEM



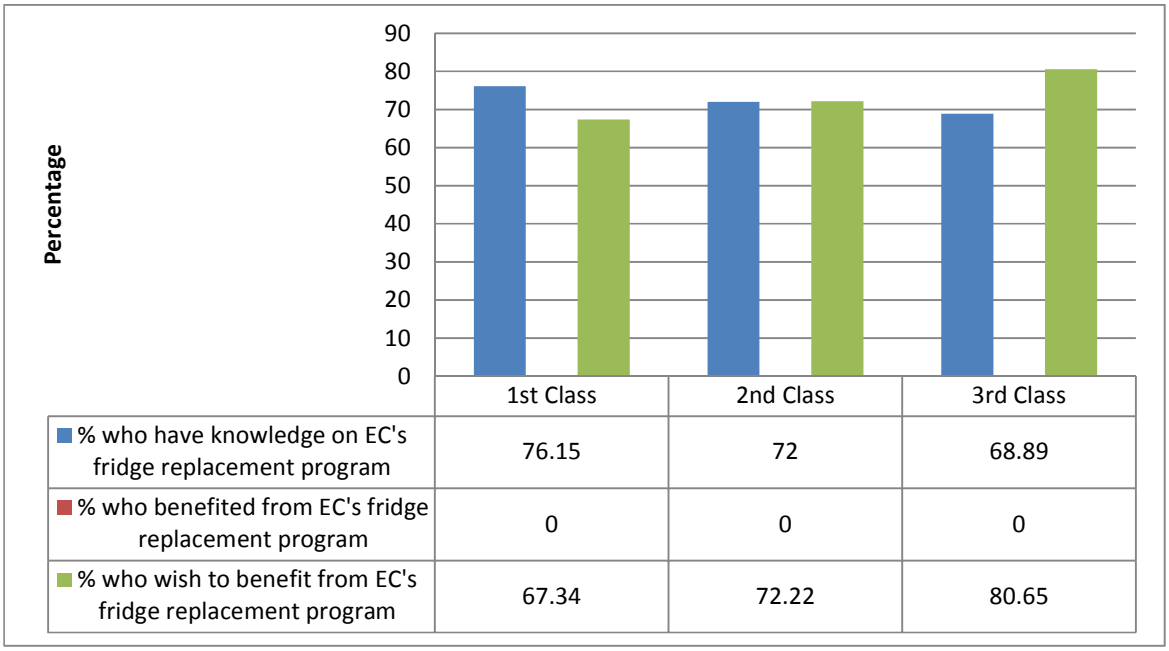
	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	87.27	85.71	76.92
% who use efficient cook stove	23.71	0	40
% who wish to use efficient cook stove	79.45	100	83.33

Source: 2014 Energy Survey

ES 4.2: Penetration level of Energy Commission's fridge replacement programmes in GEM.

With respect to the EC's fridge replacement programme, the survey results show that it is well known in the GEM. Over 60% of households across all three settlement classes have knowledge on the programme (Figure ES 9). Regardless of the high awareness, patronage of the programme is rather abysmal. None of the households in all three settlement classes participated in the programme. Meanwhile, a significant percentage (over 65%) of households that indicated their awareness of the programme wish they could benefit from it in the future.

Figure ES 9: EC's fridge replacement programme: knowledge and accessibility



	1st Class	2nd Class	3rd Class
% who have knowledge on EC's fridge replacement program	76.15	72	68.89
% who benefited from EC's fridge replacement program	0	0	0
% who wish to benefit from EC's fridge replacement program	67.34	72.22	80.65

Source: 2014 Energy Survey

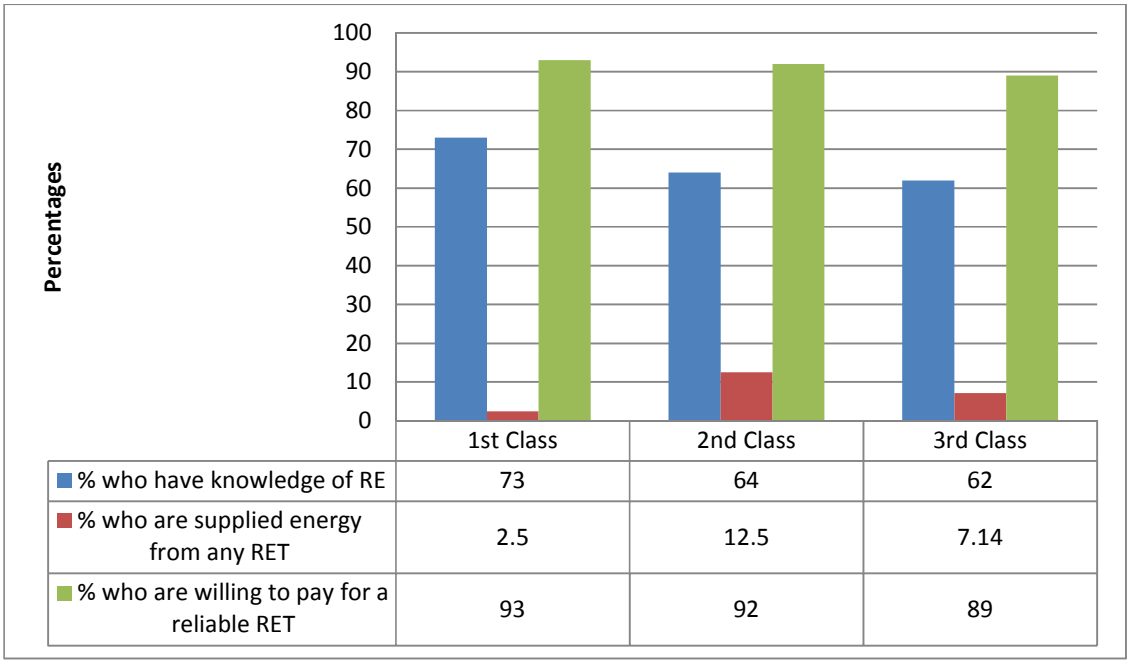
ES 4.3: Energy Commission (EC) Appliance Efficiency Labels

In the survey, households in the GEM were asked whether the new appliances they bought had the energy efficiency labels on them. For those who use air conditioners, -- in First Class households—about 88% of them bought the ACs with the EC's efficiency labels on them while 12% of them bought new ACs without the efficiency labels. For refrigerators users, about 59% of First Class households bought new refrigerators with the EC's efficiency labels displayed on them. Only 10% and 40% of Second and Third class refrigerators users bought new refrigerators with the efficiency labels displayed on them.

ES 4.4: Knowledge and use of Renewable Energy Technologies (RETs) in GEM

Public knowledge on RETs is quite encouraging in the municipality. About 73% and 42% of first class electrified and non-electrified households respectively have knowledge on renewable energy. About 64% and 57% of second class electrified and non-electrified households have knowledge on renewable energy while 62% and 54% of third class electrified and non-electrified households respectively, are also aware of renewable energy (Figures ES 10 and ES 11). The most common RETs known to these household members are solar PVs and wind. Despite the awareness level, more than 80% of these households across all three settlements are not supplied energy from these RETs. Meanwhile, there is high willingness to pay for these RETs so far as they are reliable.

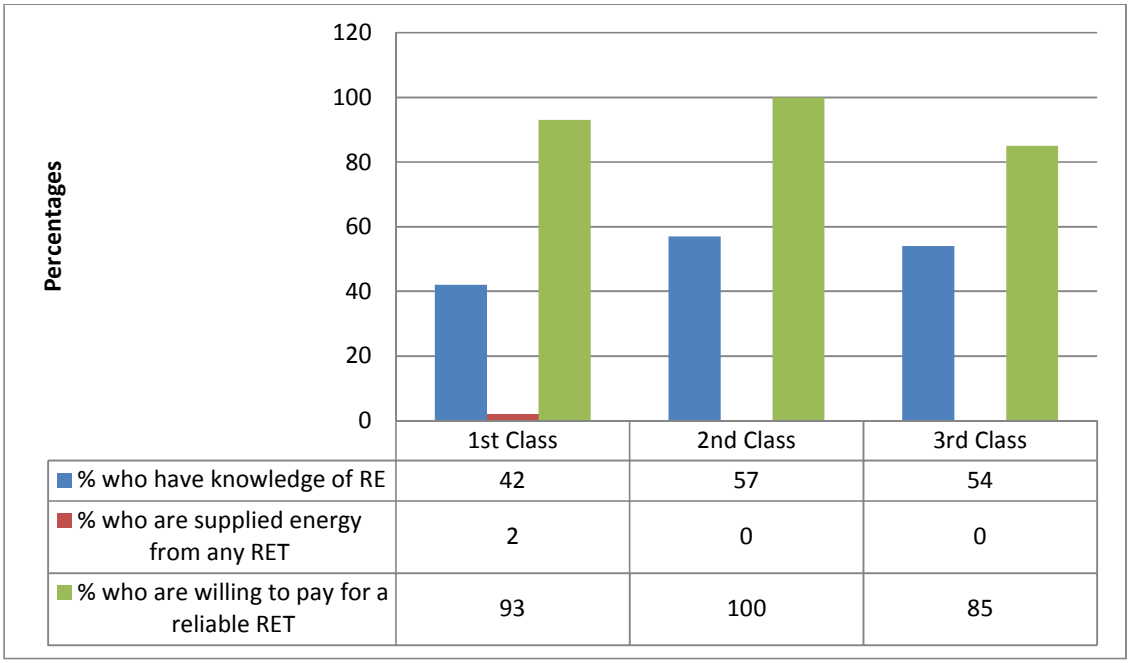
Figure ES 10: Percentage of electrified households who have knowledge of RE, supplied energy from RETs and are willing to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	73	64	62
% who are supplied energy from any RET	2.5	12.5	7.14
% who are willing to pay for a reliable RET	93	92	89

Source: 2014 Energy Survey

Figure ES 11: Percentage of non-electrified households who have knowledge of RE, supplied energy from RETs and are willing to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	42	57	54
% who are supplied energy from any RET	2	0	0
% who are willing to pay for a reliable RET	93	100	85

Source: 2014 Energy Survey

ES 5: Municipal Strategic Energy Issues

ES 5.1: Mandates of GEMA in influencing energy supply, demand and efficiency

GEMA does not produce nor distribute any form of energy to demand sectors of the municipality. All of the conventional energy carriers demanded by the various demand sectors in the municipality including the Assembly itself are supplied by national institutions. In the area of Renewable Energy Technologies (RETs), the Assembly has made little stride in terms of energy production. GEMA is partnering with La Nkwantanang-Madina municipality and a private investor to produce energy out of the waste that is deposited at the Abokobi landfill site. There are also some street lights in the municipality that are powered through the solar photovoltaic (PV) systems.

GEM oversees the general planning of the municipality before power is extended to the various dwelling units (houses and structures). In terms of residential buildings and other structures that are put up in the municipality, the Assembly has no mandate to impose building plans on individual property owners. However, all building plans go through vetting procedures at the Assembly to ensure the plans entail proper ventilation systems and minimal use of lights. Regarding spatial planning, the Assembly has prepared town layouts (schemes) for specific areas

in the municipality. Based on these town schemes, permits are issued to individual land developers who which to put up residential buildings, office structures, warehouses or other structures. In terms of transport management, there are 45 urban passenger transport operator unions in the municipality that are regulated by the Assembly. The Assembly, however, does not determine which vehicles are road-worthy or not to operate in the municipality. The Assembly only levies passenger vehicle operators in the municipality for their operations.

ES 5.2: The control of GEMA over new developments in GEM

Electricity extension to new communities and also to new residential buildings and other structures in already connected communities is an ongoing activity in the municipality. The Assembly has no direct control over such connections, but indirectly provides information regarding such communities. GEMA has full control over spatial layouts of the municipality and building structures. In 2013, 168 development permit applications were received at GEMA. A total of 224 development applications were approved in that same year which included the outstanding applications of the previous years. It is, however, not uncommon to see people putting up permanent and temporal structures at unauthorized locations without permits from the Assembly. This often attracts fines and demolition of the structures once the Assembly finds out about such activities.

With respect to the transport sector, the GEMA has no control over construction and maintenance of roads in the municipality (which are mandates of the Urban Roads Department). The Assembly, however, supervised the setting up of some new bus terminals in the municipality and also upgrade of some existing ones in the past year. About five (5) liquid fuel service stations were granted permits to site and operate in the municipality in 2013. The Assembly ensured that the locations of these fuel service stations conformed to the general layouts of the area.

SECTION ONE

BACKGROUND TO THE STUDY OF THE STATE OF ENERGY IN GEM

1.0 Introduction

Energy has been recognized as an indispensable resource for the promotion of economic activities and the enhancement of human welfare. There is therefore the need to plan properly to ensure not only adequate supply of energy to meet demand, but also the supply and use of the appropriate types of energy for sustainable development. Population growth and rapid urbanization of most African countries including Ghana are currently weighing heavily on the existing energy infrastructure, because of increase demand. Ghana has been experiencing precarious power crises since 2012 with electricity rationing among demand sectors becoming a norm in the country. As an urbanized country[1], a greater percentage of the electricity supply and other energy sources are consumed in cities and municipalities. The estimated 81% accessibility to electricity in the urban areas vis-à-vis 24.9% in rural areas as at 2010[2] speaks volume to the rate of energy consumption in urban Ghana. The current shortfall in electricity supply in Ghana, coupled with the increased demand in the urban areas are indicative of the need for long-term planning for energy in the cities and municipalities because they have potential to expand in the future.

Presently, with the entire world experiencing the negative consequences of climate change, an effective energy planning for the cities and municipalities needs to move beyond the adequate supply of conventional energy sources to incorporating measures that will propel people to transition into using renewable energy technologies and practicing energy efficiency measures that will bring about sustainability. However, to be able to fashion out such an effective and sustainable energy plan for any city or municipality requires first and foremost, knowledge on the existing state of the energy infrastructure, consumption and demand issues as well as the institutional and governance issues of energy in the city or municipality in question. In Ghana, existing energy outlooks and statistics talk about national level energy situations, with little being known of the holistic state of energy at the regional or metropolis/municipalities/districts. In the absence of such specific baseline information, effective planning for sustainable issues becomes highly impossible.

Against the backdrop of the issues outlined above, the project "Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions (SAMSET)[3]" has among its objectives, the building of a credible State of Energy (SoE) for all its municipal partners. The SoE reports for

[1] The proportion of urban population in Ghana stood at 50.9 in 2010 (GSS, 2010)
[2] Sourced from Ministry of Energy (MOE), 2010
[3] SAMSET is a four year project (2013 – 2017) funded by the EPSRC and DFID and being jointly ran by the Institute of Statistical, Social and Economic Research (ISSER), University of Ghana; Uganda Martyrs University; University of Cape Town; Durham University; University College London; Sustainable Energy Africa (SEA) in South Africa and Gamos Ltd, UK. See Website: https://samsetproject.wordpress.com/

the six partner municipalities will provide platforms for the project team to support municipal assemblies to plan effective and sustainable energy transition pathways for the municipalities. Ga East Municipality (GEM) is one of the two municipal partners[4] the SAMSET project is collaborating with in Ghana. Thus, this SoE report has been undertaken for the GEM.

The report is structured as follows. Section one covers the overview of the energy outlooks in Ghana and the Greater Accra Region supported with national and local policy frameworks and regulatory arrangements. Also captured in the first section are national climate change issues. Section two encapsulates the methodological approaches that were availed of to collect the data and the compilation of the report. In section three, the energy picture of GEM based on the data from the survey is discussed together with other relevant demographic features of the municipality. Section four discusses the breakdown of energy dynamics by the various sectors of GEM. In the fifth section, knowledge-based evidences are provided on the level of penetration of national energy efficient programmes in the municipality. The sixth section discusses the municipal strategic energy issues with respect to the mandates and the control of GEM while the last section summarises the major findings of the survey with relevant policy implications.

1.1 The Macro Picture: Ghana and Ga East Municipality Energy Picture

1.1.1 Ghana's Energy Picture

The growth rate of the total final energy consumed in Ghana stood at 8.3 percent between 2006 (0.24 ToE/capita) and 2013 (0.26 ToE/capita) (Energy Commission, 2014). Energy intensity, which is the required units of energy necessary to produce a unit of GDP, declined from 0.28 ToE/ GHS 1,000 in 2006 to 0.23 ToE/ GHS1,000 in 2010 and further dipped in 2013 to a value of 0.21 ToE/ GHS1,000; representing a negative growth rate of 17.9% and 25% respectively (Energy Commission, 2014). Energy used in Ghana is often supplied by three major sectors: power/electricity, petroleum and bioenergy. Electricity is generated from two main sources-hydro (Akosombo, Kpong and Bui) and thermal, which together generated a total of 12,870GWh in 2013, a 7% increase over 2012 total generation of 12,024GWh and a 26.6% increase over 2010 total generation of 10,167GWh (Table 1). As at 2013, the total generation capacity is estimated around 2,847MW from both hydro and thermal sources (Table 1). Total electricity consumed per GDP had a negative growth rate of 28.9 percent between 2006 and 2012. This, however, upturned in 2013 by 6.4 percent to a value of 327.4 kWh/GHS 1,000 of GDP (Energy Commission, 2014). Direct relationship has been observed between electricity generation and consumption per capita where an increase in consumption per capita always result into increments in generation per capita (see Figure 1).

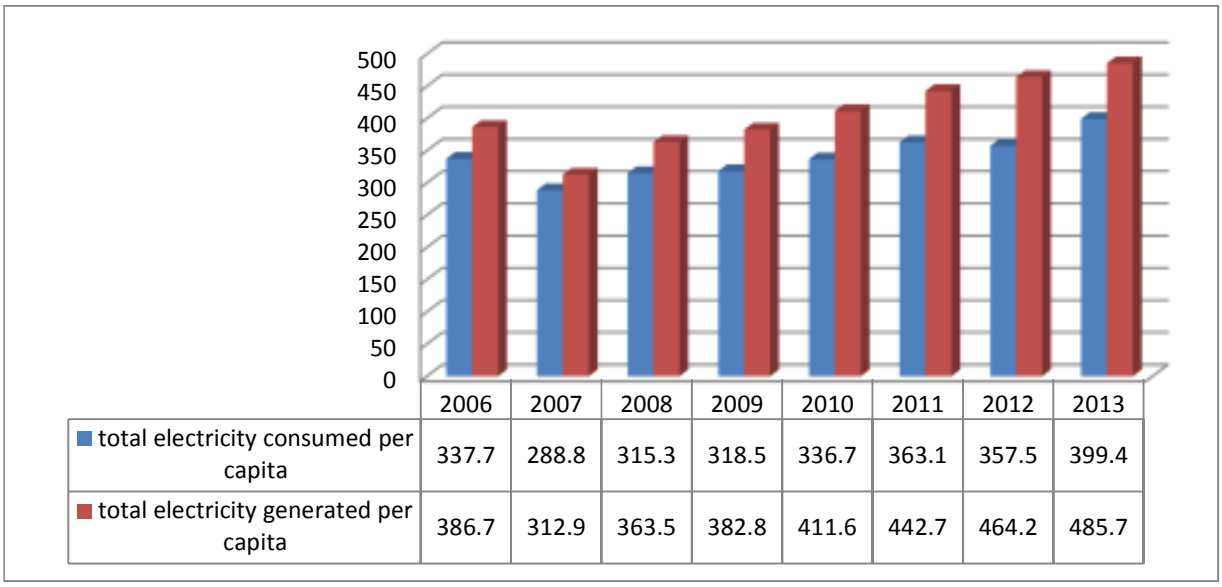
[4]Awutu Senya East Municipal Assembly is the other partner. These were selected based on their willingness to partner the project.

Table 1: Power generation sources and installed capacity/production

Energy source	2010		2011		2012		2013	
	Cap-acity (MW)	Gen. by Plant (GWh)	Cap-Acity (MW)	Gen. by Plant (GWh)	Cap-Acity (MW)	Gen. by Plant (GWh)	Cap-acity (MW)	Gen. by Plant (GWh)
Electric Power	**2185.5**	**10167**	**2169.5**	**11200**	**2280**	**12024**	**2627**	**12868**
Hydro	1180	6996	1180	7561	1180	8071	1382	8233
Thermal	1005.5	3171	989.5	3639	1100	3953	1245	4635

Source: Energy Commission, 2014

Figure 1: Relationship between electricity generated per capita and electricity consumed per capita in Ghana



	2006	2007	2008	2009	2010	2011	2012	2013
total electricity consumed per capita	337.7	288.8	315.3	318.5	336.7	363.1	357.5	399.4
total electricity generated per capita	386.7	312.9	363.5	382.8	411.6	442.7	464.2	485.7

Source: Energy Commission, 2014

Commercial oil production officially commenced in December 2010 and by the end of 2012, about 4, 133.8 kilotonnes of crude oil was produced in Ghana (Energy Commission 2014). This was however not consumed domestically hence Ghana still depends on crude oil importation through the Ghana National Petroleum Corporation (GNPC) and other partners for the purpose of supporting electricity generation and for refinery purposes. The Tema Oil Refinery (TOR) refines/produces Liquefied Petroleum Gas (LPG), Premix Gasoline, Aviation Turbine kerosene (ATK), gas and fuel oil from the crude. Despite the general upward trend in the production of these petroleum products from 1,028.4 kilotonnes in 2000, production reduced to about 891kilotonnes in 2006, 946.4 kilotonnes in 2010, 454 kilotoones in 2012 and 424 kilotonnes in 2013 when the total imported crude oil reduced in those years (Table 2). Low production of

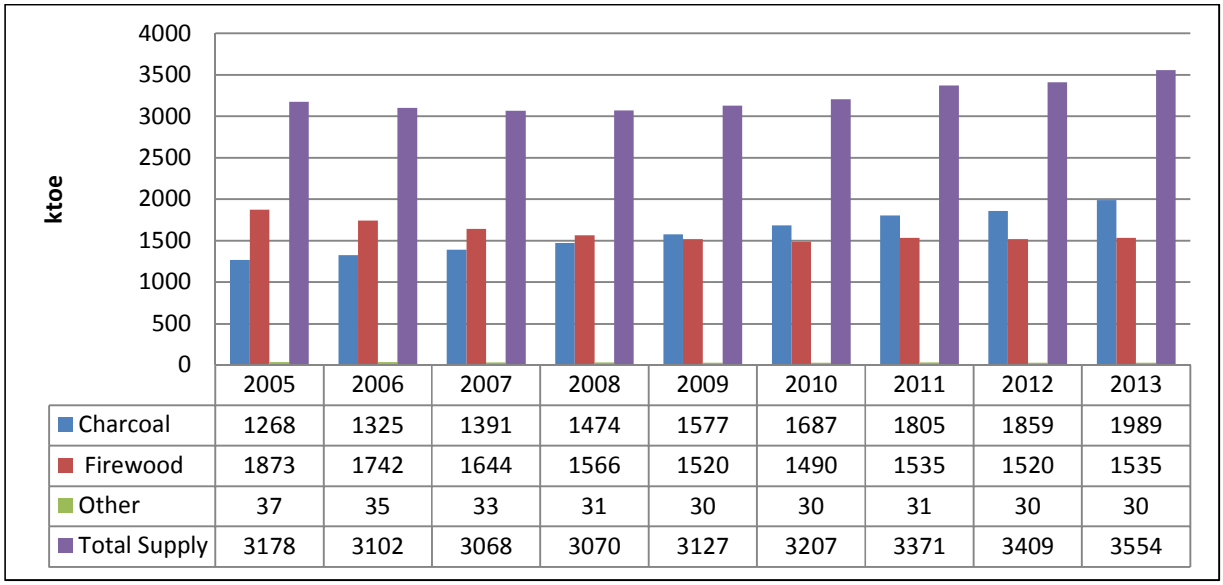
petroleum products have led to increase importation of these products in Ghana totaling 2,477.6 kilotonnes in 2012 from 1037.8 kilotonnes and 1589.9 kilotonnes in 2008 and 2010 respectively. Consumption of petroleum products per capita was 0.09 ToE/capita in 2006, increasing to 0.13ToE/capita in 2013 representing a growth rate of 44.44 percent. Woodfuel component of bioenergy in the form of fuelwood and charcoal make up 75% or more of the national energy consumption (Ghana Statistical Service, 2012). As of 2013, a total of about 3,554 kilotonnes of oil equivalence (ktoe) of biomass was supplied to the biomass demand sectors of Ghana, representing an increase of about 10.8% and 4.3% from the 2010 and 2012 total supply values respectively (Figure 2). Biomass consumption per capita dipped by 16.67% in 2013 (0.10 ToE/capita) from a value of 0.12 ToE/capita in 2006 (Energy Commission, 2014).

Table 2: Petroleum products production in Ghana (kliotonnes), 2000-2012

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
LPG	75.3	35.8	67.3	54.6	14.0	31.6	44.6	26.8	25.6
Gasoline	567.1	294.4	493	391.2	135	337.7	344.3	157.7	167.3
Kerosene	87.7	65.1	122	168.6	48.7	71	52.6	21.1	14.6
ATK	119	46.2	65.8	21.3	1.3	116.7	116.1	47.6	59.8
Gas Oil	486.3	294.2	398.2	360.5	102.8	292.6	309.8	121.5	113.3
Fuel Oil	205.4	155.5	48.7	225.4	25.3	96.8	90.6	79.2	43.5
Total	1540.8	891.2	1195	1221.6	327.1	946.4	958	453.9	424.1

Source: Tema Oil Refinery

Figure 2: Woodfuel Supply in Ghana (kilotonnes)



	2005	2006	2007	2008	2009	2010	2011	2012	2013
Charcoal	1268	1325	1391	1474	1577	1687	1805	1859	1989
Firewood	1873	1742	1644	1566	1520	1490	1535	1520	1535
Other	37	35	33	31	30	30	31	30	30
Total Supply	3178	3102	3068	3070	3127	3207	3371	3409	3554

*Other biomass fuels include saw dust, sawmill residue and crop residues

Source: Energy commission, 2014

Ghana is well endowed with lots of renewable energy resources that are yet to be tapped. By virtue of its location, the average duration of sunshine received in the country varies from a minimum of 5.3 hours per day at Kumasi in the Ashanti Region, which is in the cloudy semi-deciduous forest region, to 7.7 hours per day at Wa in the Upper West Region, which is in the dry savannah region with monthly average solar irradiation ranging between 4.4 and 5.6kWh/m^2 /day (16-20 MJ/m /day) and between 1,808-3,000 hours of sunshine per year (Hamlin and Ofori-Nyarko, 2005, cited in Bawakyillenuo, 2007). Currently, 2MW capacity of solar PV has been installed at Navrongo in the Upper East Region, bringing the total installed solar PV capacity to an estimated value of 2.5MW, due to the failure of some previously installed PVs. Ghana has about 2,000 MW of raw potential for wind energy while there are 22 exploitable mini-hydro sites in the country with total potential between 5.6MW – 24.5MW (Ministry of Energy, 2010).

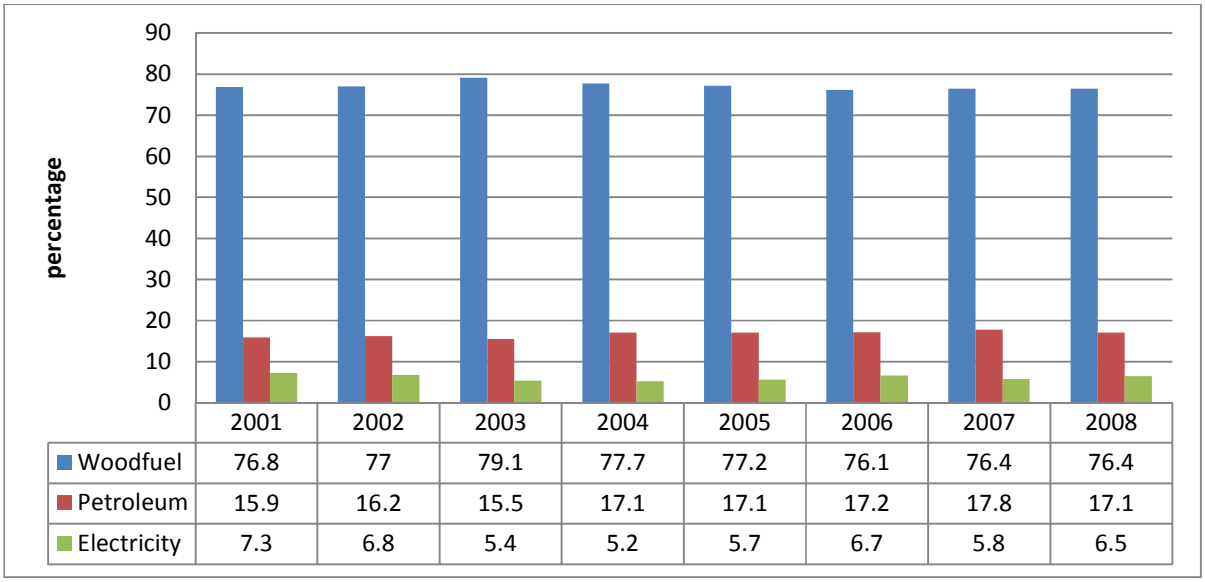
The major energy demand sectors of the economy are the residential, non-residential and the industrial sectors. The rural and urban communities make up the residential demand side of energy. Total number of households in Ghana was about 4 million in 2000, 5,467,136 in 2010 and is expected to reach between 5 – 6 million by 2020 (GSS, 2013). Utilisation of energy are usually in the form of lighting and cooking, with biomass dominating the energy types being used by most households especially in the rural communities.

The non-residential sector comprises of commercial and services, agriculture, transport and industrial sub-sectors. The commercial and services sector's share of total national energy use has on average been less than 3% per annum since 2000. The informal sector comprising chop-bars (restaurants) and street vendor cooking have had the largest share (over 55%) of energy use since 2000 followed by the tourism sub-sector (10-12%) and Education sub-sector (more than 5%). Most of the energy used in this sector come from woodfuels (over 60% since 2000) followed by electricity (about 28% share) and then petroleum, about 10% (Energy Commission, 2014). The final energy use by the agriculture sector for mechanisation, irrigation, transportation and preservation is very small, accounting for less than 5% of total energy use since 2000 (Energy Commission, 2014). The road subsector accounted for about 93% of fuel use from year 2000 to 2004. This was followed by air transport (6-7%). Energy use by the rail and the maritime subsectors is comparatively negligible, averaging 0.3% and 0.1%, respectively. The transport sector accounted for about 99.7% of gasoline consumption in the economy, with the remaining 0.3% going into industry for general use as solvent in 2000 (Energy Commission, 2006). Most (about 85%) of the diesel supplied to the economy was also taken up by the transport sector, whilst the remaining 9% and 5% went to industry and the agriculture & fisheries sectors, respectively. About 99.3% of the diesel for the transport sector was used by road transport. LPG use in the transport sector during 2000 – 2004 was relatively negligible. However, the use of LPG gained popularity in the transport sector especially by taxi services since 2007 leading to an increase in consumption levels (Energy Commission, 2014). The industrial sector without the Volta Aluminium Company Limited (VALCO) had nearly 22% of total national energy share every year since 2000. With VALCO, the industrial sector's total energy share increased slightly

to about 23% per annum (Energy Commission, 2014). The main fuels for industrial purposes are woodfuels, electricity and petroleum products (particularly, diesel and residual fuel oil).

Woodfuel energy is the most widely used energy form in Ghana with an average of about 77 percent of the total energy consumed from 2001 to 2008 (Figure 3). This is followed by petroleum and then electricity as depicted in Figure 3. According to the Ghana Statistical Service (GSS, 2013) electricity is the dominant modern energy form used in the industrial and service sectors, accounting for 69% of modern energy used in the two sectors of the national economy. It is also widely used in the residential sector for various purposes, but predominantly for lighting purpose. According to the GSS, 2013 the results of the 2010 Population and Housing Census (PHC) showed that more than sixty percent (64.2%) of households use electricity (mains) as their main source of lighting (Figure 4).

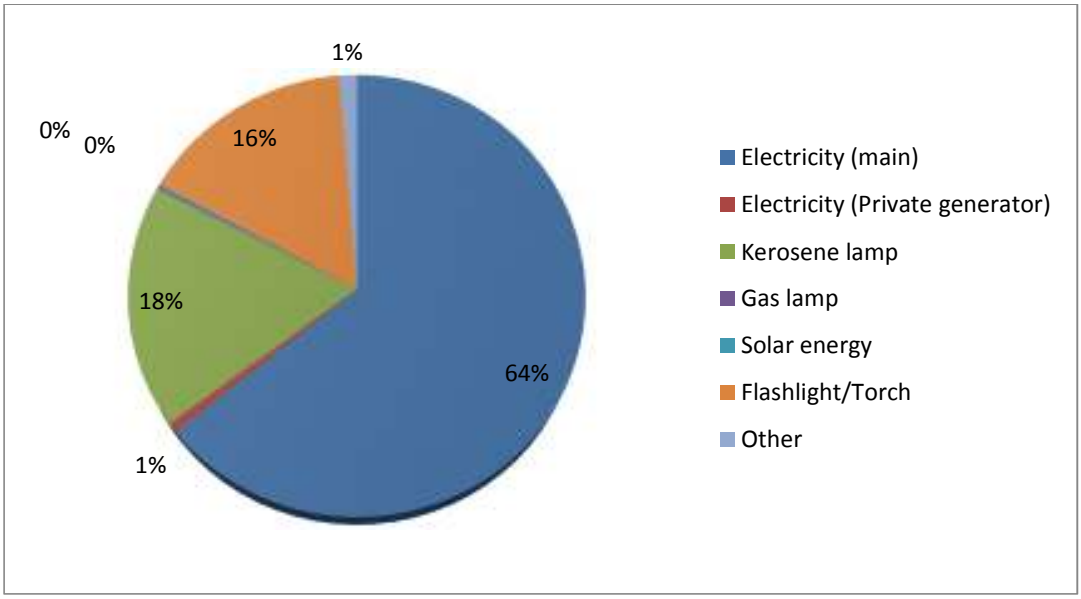
Figure 3: Trends in share of total energy consumed



	2001	2002	2003	2004	2005	2006	2007	2008
Woodfuel	76.8	77	79.1	77.7	77.2	76.1	76.4	76.4
Petroleum	15.9	16.2	15.5	17.1	17.1	17.2	17.8	17.1
Electricity	7.3	6.8	5.4	5.2	5.7	6.7	5.8	6.5

Source: Energy Commission, 2010

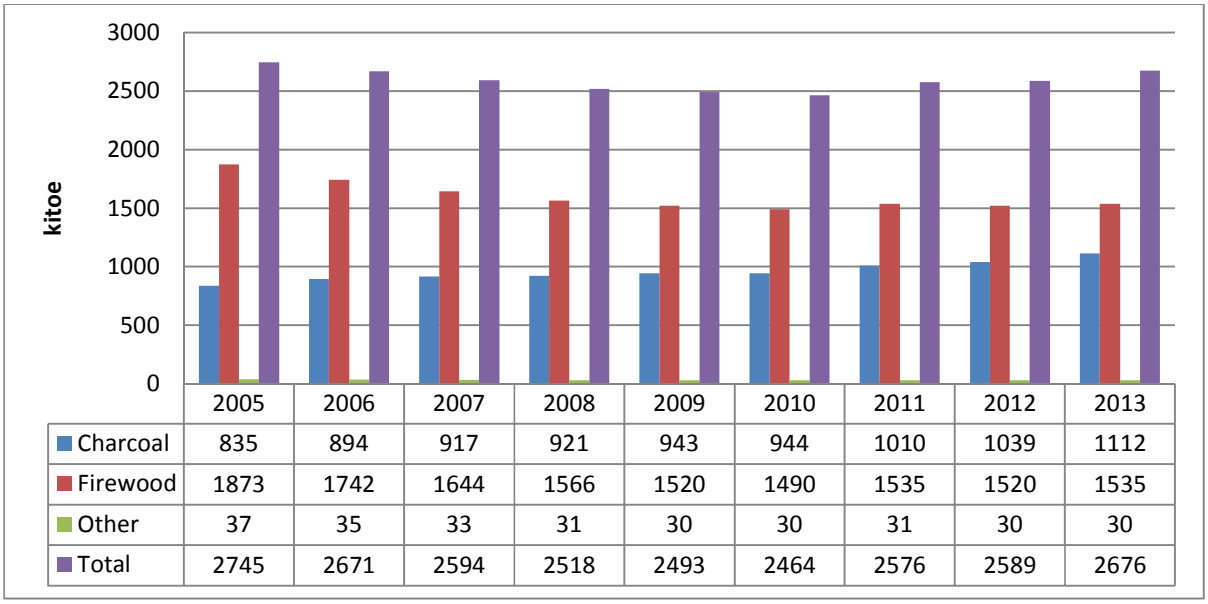
Figure 4: Energy sources for lighting



Source: GSS, 2013

Wood for charcoal has seen increasing consumption rate since 2005 as compared to firewood which declined in consumption from about 1,873 ktoe in 2005 to about 1,535 ktoe in 2013 (Figure 5). Other biomass fuels such saw dust, sawmill and crop residues are consumed in minute quantity. The biomass consumption pattern indicates a shift from wood for firewood source to charcoal energy for more urban households. LPG usage in Ghana has increased significantly to 18.2% in 2010 from 6.2% in 2000 (Table 3). This is attributed to the increasing consumption rate in the urban areas where about 42% of urban dwellers use LPG for cooking vis-à-vis only 5% of rural folks as at 2010 (GSS, 2013). However, charcoal and firewood remain the major energy sources for cooking in Ghana. About 56% of Ghanaians depended on firewood for cooking in 2000 especially rural folks who consume the most (about 85%). Though the percentage of Ghanaians who consumed firewood declined to about 40%, it remains significantly higher than the percentage of Ghanaians who use charcoal for cooking (Table 3).

Figure 5: Biomas Consumption (ktoe) in Ghana



	2005	2006	2007	2008	2009	2010	2011	2012	2013
Charcoal	835	894	917	921	943	944	1010	1039	1112
Firewood	1873	1742	1644	1566	1520	1490	1535	1520	1535
Other	37	35	33	31	30	30	31	30	30
Total	2745	2671	2594	2518	2493	2464	2576	2589	2676

*Other biomass fuels include saw dust, sawmill residue and crop residues

Source: Energy Commission, 2013

Table 3: Energy for Household Cooking in 2000 and 2010

Energy Source	2000			2010		
	National	**Urban**	**Rural**	**National**	**Urban**	**Rural**
Percentage penetration						
LPG	6.2	11.8	1.1	18.2	41.5	4.8
Charcoal	30.0	54.3	8.2	33.7	74.6	15.9
Firewood	55.8	22.9	85.2	40.2	26.7	73.4
Kerosene	2.0	2.6	1.4	0.5	1.1	0.3
Electricity	1.1	2.0	0.4	0.5	1.1	0.3

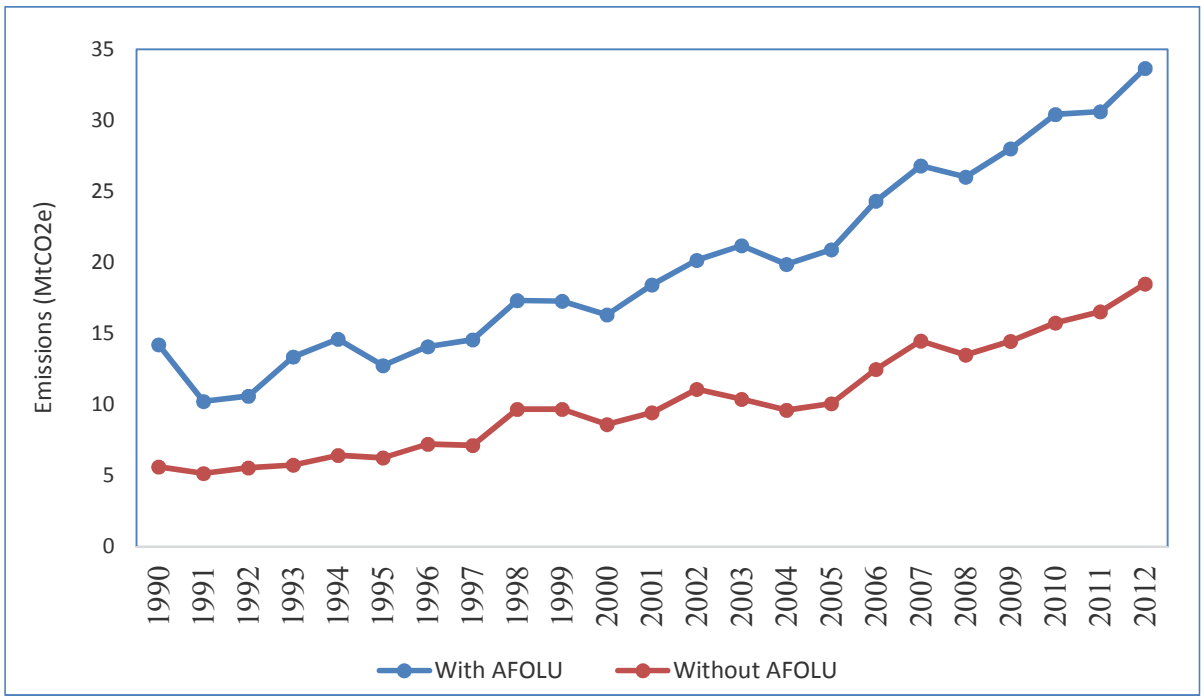
Source: GSS, 2002 and 2013

1.1.1.1 Climate Change Concerns

Ghana's total greenhouse gas emissions were 33.7 million tonnes (Mt) carbon dioxide-equivalent (CO_2e) in 2012. This represented an increase of 10.7% on total emissions recorded in 2010, and an increase of 106.2% and 136.7% above 2000 and 1990 levels respectively (see Figure 6). The net national GHG emissions in 2012 was 18.5MtCO_2e when emissions from the Agriculture,

Forestry and Other Land Use sector were excluded (AFOLU). This represented an increase of 17.4% on net emissions recorded in 2010, and 114.8% and 229.3% above 2000 and 1990 levels each. The observed increasing trends in emissions corresponded to the structural transformation agenda which has led to sustained growth and expansion of the national economy (EPA, 2015).

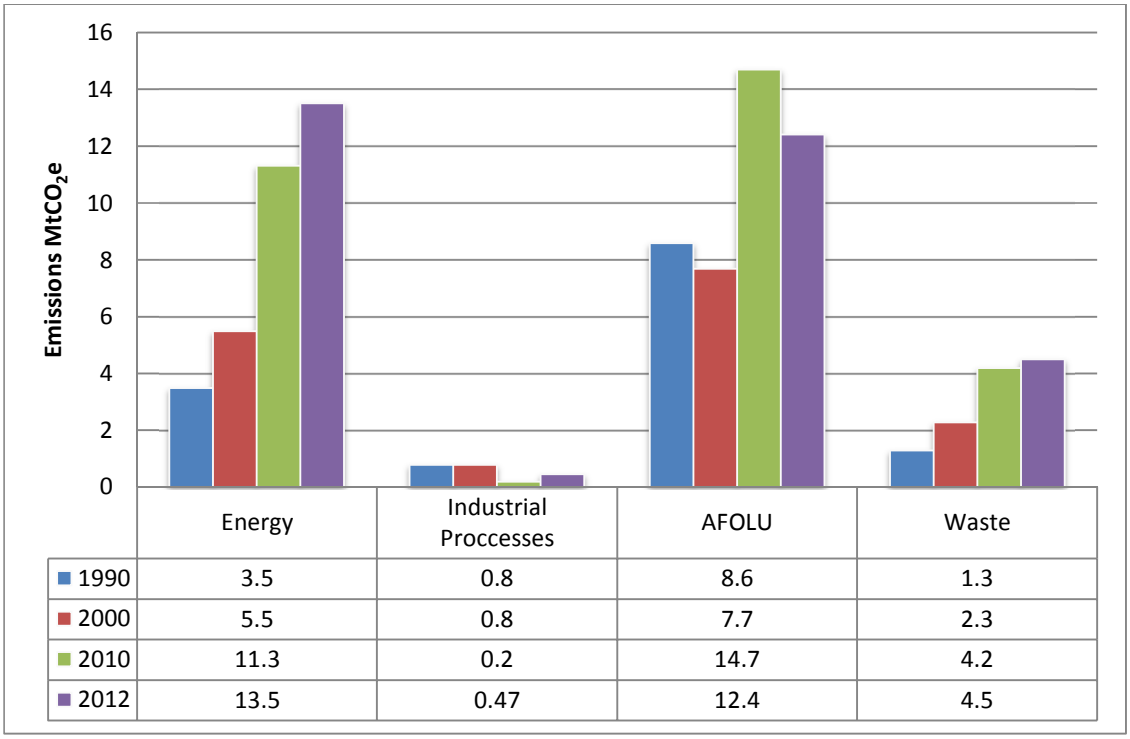
Figure 6: National emission trends with and without AFOLU



Source: EPA (2015)

The energy sector remains the largest contributor to the total greenhouse gas (GHG) emissions in the country as depicted in Figure 5 below. The energy sector emissions increased from 3.5 MtCO2e in 1990 to 11.3 MtCO2e in 2010 (representing 222.9 percent increment) and 13.5 MtCO2e in 2012 representing 285.7 percent increment (Figure 7). Within the energy sector, the largest emissions came from the transport sub-sector followed by residential sub-sector. Energy dependent industries --manufacturing industries and construction activities-- also had major impacts on the emissions from this sector. The general rise in emissions from the sector is attributed to the increasing fuel consumption in the growing number of thermal power generation plants and increasing fuel consumption (EPA, 2011). Also, poor fuel efficiency in the road transport sub-category, as well as rising biomass use in the residential sub-category have contributed significantly to GHG emissions.

Figure 7: Share of GHG emissions by sectors in 1990, 2000, 2010 and 2012 ($MtCO_2e$)



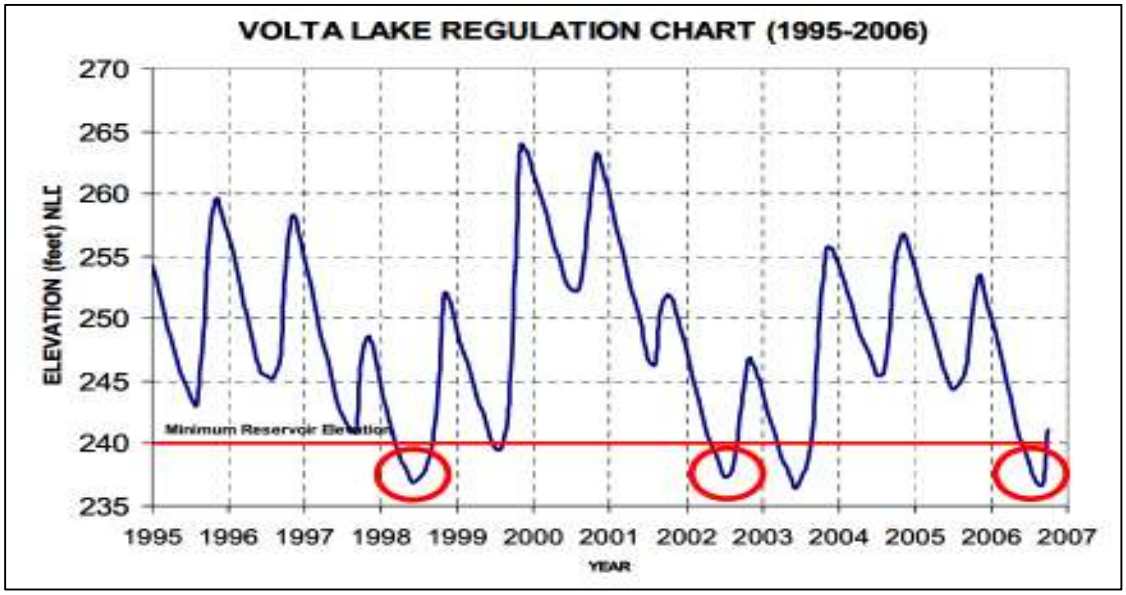
	Energy	Industrial Proccesses	AFOLU	Waste
1990	3.5	0.8	8.6	1.3
2000	5.5	0.8	7.7	2.3
2010	11.3	0.2	14.7	4.2
2012	13.5	0.47	12.4	4.5

Source: EPA (2015)

AFOLU: Agriculture, Forestry and Other Land Use

It is observable from the figures below that the years that the amount of water in the Volta Lake fell below the minimum reservoir elevation, that is, 1998/1999; 2002/2003; and 2006/2007, coincided with years in which the GHG emissions by the energy sector had sharp rise. This is attributable to the fact that with low hydro-electricity production in those years, thermal power plants' production had to increase to meet demand.

Figure 8: Volta Lake Regulation Chart (1995-2006)



Source: Volta River Authority (VRA), 2008

1.1.1.2 Policy Framework and Regulation on Energy in Ghana

1.1.1.2.1 National Energy Policy

The first major energy policy framework geared towards energy development in Ghana was undertaken in 1990 by the then National Energy Board (NEB). The NEB established five key departments: petroleum planning, electricity planning, renewable energy programmes, energy conservation programmes and energy information. Consequently, a total of 135 projects and programmes were initiated between 1989 and 1991, the key one being the National Electrification Scheme, which aims at extending electricity to all parts of the country by 2020. Other important energy policies are summarised in Table 4 with their key policy objectives.

Table 4: Fundamental Energy Policies with Key Specific Objective since 1996

Policy	Key Specific Objectives
Energy Sector Development Programme (1996-2000)	• To restore improved productivity and efficiency in the procurement, transformation, distribution and use of all energy resources; • To reduce the country's vulnerability to short term disruptions in the energy resources and supply bases; • To consolidate and further accelerate the development and use of the country's indigenous energy sources, especially woodfuels, hydro power, petroleum and solar energy; • To secure future power supply through thermal complementation of the hydro-based electricity generation
Energy for Poverty Alleviation and Economic Growth: Policy Framework, Programmes and Projects (2001-2009)	• To consolidate, improve and expand existing energy supply system; • To secure and increase future energy security by diversifying sources of energy supply • To increase access to modern energy services for poverty reduction in off-grid areas; • To accelerate the development and utilization of renewable energy and energy efficiency technologies; • To enhance private sector participation in energy transformation development and service delivery; • To minimize the environmental impacts of energy production, supply and utilization; • To strengthen institutional and human resource capacity, research and development in energy development; • To improve governance of the energy sector
Strategic National Energy Plan (SNEP) 2006-2020	• To establish an effective national infrastructure for energy planning; and • To create a consensus reference framework for the development of the energy sector.
National Energy Policy (NEP) 2010	• Secure long-term fuel supplies for the thermal power plant; • Reduce technical and commercial losses in power supply; • Support the modernization and expansion of energy infrastructure to meet growing demands and ensure reliability; • Increase access to modern forms of energy; • Improve the overall management, regulatory environment and operation of the energy sector; • Minimize the environmental impacts of energy supply and consumption through increase production and use of renewable energy and make energy delivery efficient; • Ensure cost recovery for energy supply and delivery; • Ensure the productive and efficient use of energy;

	• Promote and encourage the private sector participation in the energy sector • Diversify the national energy mix by promoting renewable energy sources, nuclear and coal power.
Ghana Renewable Energy Policy 2009-2020	• Feed-in-tariff (to be set by the PURC) • Mandate the PURC to specify Renewable purchase Obligations (RPO) for distribution utility operators and future market participants • The specification of net-metering tariffs by the PURC for captive generators • The setting up of dedicated renewable Energy Fund to help support the promotion of grid connected RE and also investment capital subsidies
VRA Renewable Energy Development Programme (REDP) 2010**	• Develop a mixed RE portfolio (wind, mini hydro, solar) in various potential locations noted to have available RE resources • Deploy RE plants as both grid connected and mini-grid (isolated grid) system • Set 5 year and 10 year RE generation capacity development projections which would be reviewed every 5 years.

Source: VRA, 2010; ISSER, 2012 ** Not a government policy but Volta River Authority

As explained in the work by Bawakyillenuo and Agbelie (2013), all the energy policies in Ghana were rooted on the Energy Sector's vision of creating an energy economy that provides reliable energy supply to all sectors, homes, businesses and for export reasons. For this reason, the policies share lots of similar objectives and goals.

1.1.1.2.2 Institutional Arrangements

Electricity generation is undertaken by the state-owned Volta River Authority (VRA), which operates the Akosombo Hydro Power Station, Kpong Hydro Power Station and some thermal plants. Bui Power Authority (BPA), another state-owned entity, has oversight responsibilities on the operations of the Bui Hydro-electric Power Project. In addition, independent power producers have been licensed to build, own and operate power plants based on various governments drives to encourage private participation in energy development in Ghana. The National Interconnected Transmission System (NITS) for electricity is owned and operated by the Ghana Grid Company (GRIDCO). The Ministry of Energy is responsible for formulating monitoring and evaluating policies, programmes and projects in the energy sector. In an attempt to salvage the erratic power crises facing the country in recent times, a new ministry was created for Power in 2014 which is expected to bring a sharper focus on the generation, supply and efficiency of power to match the economic growth of the Ghanaian economy. The

responsibilities of the major technical energy players are shown in Table 5 and Figures 9 & 10 below.

Table 5: The major players in the energy sector

AGENCY	RESPONSIBILITIES
POWER SUB-SECTOR	
• **Volta River Authority (VRA)**	• Power generation
• **Bui Power Authority**	• Power generation
• **Independent Power Producers (IPPs)**	• Power generation
• **Ghana Grid Company (GRIDCo)**	• Power generation
• **Electricity Company of Ghana (ECG)**	• Power Distribution in Southern Ghana
• **Northern Electricity Department (NED)**	• Power Distribution in Northern Ghana
PETROLEUM SUB-SECTOR	
• **Ghana National Petroleum Company**	• Oil and gas exploration development and production
• **Tema Oil Refinery (TOR)**	• Crude oil refining and sale of petroleum products
• **Bulk Oil Traders**	• Petroleum products importation and sale
• **Bulk Oil Storage and Transportation Company (BOST)**	• Bulk petroleum products transportation and storage
• **Oil Marketing Companies (OMCs)**	• Petroleum products distribution
• **Ghana Cylinder Manufacturing Company**	• LPG cylinder manufacturing
REGULATORY AGENCIES	
• **Public Utilities Regulatory Commission (PURC)**	• Electricity tariffs approval, monitoring quality of service and consumer protection
• **Energy Commission (EC)**	• Licensing of operators in the power sector and setting technical standards for their performance, sector planning and policy advice to the Energy Minister
• **National Petroleum Authority (NPA)**	• Licensing of operators in the petroleum sector and setting of technical standards and enforcement
• **Petroleum Commission**	• Regulating, managing and coordinating upstream petroleum activities
POLICY AGENCIES	
• **Ministry of Energy and Petroleum**	• Develop and ensure a reliable high quality energy service at the minimum cost to all sectors of the economy through the

• **Ministry of Power**	formulation, implementation, monitoring and evaluation of energy sector policies. • Specific policies focusing on the generation, supply and efficiency of power to all sectors of the country.

Source: Ministry of Energy, 2010 and 2014

Figure 9: Basic structure of Electricity Sector in Ghana

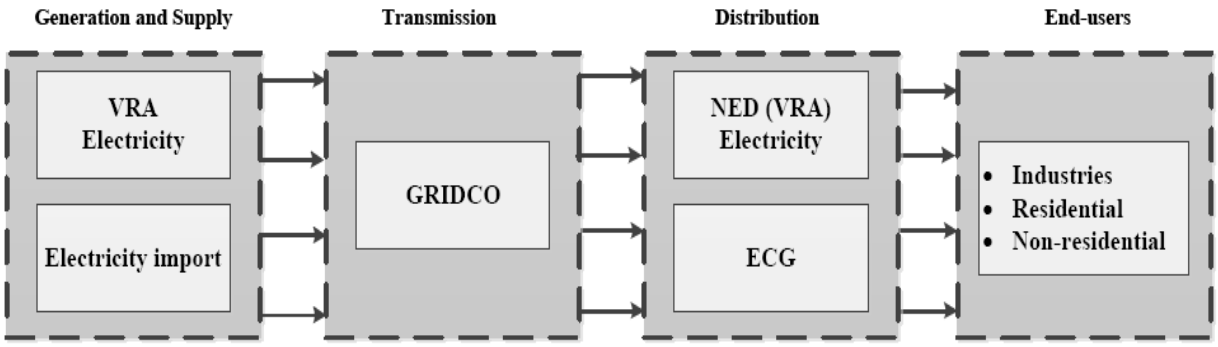
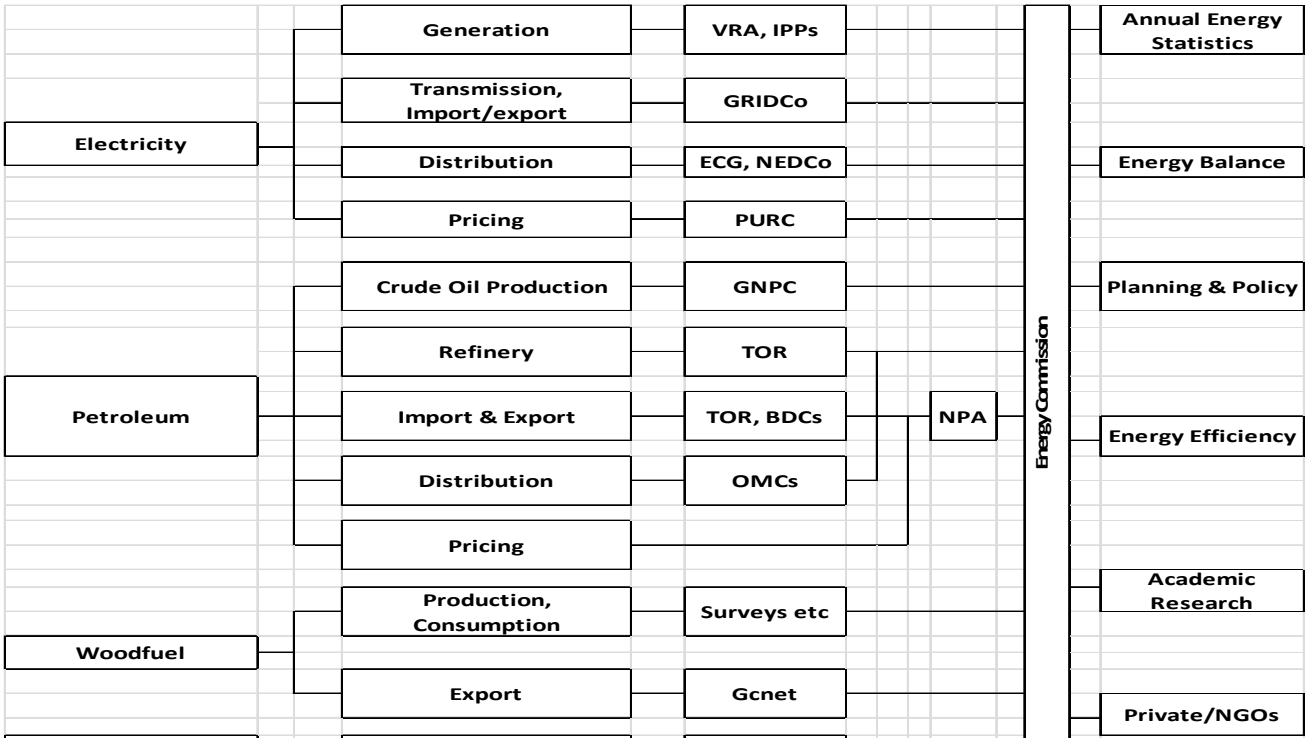


Figure 10: Organogram of the Energy Sector

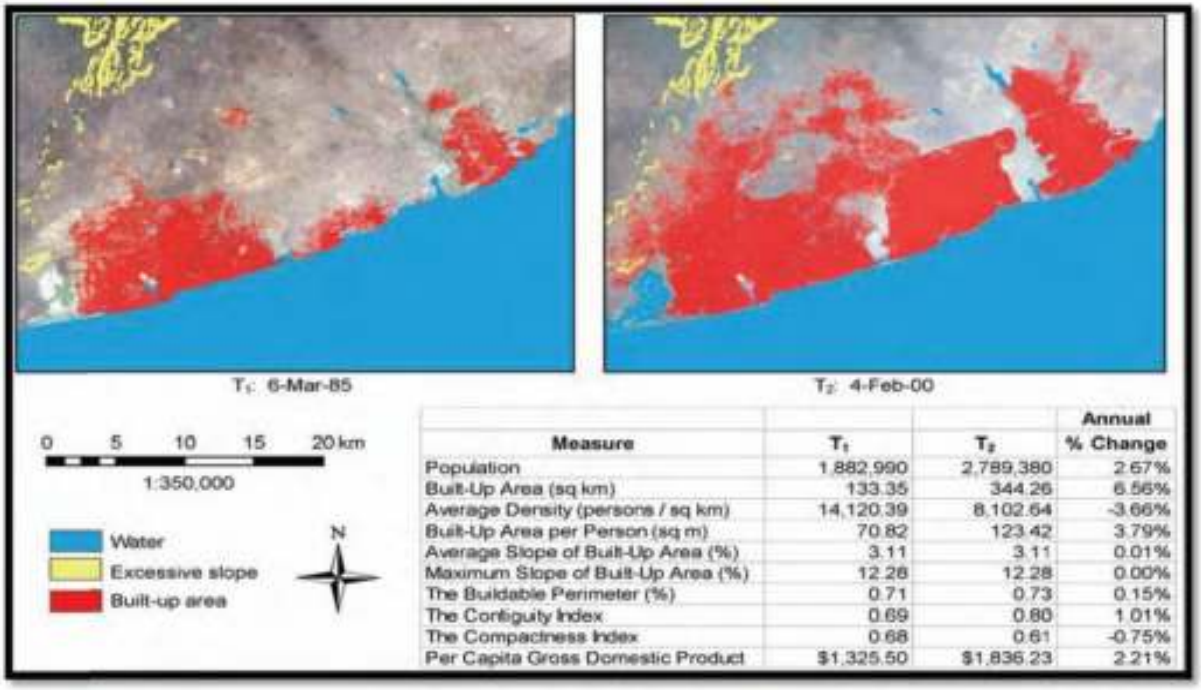


Source: Ministry of Energy 2010

1.1.2 Energy Picture of the Greater Accra Region

According to the 2010 Population and Housing Census (PHC), the population of Greater Accra Region has grown at a rate of about 38 percent from 2,905,726 in 2000 to 4,010,054 in 2010 making it the second most populated region after the Ashanti Region. Being the capital region, lots of people migrate to the region from other regions and this coupled with the high population growth rate, makes the region the most densely populated region in the country. Figure 11 below depicts the growth in population of Greater Accra Region between 1985 and 2000.

Figure 11: Urban sprawl in southern Ghana

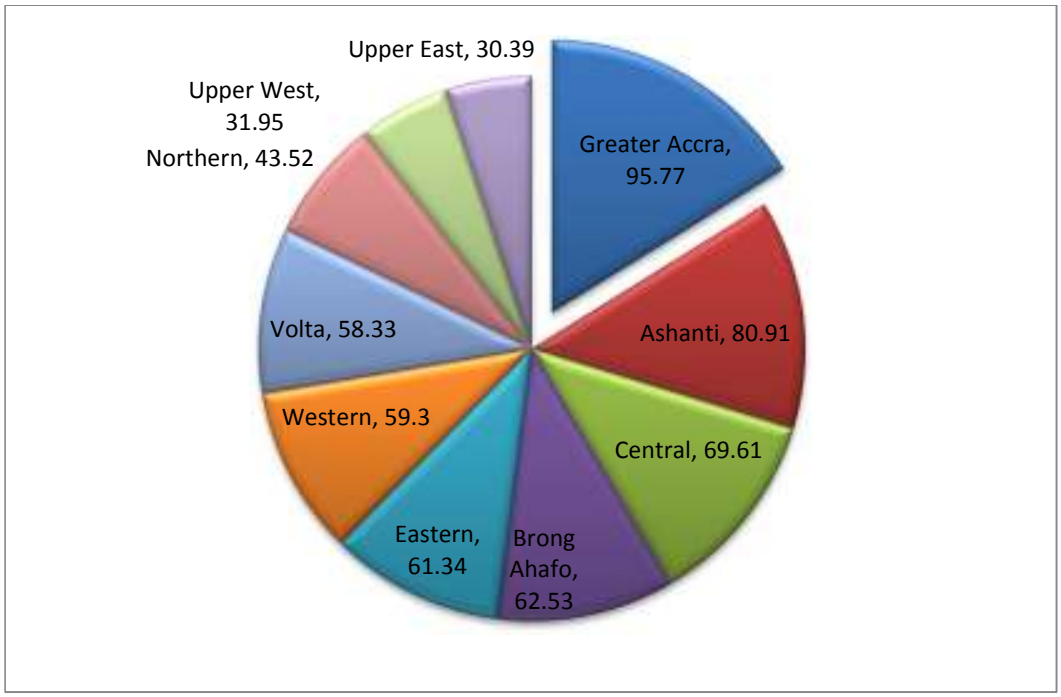


Measure	T_1	T_2	Annual % Change
Population	1,882,990	2,789,380	2.67%
Built-Up Area (sq km)	133.35	344.26	6.56%
Average Density (persons / sq km)	14,120.39	8,102.64	-3.66%
Built-Up Area per Person (sq m)	70.82	123.42	3.79%
Average Slope of Built-Up Area (%)	3.11	3.11	0.01%
Maximum Slope of Built-Up Area (%)	12.28	12.28	0.00%
The Buildable Perimeter (%)	0.71	0.73	0.15%
The Contiguity Index	0.69	0.80	1.01%
The Compactness Index	0.68	0.61	-0.75%
Per Capita Gross Domestic Product	$1,325.50	$1,836.23	2.21%

There are about 1,036,426 households in the Greater Accra Region out of which 950,391 representing 91.7 percent are located in urban areas. Various forms of energy are consumed in the region but the dominant three include Electricity, Petroleum and Biomas. About 95.8 percent of the regional population has access to electricity from the national grid (see Figure 12). Electricity from the main national grid is the major source of lighting (87.1%) for households in Greater Accra Region. However, few households use kerosene lamps (5.9%), and flashlight/torch (3.9%) and generators (0.6%). The use of generators is a recent phenomenon that has ensued as a result of the frequent power outages and load shedding that have gripped the entire country. Electricity is the dominant energy source for lighting in urban areas in the region. In rural areas however, the use of kerosene lamp is much common (23.8%) than in urban areas (4.3%).

Charcoal is the main fuel used for cooking in Greater Accra (45.4%), followed by LPG (41.4%), wood (3.5%), kerosene (1.1%) and other energy sources. For a predominantly urban region like the Greater Accra Region, it is not expected to have such high proportions of households using charcoal and wood for cooking. The sources of the charcoal and woodfuel are outside the region, mainly from the Afram Plains in the Eastern Region (Codjoe and Owusu 2011).

Figure 12: Percentage of regional population with access to electricity as at 2012



Source: ISSER 2012

SECTION TWO

METHODOLOGY

2.0 Introduction

The collection of the right data and writing of the SoE report required the deployment of diverse approaches that complement one another. Broadly, data for the SoE Report for GEM were gathered in two phases, with each embodying different collection tools. Phase one involved scoping and desk review of existing energy data on GEM. Phase two involved the gathering of primary data through a commissioned survey in a bid to gather non-existent energy data on the municipality. Data collection techniques used within this phase two included questionnaires and focus group discussion. Details of the two phases that led to the generation of data for the GEM SoE report are given below.

2.1 Phase One: Scoping and Desk Review of Existing Energy Data

The first step that was initiated to gather data for the GEM SoE report involved scoping and review of relevant existing secondary data sources. These scoping and review activities took place in the months of May and June, 2014. The main data sources that were consulted include the National energy statistics (2014), the 2014 Energy (Supply and Demand) Outlook for Ghana, Greater Accra Region Analytical Report for the 2010 Population and Housing Census and the Ga East Municipality Analytical Report for the 2010 Population and Housing Census. This first phase activities helped in unraveling the huge paucity in energy data for the municipality, thereby forming the basis for carrying out the phase two activities. A draft report on the SoE in GEM[5] was produced using the data gathered from the phase one activities. The draft is less informative, based on its scanty nature and, therefore can't support any effective sustainable energy strategy planning for the municipality. Nevertheless, these secondary sources were useful in preparing the state of energy picture for the country, as shown in section one.

2.2 Phase Two: Conduction of Primary Data Collection

After identifying from phase one that, the existing energy data on GEM were not adequate to depict a complete picture of its state of energy, a primary survey was initiated. This involved the collection of data on the energy supply and demand sectors across the municipality with high level engagement between the Ghana SAMSET team and various stakeholders. The supply sectors include the energy resources available in the municipality as well as generation of various energy carriers. The demand sectors include the residential or household sector, the commercial

[5] The SoE draft report for GEM is available at ISSER, University of Ghana.

sector, industrial sector, agricultural sector, transport sector and the local government sector. Two fundamental instruments were used in the data collection depending on the sector:

- the questionnaire (face-to-face) interview; and
- Focus Group Discussions (FGD).

2.2.1 The Questionnaire

The SAMSET team prepared a structured questionnaire which was meant to guide the enumerators through the face-to-face interview with the appropriate respondents. The questionnaire survey instrument was employed for sectors whose players were easy to identify and locate in the municipality. The questionnaire involves a set of structured questions tailored towards specific sectors in order to obtain the right responses regarding the state of energy within those sectors. The sectors for which the questionnaire survey instrument was used are discussed below;

2.2.1.1 Residential/Household Sector

According to the Ghana Statistical Service, household is a person or a group of persons, who lived together in the same house or compound and shared the same house-keeping arrangements. Understanding the dynamics of energy usage within the households in GEM required the development of a structured questionnaire which was administered through face-to-face interviews. While the questionnaires were designed by the Ghana SAMSET team, other SAMSET partners including Sustainable Energy Africa (SEA) made insightful suggestions, which informed the final output. While on the field, enumerators recorded responses to various questions in the questionnaire booklets and submitted them to the collation office at ISSER.

The household survey was carried out within GEMA's three broad classification of settlements - First Class; Second Class and Third Class. These classifications are done based on the availability of certain basic amenities and facilities in various communities[6]. The research team initially wanted to interview households based on income. However, as a result of the difficulty involved in establishing various income categories of households in the country, the reaearch team adopted the settlement classifications used by GEMA for levying and revenue collection purposes as proxies for income levels – 1st Class, 2nd Class and 3rd Class settlements. Sampling for the survey was also done along these classifications.

Resorting to the Ghana Statistical Service (GSS) personnel, the total number of households (33,949) in GEM was extracted from the 2010 PHC. Using the list of communities or settlements provided by GEMA in each class, the GSS further broke down the total number of households per each settlement classification – 1st Class, 2nd Class and 3rd (Table 6).

[6] Details of these classifications are provided in section four.

Table 6: Total number of Households Settlement Classes in GEM

HOUSEHOLD CLASS	GA EAST MUNICIPALITY
TOTAL NUMBER OF HOUSEHOLD	**33,949**
1ST CLASS HOUSEHOLDS	28,743
2ND CLASS HOUSEHOLDS	1,870
3RD CLASS HOUSEHOLDS	3,336

Source: GSS, 2013

An online sampling tool[7] was utilized in the sampling process. The sampling tool uses the sampling formula stated below in the sampling process:

$$sample\,size\,(ss) = \frac{Z^2 * (p) * (1-p)}{C^2} \qquad newss = \frac{ss}{1 + \frac{ss-1}{popn}}$$

where 'Z' is confidence level, 'C' is confidence interval and 'p' percentage picking a choice and 'popn' is population. Using a confidence level of 95% and confidence interval of 4 with zero non-response rate, a total of 590 households were sampled for the household survey in the GEM. This sample is statistically representative of the population with a 95% confidence backing. This total sample was further broken down into the various classes representatively (Table 7), using the same sampling tool.

Table 7: Sampled Households Settlement Per Classes in GEM

SECTOR	GA EAST MUNICIPALITY	
	Population	**Sample**
TOTAL NUMBER OF HOUSEHOLD	33,949	590
1ST CLASS HOUSEHOLDS	28,743	500
2ND CLASS HOUSEHOLDS	1,870	32
3RD CLASS HOUSEHOLDS	3,336	58

[7] Available at surveysystem.com

The household survey was designed to capture the state of energy among electrified and non-electrified households. The rationale is to enhance the understanding of energy demand pattern of households that are electrified as well as those that do not depend on the national power grid. In this regard, the sampled households in each settlement classification were further segmented into electrified and non-electrified households. The representative samples are shown in Table 8 below.

Table 8: Household sample breakdown among electrified and non-electrified households

	FIRST CLASS			SECOND CLASS			THIRD CLASS		
	Electrified	**Non-elect**	**Total**	**Electrified**	**Non-elect**	**Total**	**Electrified**	**Non-elect**	**Total**
GEM	390	110	**500**	25	7	**32**	45	13	**58**

The relative sample proportions of electrified and non-electrified households were premised on the yardstick that 78% of households are electrified as against 22% non-electrified in GEM. Applying these relative percentages to the sample, the proportions for electrified and non-electrified households in each class were determined for the survey. Houses/dwellings in these classes of settlements were selected through a systematic random approach using a fixed interval of **FOUR**. That is, the **FOURTH** house/dwelling from the *start point* in the community was selected, and after every selected house/dwelling.

2.2.1.2 Commercial Sector

There are lots of commercial activities prevailing in GEM. These activities vary across formal and informal sub-sectors and they are all dependent on energy for their operations. In order to understand the energy situations within the commercial sector of GEM including the quantity of energy supplied to commercial activities as well as the quantity of fuel types consumed by these activities, a structured questionnaire was designed and administered to sampled formal and informal commercial activities. The Ghana SAMSET team acquired a list of commercial activities in the municipality from Ga East Municipal Assembly (GEMA) consisting of 310 registered commercial activities. The full list of 310 commercial activities provided by the GEMA was used for the commercial survey. That is not to say there are only 310 commercial activities in the municipality, in fact, there are several commercial activities especially, informal activities whose existence and operations are unknown to the Assembly. Out of the 310 sampled commercial activities, about 20% were formal commercial activities including schools, hospitals,

clinics, banking and non-banking financial services, offices such as Information and Communication Technology (ICT) providers, consultancy firms etc., tourism and hospitality services (hotels, motels and guest houses). 80% of the 310 commercial activities sampled were informal activities including saloon and barbering shops, tailoring and seamstress services, fitting and mechanic shops, drinking bars, restaurants and catering services, petty trading, retail shops, carpentry and welding shops, electronic repair shops and others. The ratio of sampled formal commercial activities to informal commercial activities in GEM for the survey is 2:8. This commercial activities ratio was based on GSS's definition of informal sector composition in Ghana and the study of Osei-Boateng and Ampratwum (2011).

2.2.1.3 Industrial Sector

A questionnaire was designed to capture energy issues within the industrial sector as a whole and within the various sub sectors including the Mining and Quarrying, Manufacturing, Water and Sewerage and Construction sectors. Rapid inventory stocktaking technique was used for the collation of industrial activities in the municipality. That is, the enumerators, while administering the questionnaires in the other sectors, were also listing industrial activities they came across in the municipality. By this rapid inventory stocktaking approach, 70 industrial activities were identified and 50 were sampled using the online sampling tool discussed above, under the household survey. The enumerators then carried out face-to-face interviews across all the industrial sub-sectors to gather information on the state of energy within these industrial activities.

2.2.2 Focus Group Discussions (FGD)

FGDs were organized and moderated by the Ghana SAMSET team for sectors whose players are diverse, mobile and difficult to locate. Thus, the FGDs sought to elicit the views, opinions and perceptions regarding energy issues in these sectors from groups of well-informed and knowledgeable people. The SAMSET team ensured that the groups were properly represented to enhance rich discussions around building an energy picture in the respective sectors. The FGDs were structured around a set of carefully predetermined questions but the discussions were free-flowing. Questions were asked in an interactive group setting where participants were free to talk with other group members. The SAMSET team met the various stakeholders from different sectors separately at different days and times. The FGD survey instrument was applied to the following sectors.

2.2.2.1 Transport Sector

The transport sector in GEM is very vast and involves many players ranging from drivers, fuel service operators to transport union managers. Due to the highly mobile nature of its players, mobilizing key stakeholders from the sector in a FGD setting in GEM to offer them the opportunity to express their views on energy was considered the best approach to understanding energy situations in the sector. The transport sector FGD took place at the premises of GEMA on the 29th September, 2014. Participants or key stakeholders were drawn from the following transport sector player groups.

- Liquid and Gas Fuel Filling Station Association
- Ghana Private Road Transport Union (GPRTU)
- Toll Booth Workers
- Trotro Unions
- Taxi Unions
- Truck Drivers Union
- Ga East Municipal Assembly

2.2.2.2 Local Government Sector

The FGD survey instrument was used to get an understanding of energy consumption issues by GEMA. GEMA operates through different departments and one representative belonging to a particular department is unlikely to be well informed about the activities of other departments hence making the questionnaire instrument inappropriate. The approach deemed appropriate by the Ghana SAMSET team was to organize stakeholders from different departments of GEMA in a FGD setting in order to build a comprehensive picture of the state of energy in the Assembly. The Local Government Sector FGD was undertaken at the premises of GEMA on the 30th September, 2014. Participants were drawn from the following departments of GEMA.

- Transport
- Works and Housing
- Electricity
- Planning

2.2.2.3 Energy Resources in GEM

The FGD survey instrument was employed to ascertain the quantities of power (electricity), biomass (wood fuel and Charcoal) and petroleum products (kerosene, LPG, diesel and petrol) that are available to be imported into the municipality as well as the total quantities that are imported into GEM. To obtain reliable quantities of different energy resources available in GEM required unanimous opinions and perceptions from a group of people working in these sectors as

well as being knowledgeable. Bringing key stakeholders together from different groups of the energy resource sector resulted in a rich discussion and gave a very clear picture on energy resource availability issues in GEM. The FGD was undertaken at the premises of GEMA on the 29th September, 2014. Participants in this Energy Resources FGD in GEM were drawn from the following groups.

- Charcoal Sellers Association
- Charcoal Transporters Association
- Firewood Sellers Association
- Electricity Company of Ghana
- Liquid and Gas Fuel Filling Station Association and
- Ga East Municipal Assembly

2.2.2.4 Fuel Generation in GEM

With respect to the different fuel types that are generated in GEM, the Ghana SAMSET team sought opinions through the FGD survey instrument. The FGD participants were organized from relevant stakeholder groups to assist in the understanding of the quantity of fuel types that are generated within and outside the municipality. The discussion took place on the 30th September, 2014, at the GEMA premises. Key stakeholders from the following groups were engaged in the Fuel Generation Sector FGD.

- Charcoal Sellers Association
- Charcoal Transporters Association
- Firewood Sellers Association
- Electricity Company of Ghana
- Liquid and Gas Fuel Filling Station Association and
- Ga East Municipal Assembly

Other national documents such as the 2014 Nation Energy Statistics was used for fuel types that are only generated at national levels and the national stock values were confirmed by the various stakeholders.

2.2.2.5 Procedure used in selecting FGD stakeholders

All the stakeholders for the FGDs were carefully identified by GEMA. After identifying a spectrum of potential participants, only knowledgeable persons who have practical knowledge in their respective fields of energy supply and usage in the various sectors were invited for the FGD. Eight (8) participants were present during the transport sector FGD while seven (7) were

present during the local government sector FGD. Seven (7) and Six (6) respectively were present during the energy resource and fuel generation sectors FGD. Some stakeholders participated in more than one FGD due to their perceived experiences and wealth of knowledge they possess.

2.2.3 Survey Planning and Quality Control Measures

2.2.3.1 Survey Planning

The household survey was carefully planned by the Ghana SAMSET team with assistance from other SAMSET project partners including Sustainable Energy Africa (SEA). The process involved the development of overall strategy to adopt, the structure for the survey and the preparation of a comprehensive budget for the survey. This initial process started in July, 2014. The Ghana SAMSET team later visited Ga East Municipal Assembly (GEMA) to discuss the essence of the survey, the strategies and methods to adopt and the roles each party was going to play during the entire survey.

2.2.3.2 Training of Enumerators

The Ghana SAMSET team carefully selected 12 enumerators from a pool of potential data collectors that have been used on several surveys over the years by ISSER. These enumerators were taken through a 3-day training so as to get acquainted with the purpose of the study, terminologies, as well as the interviewer's guide. All the enumerators took part in role-plays to practise how the questions constructed in English could be interpreted in the local dialects for easy understanding by the respondents. There were checks and supervisions to ensure the questions were correctly interpreted by the enumerators during the training. At the end of the training, the enumerators were supplied with their logistics such as bags for the questionnaire booklets, pencils, erasers, note pads, introductory letters from the Ga East Municipal Assembly and ISSER and the questionnaires.

2.2.3.3 Piloting of survey instrument

After the training, the enumerators embarked on a 1-day pilot test of the survey instrument (questionnaire). This exercise was undertaken to gauge the accuracy of the instrument, the enumerators as well as the respondents' understanding of the questionnaire. Feedbacks were taken from the enumerators on areas of the questionnaire that needed revisions as well as other items that needed to be added. The pilot exercise brought clarity to all segments of the survey instrument.

2.2.3.4 Actual Enumeration

After the pilot study and the subsequent revision of the survey instrument, the actual household survey commenced on the 23rd September, 2014 and ended on the 7th October, 2014 in the Ga East Municipality. The responses were recorded in the questionnaire booklet and the filled questionnaires were brought back to the collation office after the enumerators had done a thorough editing. The sampled households were proportionally distributed among the enumerators and exercise was carried out along the settlement classifications as discussed above.

2.2.3.5 Monitoring

The Ghana SAMSET team regularly monitored the progress of activities during the fieldwork. All queries during the household survey were addressed on the field by the visiting supervisory team, through mobile communications or at the collation office at ISSER. Selected households that refused to be interviewed were replaced based on the advice of the monitoring team.

2.2.4 Definition of Units of Measurement

The fuel types investigated in the survey include electricity, firewood, charcoal, kerosene, LPG, petrol, diesel, biogas, dry cell batteries, candle, solar and natural gas. The units of measurement of these fuel types are shown in Table 9. Electricity and Solar fuels are measured in Kilowatt hour (KWh). Firewood is measured in kilogram while charcoal fuel is measured in mini or maxi bags. A mini bag of charcoal weighs about 26 kg while a maxi bag of charcoal weighs 52.5 kg. Kerosene, petrol and diesel fuels are measured in litres while LPG is measured in kilogram. LPG is usually stored in metal cylinders that come in different sizes starting from 3kg. Candles and dry cell batteries are measured in their numbers, biogas is measured in British Thermal Unit (BTU) and natural gas is measures in million BTU per Gigajoules.

Table 9: Unit of measurement for the various fuel types

FUEL TYPE	UNIT OF MEASUREMENT
ELECTRICITY	KWH
WOOD	KILOGRAM (KG)
CHARCOAL	MINI OR MAXI BAG (converted to kg)
KEROSENE	LITRE
LPG	KG (BY CYLINDER) 3kg, 6kg, 9kg, 15kg…
PETROL	LITRE
DIESEL	LITRE
BIOGAS	BTU
DRY CELL BATTERIES	NUMBER
CANDLE	NUMBER
SOLAR	KWH
NATURAL GAS	MMBTU/GJ

2.2.5 Data Entry and Processing

After all the questionnaires for the various sectors were submitted to the collation office at ISSER, they were counted and carefully sorted to ensure that none had gone missing. The completed questionnaires were then sent to a private data entry and processing firm. There was regular communication between the firm and the Ghana SAMSET team to ensure that the questionnaires were understood by this firm and the responses were rightly captured in the data. To avoid any misunderstanding during this crucial phase, the Ghana SAMSET team involved the firm in the exercise right from the enumerators' training stage. The presence of personnel from this firm during the enumerators' training offered them the opportunity to capture the piloted data to be sure the templates were designed rightly and the responses were captured correctly.

2.2.6 Data Analysis and Reporting

The quantitative data was captured using two statistical softwares, SPSS and STATA and analyses were carried out through them as well. The production of descriptive tables, graphs and frequencies from the different datasets for the various sectors, provided the basis for the description of the state of energy in the GEM.

SECTION THREE

GA EAST MUNICIPALITY ENERGY PICTURE

3.1 Municipal Profile

3.1.1 Population and structure

The Ga East Municipal is one of the sixteen districts in the Greater Accra Region and has a population of about 147,742 of which 49 percent (72,987) are males and 51 percent (74,755) are females (Ghana Statistical Service, 2014). The municipality has large proportion of youths than adults. About 22.9 percent of the population are within the age category of 20 to 29 and 40.3 percent under age 20. Thus less than 40 percent of the population are above age 30. Working age (16-64) population is estimated to be about 65.93 percent and engage in economic activities such as agricultural, industry, service and commerce within or outside the municipality. The municipality has high dependency ratio. As high as 52 percent of its population mostly depend on others for survival.

There are 52 settlements (towns and villages) within GEM. About 82 percent of the population dwell in urban areas and the remaining 18 percent live in rural areas (Ghana Statistical Service, 2014). The municipality has large towns such as Dome, Haatso, Taifa and Kwabanya where most of its economic activities such as service and commerce take place. The municipality also has other small towns which are linked to the trunk road via feeder roads. Dome is the Largest and the highest ranked community with most basic facilities and services. It functions as a commercial center because of its threshold population that supports almost all economic activities. Due to the proximity of the municipality to the capital city of Ghana, Accra, there is a high influx of immigrants from near and far into the municipal. This has contributed to the development of illegal structures and the conversion of commercial facilities into residential use as majority of such immigrants are unable to afford a decent accommodation either due to high prices of accommodation or inadequacy in residential facilities within the municipal. Slums have developed in areas like Dome, Taifa, Kwabenya and Haatso in the municipality (Ghana Statistical Service, 2014).

3.1.2 Land Tenure System

Land in the Municipality is owned by chiefs, clans or family heads who hold them in trust for their subjects. Land can be acquired through direct purchase, rented, leasehold and share cropping (nnoboboa). The fact that these parcels of land can be inherited through parents or grandparents has led to multiple sales resulting in land litigations and chieftaincy disputes. This situation has also contributed to the rapid loss of farm lands to residential structures with its associated problems of youth unemployment and migration to adjoining districts such as the

Tema Metropolitan Assembly (TMA) and Accra Metropolitan Assembly (AMA) (Ghana Statistical Service, 2014).

3.1.3 Water and Sanitation

Acute water shortage and indiscriminate disposal of waste are challenges confronting the municipality. Pipe-borne water is mostly lacking in the municipality and much severe in places such as Dome, Taifa, Agbogba, and Ashongman Musuko. This has contributed to uncontrolled price increments from water services providers such as private tanker services and bore-hole operators. To improve this situation, GEMA is currently managing two small towns' piped schemes through Water and Sanitation Development Boards (WSDB). These are Abokobi-Oyarifa-Teiman-Sesemi scheme, and Pantang Area Pipe scheme. The two schemes cover fifteen communities placing an obligation on GEMA to ensure that the facilities are managed in a sustainable manner.

Sanitation is a challenge in GEM. Large quantities of solid and liquid wastes are generated in the municipality due to the extensive informal commercial activities in the municipality. The inability to properly manage waste has led to poor sanitation practices in the municipality. It is estimated that only 67 percent of the 385 tons of solid waste generated monthly are properly collected and disposed off at the Abokobi waste landfill site (Zoomlion Ghana Limited, 2013). The backlog of uncollected waste are improperly managed creating all kinds of inconveniences including health hazards and flooding.

3.1.4 Health Service delivery and Education

The municipal is known for its contribution to health care and education. The Ga East Municipal Health Management Team (MHMT) is responsible for all health service delivery in the entire municipality. The municipality houses several private and public health institutions. The four sub municipal areas namely Abokobi, Dome, Taifa and Haatso have at least one community clinic which has a doctor-patient ratio of 40,246:1 and nurse patient ratio of 2,012:1 (Ghana Statistical Service, 2014). There are other care providers such as chemical shop dealers, maternity homes, traditional healers etc. in the municipality.

The municipality houses several educational institutions of all levels with private institutions dominating. About 31 public basic schools are located within the municipal vis-à-vis 109 private basic schools, 6 private Senior High School as against no public provided Senior High School (Ghana Statistical Service, 2014). Also located in GEM is the University of Allied Science that has trained many high and low level manpower management needs of the municipality and also

the Ghana Atomic Energy School and Research which has done a lot of research in the area of energy.

3.1.5 Economic Activities

Agricultural, industrial, service and commercial are the economic activities identified within the municipality. About 55 percent of the municipality's economic active population engages in agricultural practices (Ghana Statistical Service, 2014). 70 percent of the rural population depends on agriculture as their main source of livelihood with about 95 percent of them being small holders. Crop production, livestock production, cash crop production, retailing of agricultural products and agro-processing are some agricultural activities engaged within the municipal but not on mechanized basis.

The dominant industrial sub-sectors in the municipality include manufacturing, water and sewerage and construction sub-sectors. An example of a manufacturing industry in the municipality is the Royal Aluminum Company located in the Dome area. The construction sub-sector (estate development) is a fast growing sub-sector in the municipality. With the availability of natural building materials of high quality coupled with large tracts of undeveloped lands especially in the peri-urban sectors of the municipality, the municipality has become a favourite area for estate development and the supply of sand, stone and latrite which are mined indiscriminately all year round especially around Kwabenya. Currently a very wide range of housing units are being developed in Ashongman and Abokobi areas. These sub-sectors employ both indigenous and non-indigenous workers of the municipality.

The proportion of formal to informal commercial activities and services is 20:80 just as the national picture. According to the district analytical report of GEM, formal commercial activities include education and health services (schools, hospitals, clinics), banking and non-banking financial services, offices such as Information and Communication Technology (ICT) providers, consultancy firms etc., tourism and hospitality services (hotels, motels and guest houses). Informal commercial activities include the operations of saloon and barbering shops, tailoring and seamstress services, fitting and mechanic works, drinking bars, restaurants and catering services, petty trading, retail shops, carpentry and welding shops, electronic repair shops and others. A large proportion of these informal commercial activities do not register formally with the GEMA hence the Assembly is unable to keep record of the total commercial activities in the municipality. Just like the industries, the commercial sector employs both indigenous and non-indigenous workers in the municipality.

3.1.6 Road Network and Transportation

The municipal has high influx of commercial and private vehicles from both far and near albeit underdevelopment of its road network. Total length of road network is estimated to be about 561 kilometers with paved road (Asphalt and surface treatment) estimated to be about 108 kilometers representing 19.25 percent with the remaining unpaved (Ghana Statistical Service, 2014). Owning to the linkage of this municipal to the capital city it is imperative that urgent attention needs to done to improve the deployable status of roads within the municipal at places such as Dome, Haatso, Taifa, New Ashongman, Westlands, Kwabenya, Musuko and Adenkrabi within the municipality.

3.1.7 Settlement classifications by GEMA

GEMA has demarcated the municipality into three classes based on the kinds of amenities and infrastructure available in the communities or settlements. These demarcations are done for the purpose of property charges and revenue collection such that, properties in the different classes attract different property rates.

First class settlements are communities or settlements where good infrastructures and amenities abound. These are communities or settlements within which there is high power (electricity) connectivity to the national grid, well laid potable water pipelines connected to a significantly large proportion of households and good access roads. Other features of first class settlements include the availability of good schools and health facilities. With the availability of these infrastructures, first class settlements are often dominated by high income households who live in very expensive residential structures and mansions. By virtue of their locations, these structures attract high property rates, per GEMA's criteria. It is not uncommon to find both middle and low income classes' households residing within first class settlements. However, these two income classes are easily distinguishable because they live in less expensive houses compared to their high income class counterparts. First class settlements in GEM include Dome, Haatso, Kwabenya, Agbogba, Ashongman and Atomic.

Second class settlements have moderate access to infrastructures and various amenities including, electricity connectivity, potable water from pipelines, etc. Relatively, there are a few good roads, but predominantly more deplorable ones within these settlements. A few schools and health facilities also exist. Second class settlements in GEMA are dominated by middle income households that live in medium size residential structures. Properties in the second class settlements attract medium rates compared to the first class, but higher than the third class settlements. There may be a few high income group settlers in the second class settlements as well as low income settlers. Some communities classified as second class communities include Abokobi, West Abladjei and Taifa North.

Third class settlements lack most basic amenities and infrastructures. These settlements mostly lack potable water and good access roads. The roads are often third class untarred roads connecting the settlements. There is low electricity coverage in these settlements, with high level of illegal power connectivity. Schools are very few, but with correspondingly high pupils population. Health facilities are also few or non-existence in such communities. Third class settlements are characterized with more "slummy" areas and dominated by low income households. Only a few middle class income households are located in the third class settlements and, they live in relatively more expensive residential apartments. Examples of communities classified under third class settlements in GEM include Agbogba Village, Boi, Old Ashongman and Adoteiman. All the communities in GEM per GEMA's settlement classification means are attached in Appendix 1.

3.2 Overview of Ga East Municipality Energy Supply and Demand

3.2.1 Energy Generation and Supply in the Ga East Municipality

There is not any major known fuel that is being generated in GEM. It therefore implies that the municipality depends largely on fuels being generated from other parts of the country. Electricity that is consumed in the municipality is primarily generated by VRA through the national hydro power source and thermal plants, which is distributed and sold to the demand sectors of the municipality by Electricity Company of Ghana (ECG). By way of facilitating electricity extension to various parts of the municipality, GEMA sometimes procures and installs electricity poles in non-electrified areas before ECG installs the cables on them. Information gathered from the Focus Group Discussion reveal that, the stock of electricity power available for importation to the GEM was about 51.2 MW by 2013. Out of this stock, about 36.7MW was imported into the municipality and distributed among the various demand sectors including residential areas, industries and commercial activities.

All petroleum products are imported from the national stock at Bulk Oil storage and Transport Limited (BOST), which stores and transports refined petroleum products to consumers after they are either refined at Tema Oil Refinery or imported. The quantity of petroleum products available for importation to GEM and the actual quantity imported in 2013 are shown in Table 10 below.

Table 10: Quantity of fuels available for importation and quantity imported to GEM

Products	Quantity available for importation	Quantity imported to GEM
Kerosene	27.8 kilotonnes (kt)	300000 lit (0.24 kt)
LPG	251.8 kilotonnes (kt)	97970960 kg (97.97 kt)
Diesel	1722.6 kilotonnes (kt)	2800000 lit (2.373 kt)
Petrol	1080.6 kilotonnes (kt)	2400000 lit (1.791 kt)

Source: GSS, 2014 and Energy Survey, 2014

Neither charcoal nor wood fuel is generated directly in the municipality but is imported from neighboring districts and sometimes from other regions. Information gathered from the FGD revealed that, the quantity of wood fuel and charcoal available for importation to the GEM was 1535 ktoe and 1989 ktoe respectively as at 2013. In the same year, about 105000 KG (0.0378 ktoe) of wood fuel and 182000 KG (0.16016 ktoe) of charcoal were actually imported to the municipality and used by the household sector extensively, and to some level, the commercial sector (2014 Energy Survey). The prices of charcoal per bag[8] vary depending on where the charcoal was transported from. In 2010, the main charcoal production areas in Ghana included Kintampo, Wenchi, Atebubu, Mampong and Techiman (2014 Energy Survey). By 2013, the production of charcoal moved further up north in areas like Bole where charcoal consumed in GEM was transported from. This is as a result of receding of the forest cover due to excessive cutting of trees. Charcoal production is now taking place in the savanna zone and transported all the way to southern municipalities such as GEM. This has increased transportation cost of charcoal over the years.

3.2.2 Energy Consumption in GEM

Based on the survey results, the total energy consumed in the municipality is about 8822788.3 Gigajoules in 2013. This total was based on the sampled figures of households, commercial and industrial activities in the municipality. With reference to the total number of households, commercial and industrial activities in GEM, the total energy consumed is estimated around 10111293.49 GJ (Table 11).

[8] Maxi Charcoal bag (50-63 kg) was priced around GHS 21.33, GHS 22.08 and GHS 26.49 in 2011, 2012 and 2013 respectively while the mini-bag (25-32 kg) was priced around GHS 11.41, GHS 13.95 and GHS 19.83 in 2011, 2012 and 2013 respectively in the Central Region. The per kg prices for the charcoal maxi-bag were GHS 0.35, GHS 0.37 and GHS 0.44 in 2011, 2012 and 2013 while the per kg prices for the mini-bag were GHS 0.35, GHS 0.44 and GHS 0.63 in 2011, 2012 and 2013 in the Central Region. [Sourced from the Energy Commission, 2014].

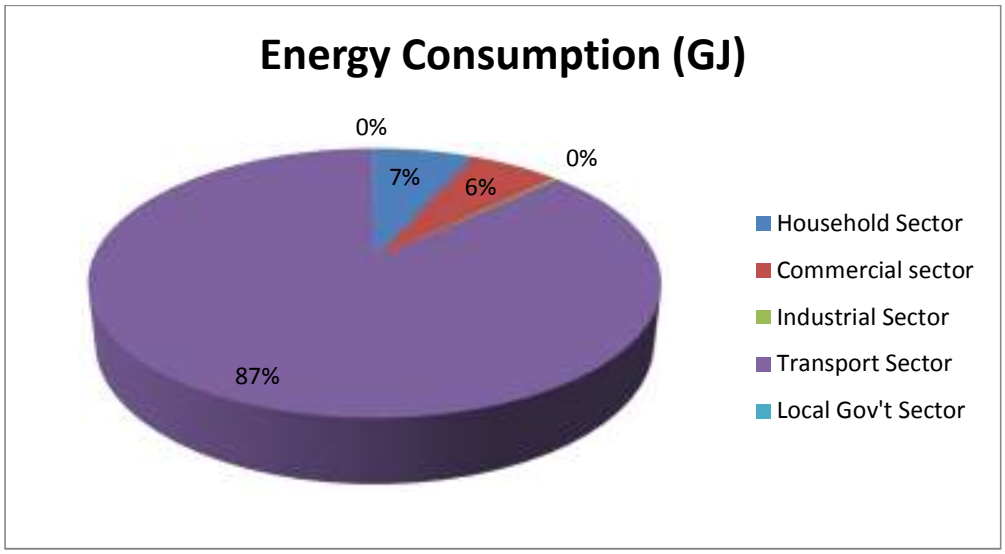
Table 11: Total aggregate energy demand by sector in 2013

Sector	Energy demand (GJ)*	Energy demand (GJ)**
Household Sector	11865.8	682766.18
Commercial Sector	10204.6	608655.01
Industrial Sector	6384.8	25539.2
Transport Sector	8782423.8	8782423.8
Local Government Sector	11909.3	11909.3
TOTAL	**8822788.3**	**10111293.49**

*Energy demand based on sampled household, commercial and industrial sectors
**Energy demand based on total estimated household, commercial and industrial sectors.

The transport sector constitutes the largest share in the total energy consumed in the municipality, that is, 8782423.8 GJ (representing 87% of the total energy consumed in GEM). The energy carriers mainly consumed in this sector are diesel, petrol and LPG fuels. Diesel constitutes about 75% of the fuels consumed within the transport sector, followed by petrol (23.5%) and LPG (1.5%). The household sector is the second largest energy consuming sector in GEM, constituting about 7% of the total energy consumed, followed by the commercial sector, 6%. The industrial sector and the local government sectors consume about 25539.2 GJ and 11909.3 GJ representing less than one percent of the total energy consumed in the municipality (Figure 13).

Figure 13: Energy consumption by sectors of GEM



Source: 2014 Energy Survey

SECTION FOUR

SECTORAL PERSPECTIVES OF ENERGY IN GEM

4.0 Introduction

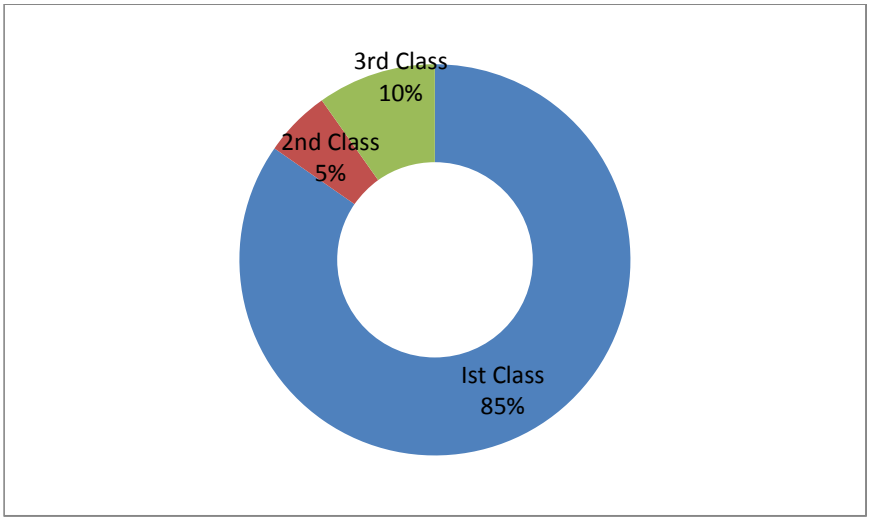
The sectoral energy supply and demand dimensions of GEM are discussed this section of the SoE report. The sectors include the household or residential sector, commercial sector, industrial sector, transport sector and local government sector (GEMA).

4.1 Household/Residential Sector

There are about 33949 households in GEM according to the Ghana Statistical Service projections for 2013. Of this total, 590 households were randomly sampled for the energy survey through the application of the online sampling approach that is in the methodological section above. The state of energy within these sampled households which shall also represent the energy picture of the entire municipality is discussed around two units: first, the settlement classification and second, electrified verses non-electrified households in the municipality. The essence of doing the discussion around these two units of analysis is geared towards understanding the energy consumption patterns among these different classes of settlements as well as, among electrified and non-electrified households in the municipality.

GEMA demarcated the entire municipality into three classifications – First, Second and Third Classes – (see section three for attributes of these classes). Regarding their sizes, First Class is the largest, constituting 85% of all settlements, followed by Third Class (10%) and Second Class (5%) in the municipality (Figure 14). About 78% of the total households in the GEM are electrified (Table 12).

Figure 14: Settlement classifications and sizes composition in GEM



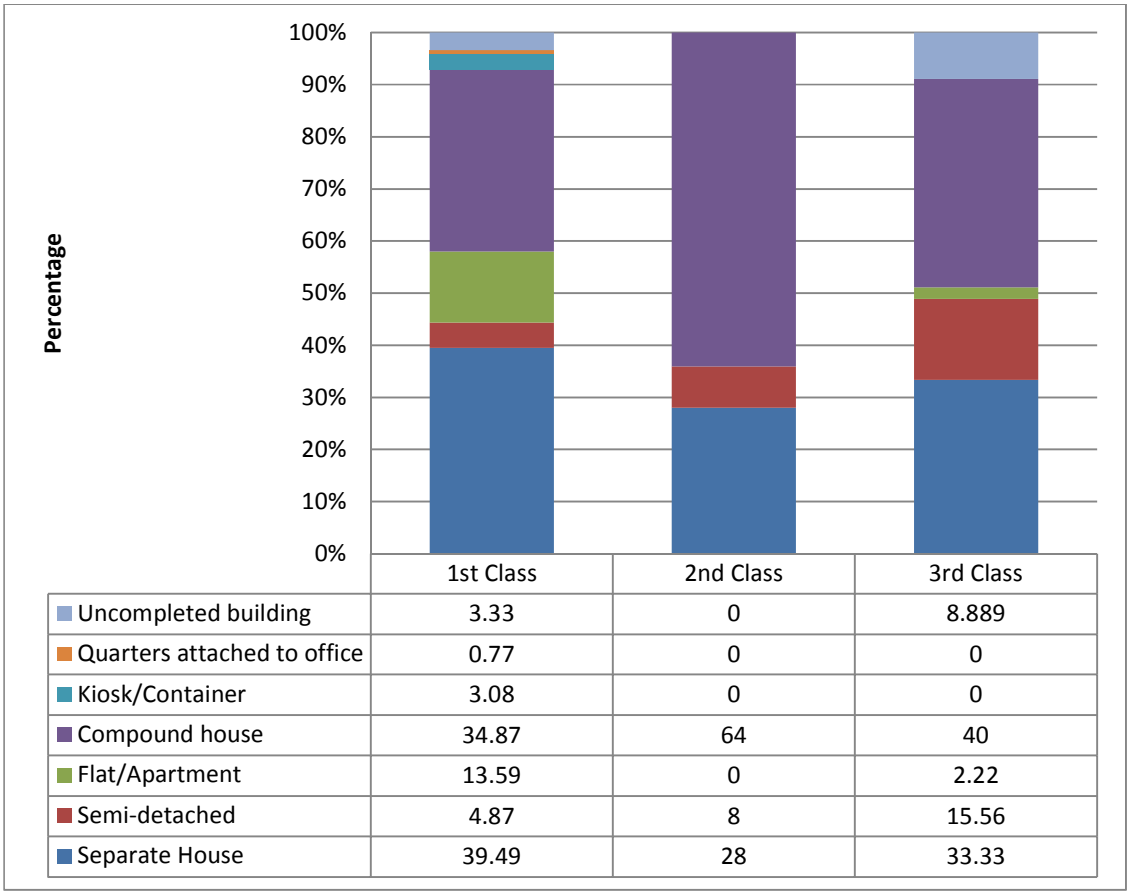
Source: 2014 Energy Survey

Table 12: Percentage of households electrified across all classes of settlements in GEM.

	1st Class	2nd Class	3rd Class
Electrified	78.00	78.13	77.59
Non-electrified	22.00	21.88	22.41

The dwelling characteristics of electrified households are shown in Figure 15. Most electrified households in First class settlements dwell in separate houses (39.49%), compound houses (34.87%) and flat apartments (19.59%). In the Second class settlements, most electrified households reside in compound houses (64%) and separate houses (28%). In the Third class settlements, about 40% of electrified households live in compound houses, 33% live in separate houses and 16% live in semi-detached houses. The number of electrified households who live in uncompleted buildings and kiosks/containers in all three classified settlements are relatively few compared to non-electrified households.

Figure 15: Dwelling units of electrified households in GEM

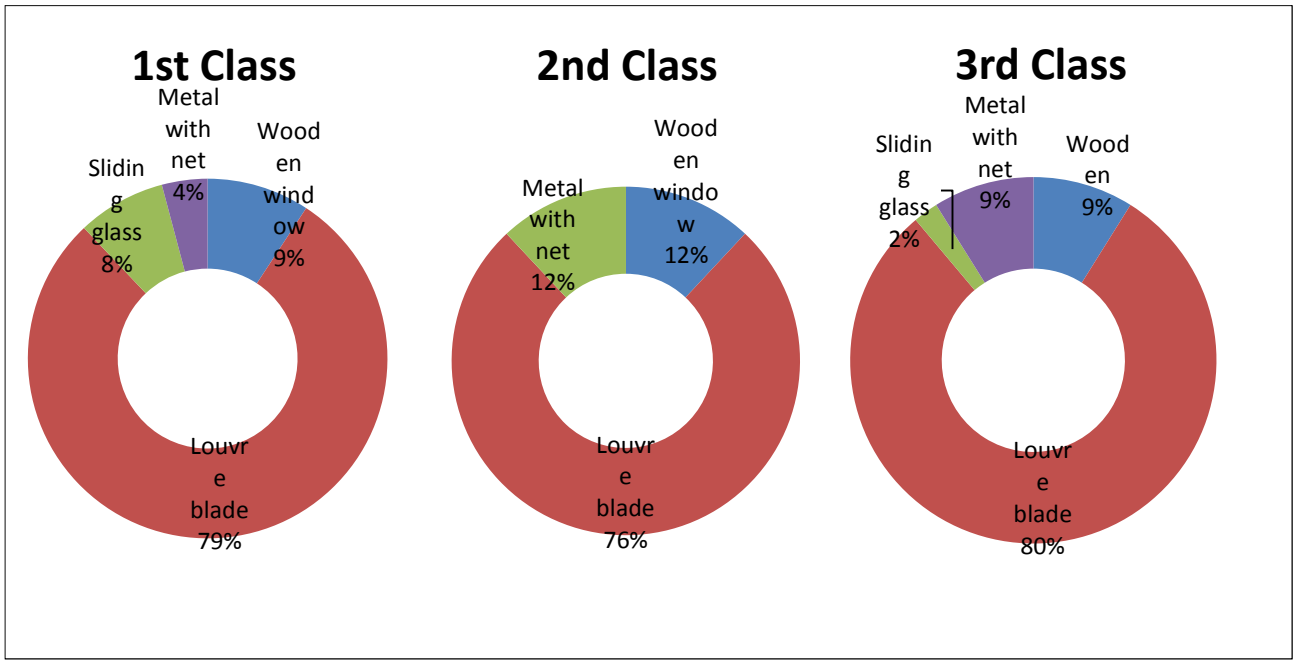


	1st Class	2nd Class	3rd Class
Uncompleted building	3.33	0	8.889
Quarters attached to office	0.77	0	0
Kiosk/Container	3.08	0	0
Compound house	34.87	64	40
Flat/Apartment	13.59	0	2.22
Semi-detached	4.87	8	15.56
Separate House	39.49	28	33.33

Source: 2014 Energy Survey

The predominant window types in most electrified households in GEM are the louvre blades (glass and wood) (see picture in Figure 17). About 79% of First Class electrified households use louvre blades, 9% wooden windows, 8% sliding glass windows and 4% metals with net windows in their dwelling units. Within Second Class electrified households, about 76% use louvre blades, 12% wooden windows and 12% metals with net windows in their dwelling units. Meanwhile in the Third Class, about 80% of electrified households use louver blades, 9% metal with net and wooden windows and 2% sliding glass windows in their dwelling units (see Figures 16 and 17).

Figure 16: Window types within dwelling units in electrified households in GEM



Source: 2014 Energy Survey

Figure 17: Different Window types used in GEM

Metal with net windows

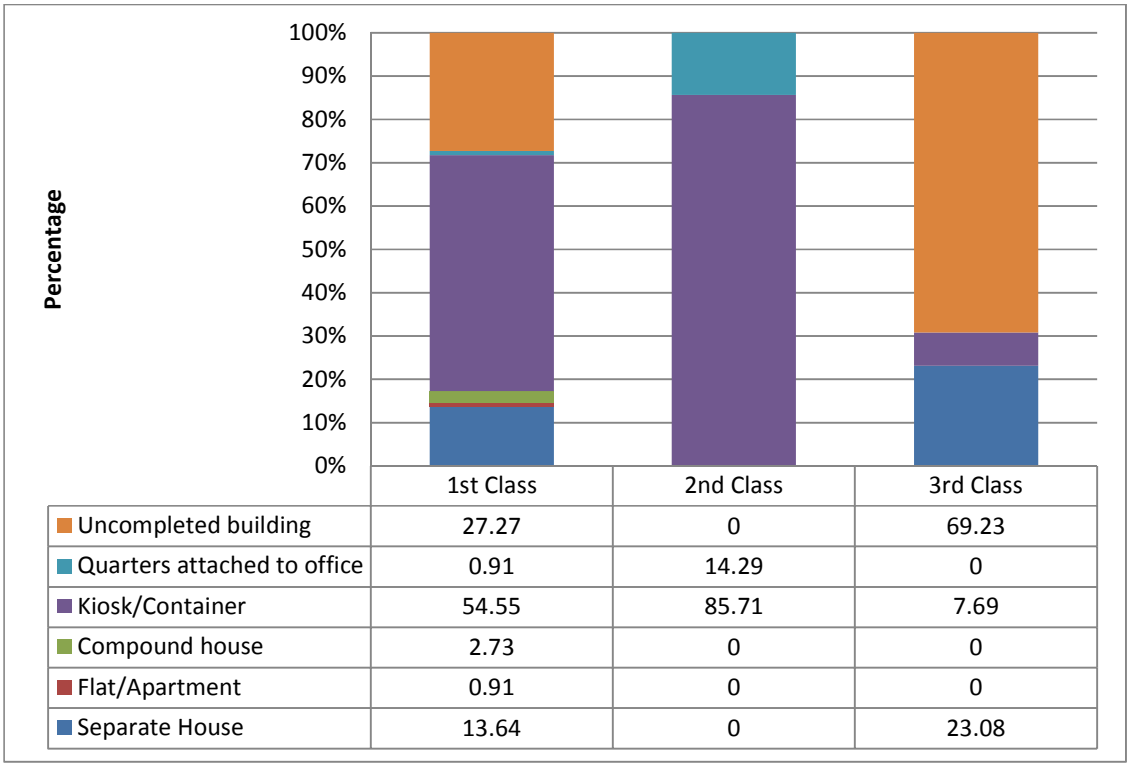
Traditional wooden windows

Louvre blade Windows

Glazed windows

Majority of non-electrified households in First Class settlements live in kiosk/containers (54.55%), uncompleted buildings (27.27%) and separate houses (13.64%) while most non-electrified households in Second Class settlements reside in kiosks/containers (85.71%) and quarters attached to offices (14.29%). In the Third class settlements, majority of non-electrified households live in uncompleted buildings (69.23%), separate houses (23%) and kiosks/containers (7.69%) (Figure 18).

Figure 18: Dwelling units of non-electrified households in GEM

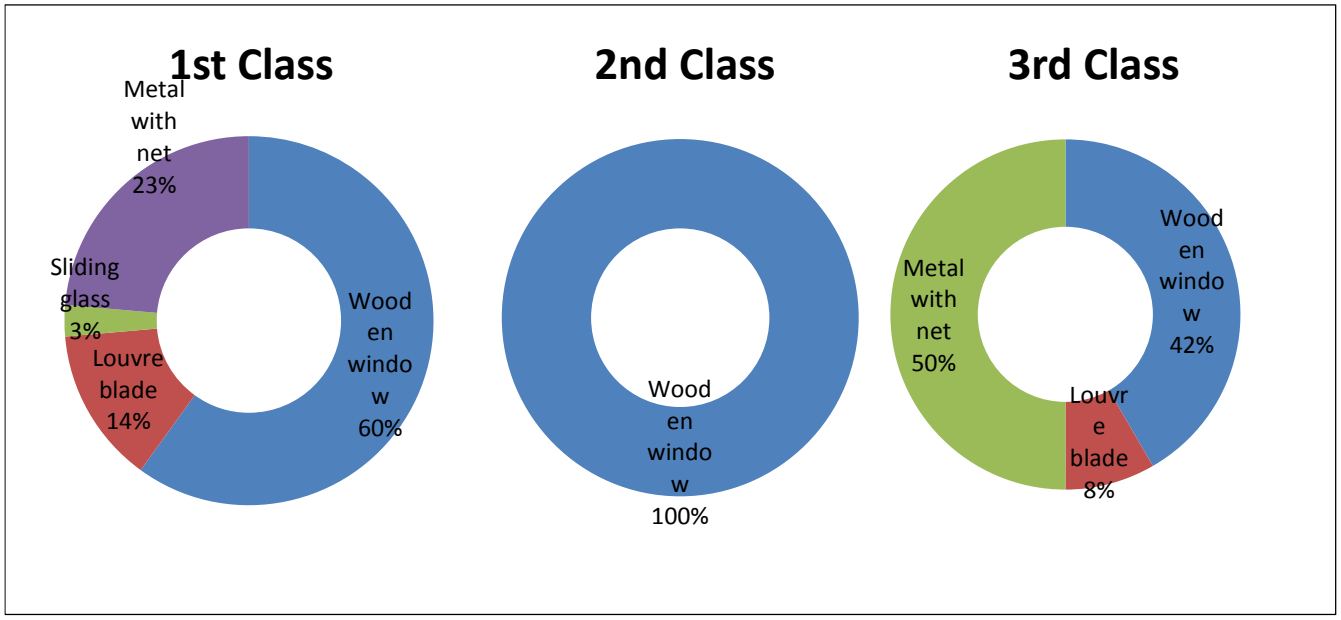


	1st Class	2nd Class	3rd Class
Uncompleted building	27.27	0	69.23
Quarters attached to office	0.91	14.29	0
Kiosk/Container	54.55	85.71	7.69
Compound house	2.73	0	0
Flat/Apartment	0.91	0	0
Separate House	13.64	0	23.08

Source: 2014 Energy Survey

The predominant window types among non-electrified households in GEM are the wooden windows. About 60% of First Class non-electrified households use wooden windows, 23% metals with net, 14% louvre blades and 3% sliding glass windows within their dwelling units. Almost all non-electrified households in Second Class settlements use wooden windows. In third class settlements, about 50% of non-electrified households use metals with net, 42% wooden windows and 8% louvre blades in their dwelling units (Figure 19).

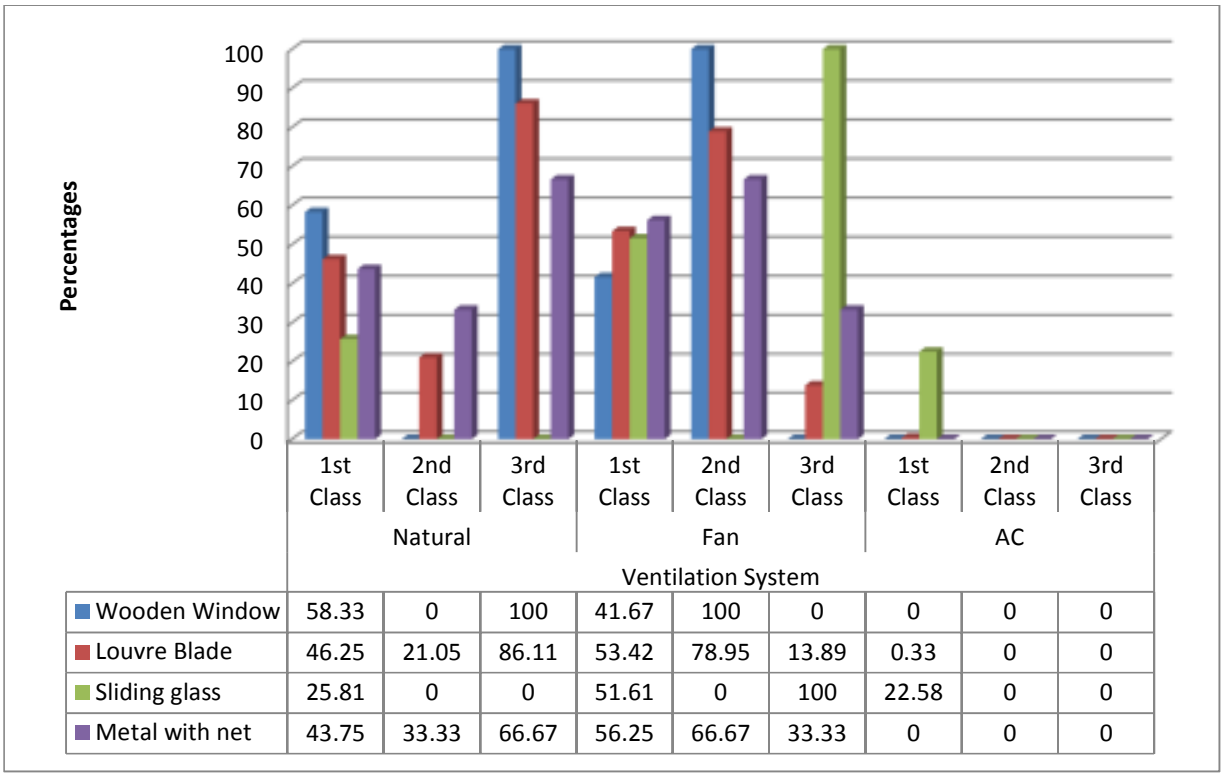
Figure 19: Window type within dwelling units in non-electrified households in GEM



Source: 2014 Energy Survey

Majority of electrified households who use wooden windows in the municipality depend on natural air ventilation system. 58% of First Class households who use wooden windows depend on natural ventilation system while 42% use fan. For households who use louvre blades, 46%, 21% and 86% of First, Second and Third class electrified households respectively use natural ventilation system while 53%, 79% and 14% of First, Second and Third class households respectively use fan as their main ventilation systems. About 0.33% of First class electrified households who have louvre blades as their window types use air conditioners (AC) as their main ventilation systems. About 26%, 52% and 23% of First class households who have sliding glazed windows use natural air, fan and AC respectively as their main ventilation systems. Second and Third class households with louvre blades mostly use fans. Households with metal and net windows mostly depend on the natural ventilation systems or fans (Figure 20).

Figure 20: Window type in the dwelling unit vis-à-vis ventilation system (%) being used in GEM



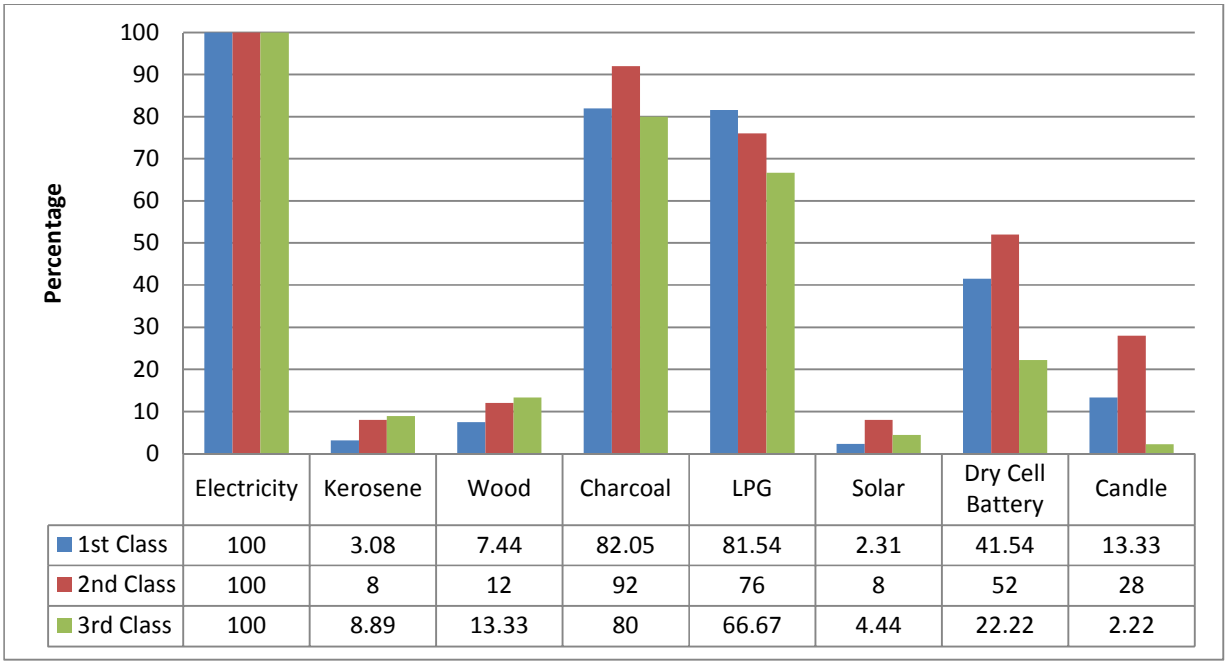
Wooden Window	58.33	0	100	41.67	100	0	0	0	0
Louvre Blade	46.25	21.05	86.11	53.42	78.95	13.89	0.33	0	0
Sliding glass	25.81	0	0	51.61	0	100	22.58	0	0
Metal with net	43.75	33.33	66.67	56.25	66.67	33.33	0	0	0

Source: 2014 Energy Survey

4.1.1 Residential Energy Consumption

All electrified households in the municipality use electricity, 82%, 76% and 66% of First, Second and Third class households respectively use LPG fuel, 82%, 92% and 80% of First, Second and Third class households respectively use charcoal fuel while 7%, 12% and 13% of First, Second and Third class households respectively use wood fuel. Other fuel types such dry cell batteries and candles also have significant usage rate in the municipality. 42%, 52% and 22% of first, second and third class households respectively use dry cell batteries while 13%, 28% and 2% of first, second and third class households respectively use candles in the municipality (Figure 21).

Figure 21: Percentage of electrified household who use various fuel types

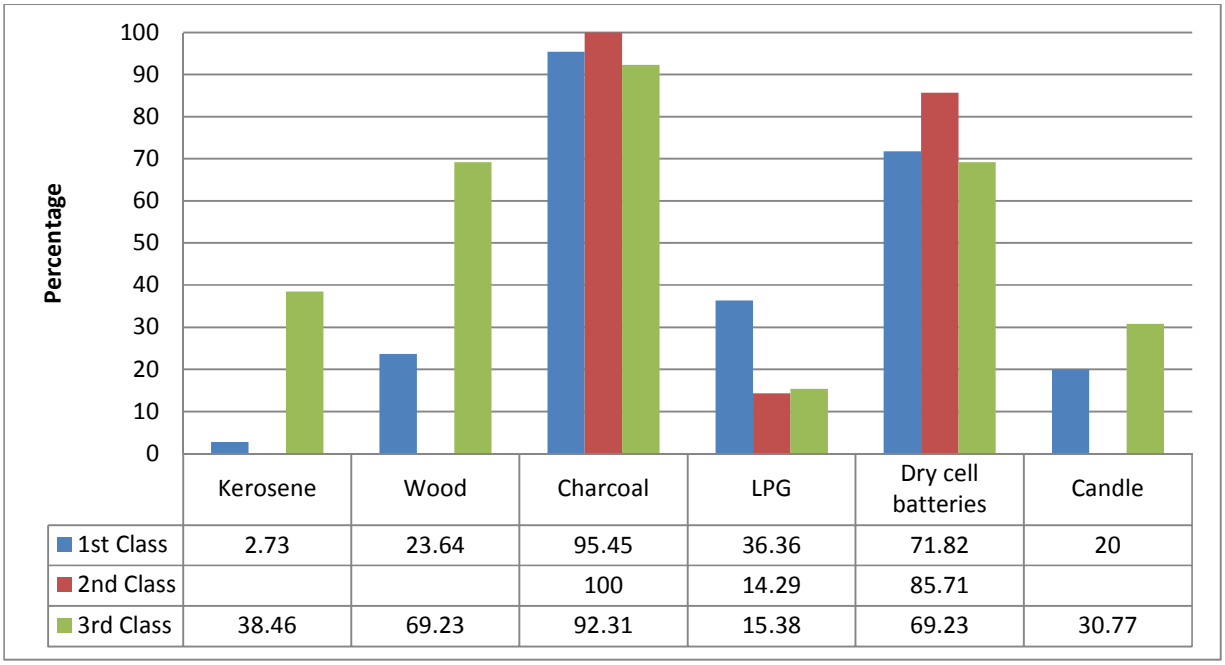


	Electricity	Kerosene	Wood	Charcoal	LPG	Solar	Dry Cell Battery	Candle
1st Class	100	3.08	7.44	82.05	81.54	2.31	41.54	13.33
2nd Class	100	8	12	92	76	8	52	28
3rd Class	100	8.89	13.33	80	66.67	4.44	22.22	2.22

Source: 2014 Energy Survey

For non-electrified households in GEM, electricity from other sources such as private generators does not exist. About 36%, 14% and 15% of First, Second and Third class households respectively use LPG fuel, 95%, 100% and 92% of First, Second and Third class households use charcoal fuel while 24% and 69% of First and Third class households respectively use wood fuel. Non-electrified households extensively use other fuel types such as dry cell batteries and candles as well. About 72%, 86% and 69% of First, Second and Third class households respectively use dry cell batteries while 20% and 31% of First and Third class households respectively use candles (Figure 22).

Figure 22: Fuel types and percentage of usage in non-electrified household in GEM

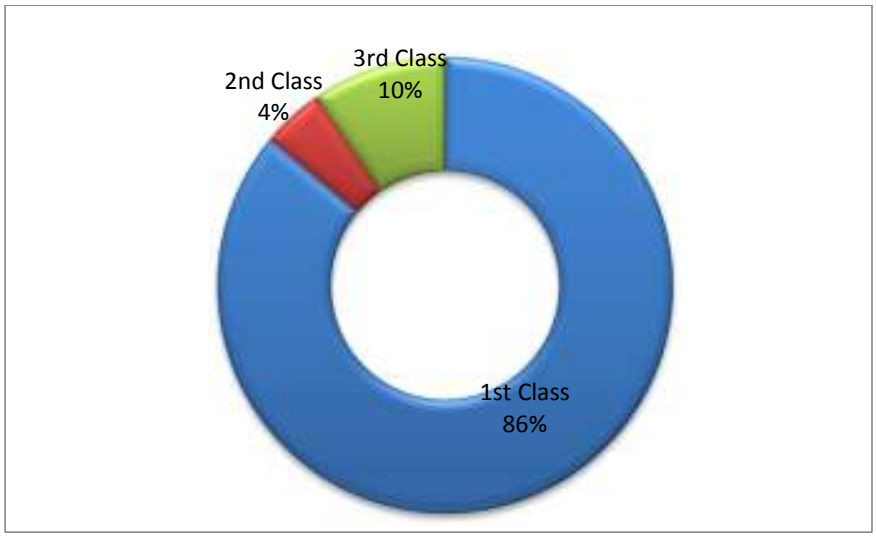


	Kerosene	Wood	Charcoal	LPG	Dry cell batteries	Candle
1st Class	2.73	23.64	95.45	36.36	71.82	20
2nd Class			100	14.29	85.71	
3rd Class	38.46	69.23	92.31	15.38	69.23	30.77

Source: 2014 Energy Survey

The residential sector accounts for 7% of the total energy consumed within GEM and ranks, the second largest consumer of energy after the transport sector in 2013. First class households consume about 86% of the total energy being consumed by the residential sector in the municipality, followed by the Third and Second class households which constitute 10% and 4% respectively of the total energy being consumed by the residential sector (Figure 23). The relative shares of energy consumption among the various settlement classes are due to the composition of these classes of settlements in the municipality.

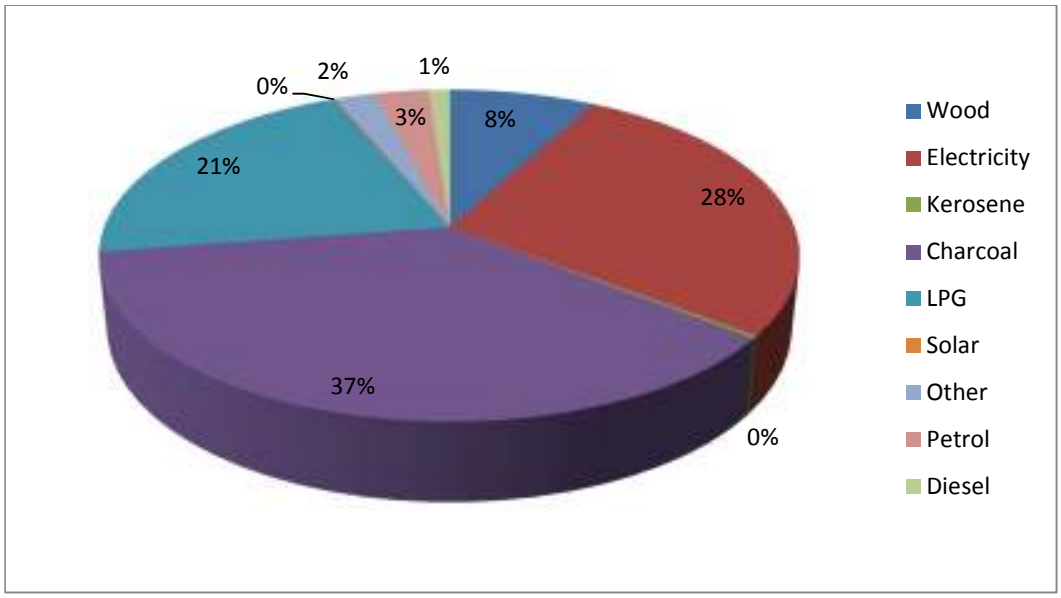
Figure 23: Percentage share of total energy consumption by settlement classifications in GEM



Source: 2014 Energy Survey

Charcoal fuel constitutes the largest share (37%) of the total energy consumed by the household sector in GEM. This is followed by electricity (28%), LPG (21%) and firewood (8%). Petrol constitutes about 3% of the total energy consumed by the residential sector while diesel constitutes about 2%. Dry Cell batteries and candles which make up the other fuel type constitute 2% of the total energy consumed by the residential sector in the municipality. Kerosene and diesel constitute less than one percent of the total energy consumed by the residential sector in the municipality (Figure 24).

Figure 24: Percentage share of total energy consumption per energy carrier in households in GEM as of 2013



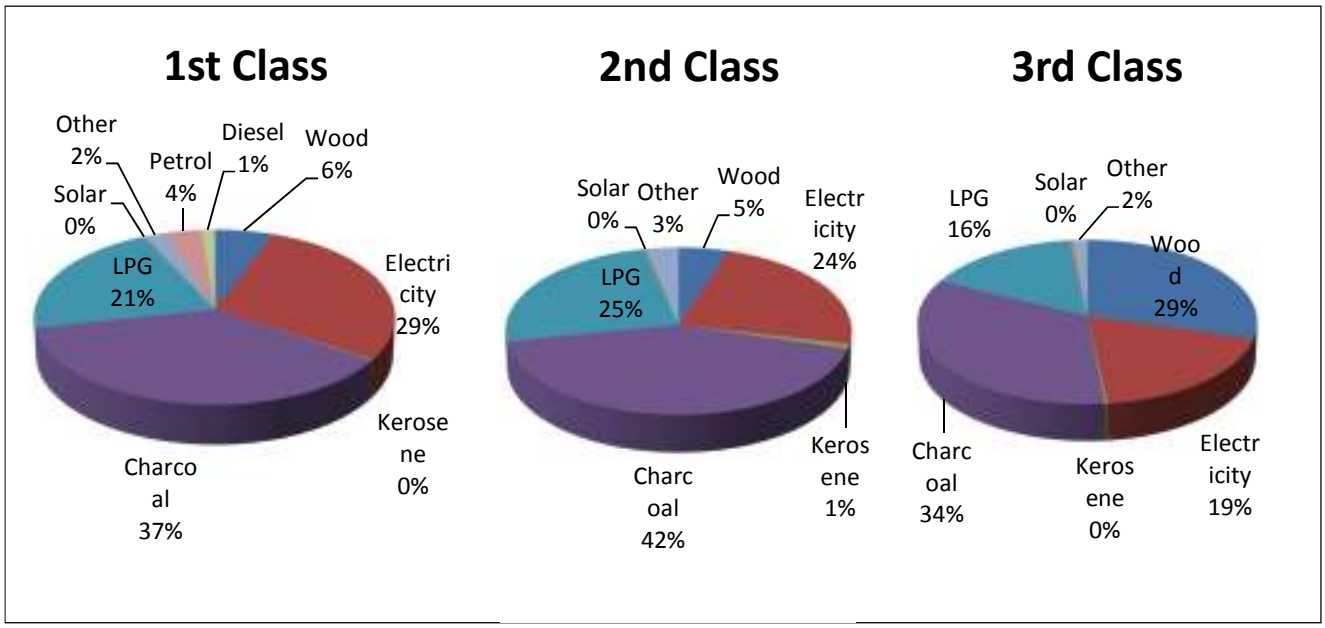
Source: 2014 Energy Survey

Figure 25 depicts all the energy related consumption issues in the three settlement classes in GEM. Biomass energy is widely consumed in GEM. Within the three settlement classes, charcoal consumption is the largest among all the energy carriers in the municipality. Despite the substantial amount of biomass energy consumption, there is evidence of the consumption of modern forms of energy (electricity and LPG) in the municipality. Modern forms of energy together constitute about 50% share of total energy consumed among First Class households, 49% share of total energy consumed by Second Class households and 35% share in the total energy consumed by Third Class households.

In First Class households, charcoal constitutes about 37% of the total energy consumed while electricity and LPG constitute 29% and 21% respectively. Wood constitutes about 6% of the total energy consumed by the First Class households in GEM while petrol and diesel constitute 4% and 1% respectively. Other fuels such as dry cell batteries and candles constitute 2% of the total energy consumed by the residential sector in GEM. Similar to the First Class households, charcoal constitutes the largest share (42%) in the total energy consumed in Second Class households in the municipality. LPG follows with 25% while electricity constitutes 24% of the total energy consumed in Second Class households. Firewood constitutes about 5% of the total energy consumed in the second class settlements while other fuel types (dry cell batteries and candles) and kerosene fuel constitute about 3% and 1% respectively. Solar energy consumption constitutes less than one percent of the total energy consumed in the Second class settlements.

In the Third Class settlements, charcoal consumption again constitutes the largest share (34%) of all energy carriers. However, firewood comes second with 29% share in the total energy consumed in the third class households. This is an indication of the level of dependence of Third Class households on biomass compared to First and Second class households in GEM. Electricity constitutes about 19% while LPG constitutes about 16%. Dry cell batteries and candles constitute about 2% while solar and kerosene constitute less than one percent of the total energy consumed by Third class households (Figure 25).

Figure 25: Percentage of total fuel consumed by settlement classification from energy sources in GEM



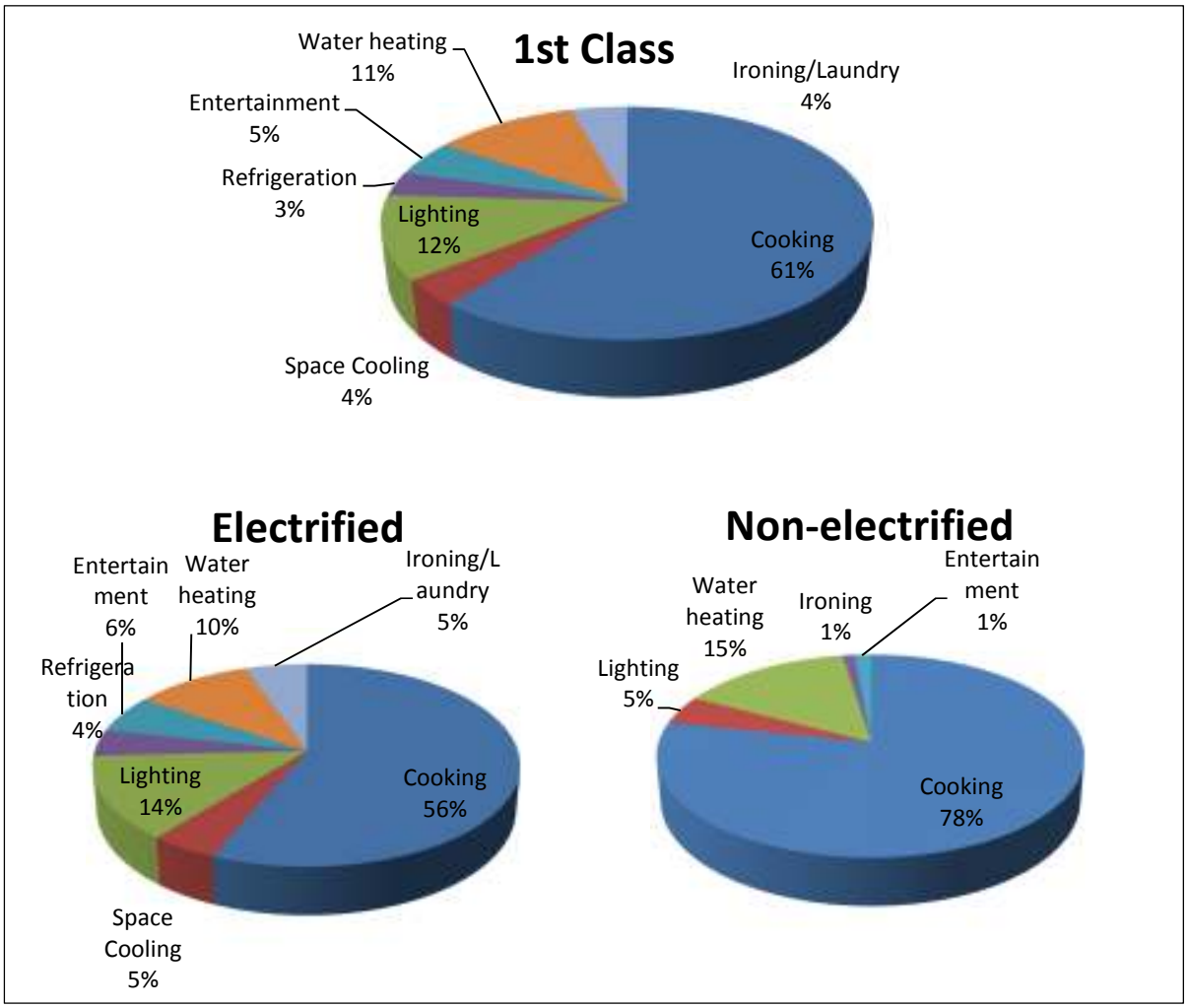
Source: 2014 Energy Survey

4.1.2 Energy Consumption by End-Uses in the Residential Sector in GEM

Among the various end-uses of energy in the First Class households, cooking consumes the highest energy (61%), followed by lighting (12%) and water heating 11%). Entertainment consume about 5% while space cooling and ironing/laundry consume about 4% each of the total energy of First Class households (Figure 26). The consumption patterns do not differ significantly among electrified and non-electrified First Class households as Figure 26 shows. Cooking consumes 56% of the total energy in electrified households, followed by lighting (14%) and water heating (10%). Space cooling and laundry consume 5% each, while entertainment consumes 4% of the total electrified First Class household energy. Among non-electrified First

Class households, cooking consumes about 78% of the total energy while water heating consumes about 15%. Lighting consumes about 5% of the total energy in the first class non-electrified households while ironing and entertainment together consume just about 2%.

Figure 26: Percentage share of energy consumption by end-uses in First Class households in GEM

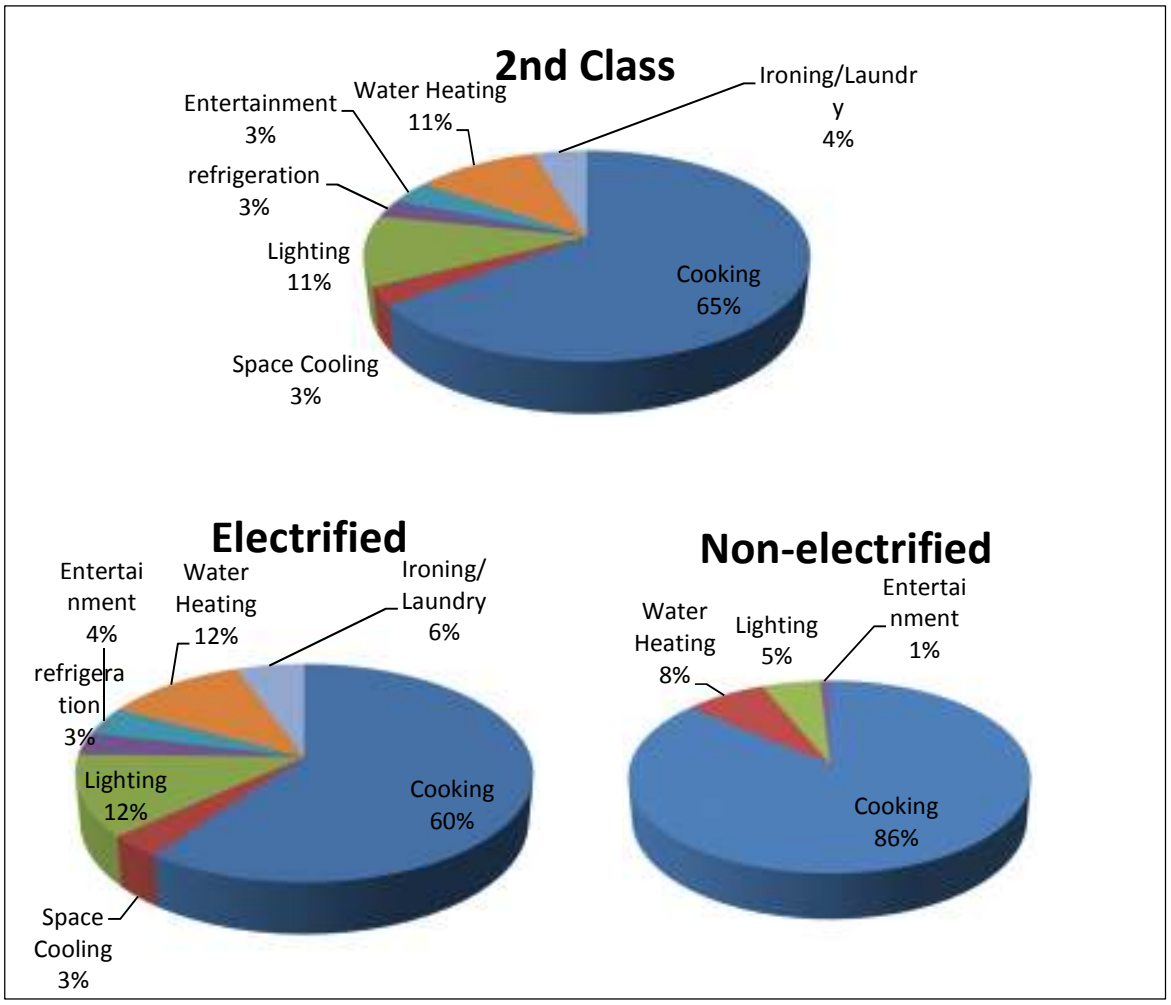


Source: 2014 Energy Survey

The end-uses of energy in the Second Class settlements are not significantly different from that of First Class settlements. Cooking is the most energy intensive end-user in Second Class households, consuming about 65% of the total energy of these households. Lighting and water heating each consumes about 11% while ironing/laundry consumes about 4%. Entertainment, refrigeration and space cooling consume 3% each of the total energy consumed by Second Class

households in GEM (Figure 27). Among Second Class electrified households, cooking consumes about 60% while lighting and water heating consume about 12% each. Among non-electrified households in the Second Class, cooking consumes about 86% of the total energy while water heating, lighting and entertainment consume 8%, 5% and 1% respectively.

Figure 27: Percentage share of energy consumption by end-uses in Second Class households in GEM

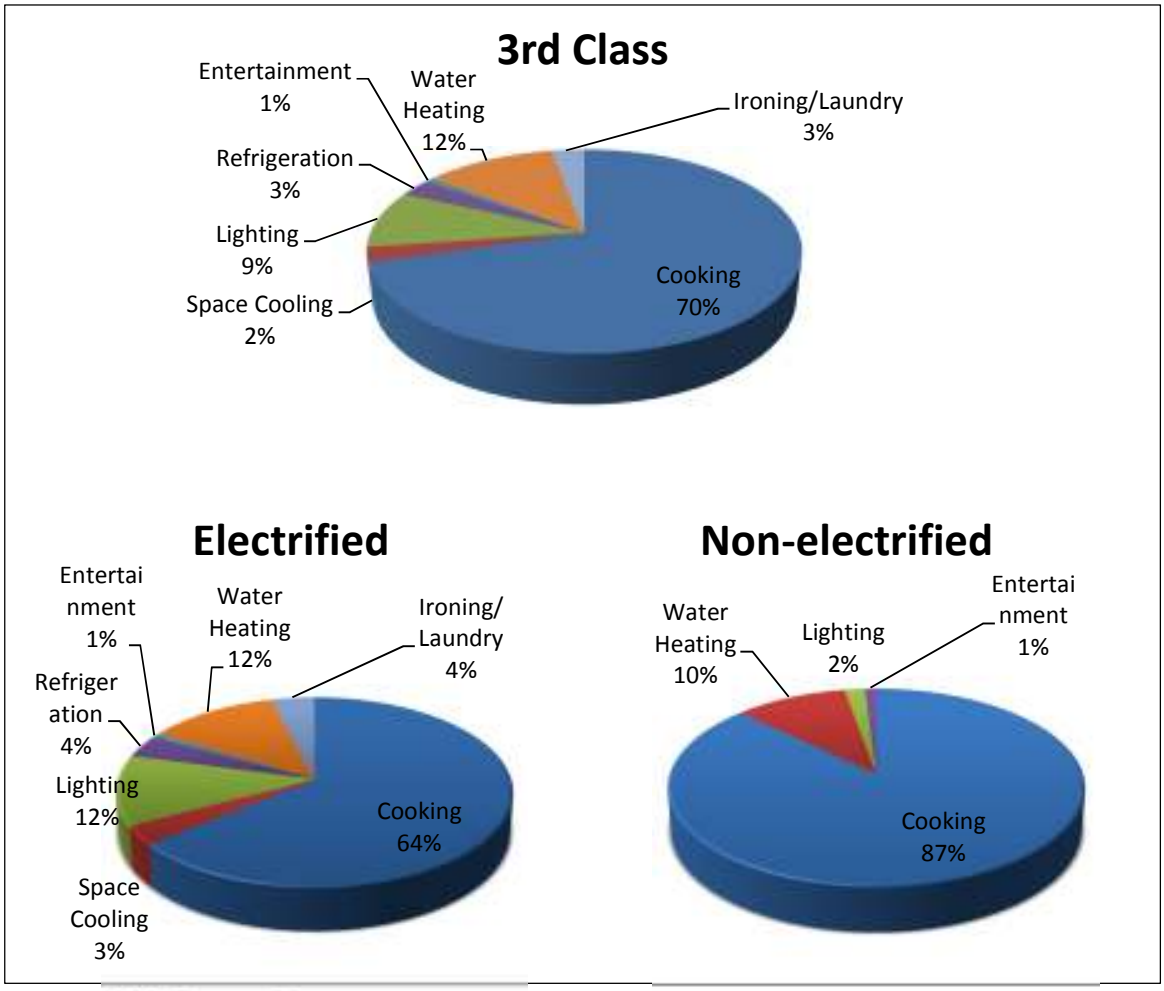


Source: 2014 Energy Survey

The pattern of end-uses of energy among Third Class follows the trends of First and second Class households. Cooking consumes about 70% of the total energy of Third Class households, followed by water heating (12%) and lighting (9%). Among Third Class electrified households, about 64% of the total energy consumed goes into cooking while water heating and lighting

consume 12% each. Laundry and refrigeration consume about 4% each while space cooling consumes 3%. Within Third Class non-electrified households, cooking consumes about 87% of the total energy while water heating consumes about 10%. Entertainment and lighting consume the remaining 3% (Figure 28).

Figure 28: Percentage share of energy consumption by end-uses in Third Class households in GEM

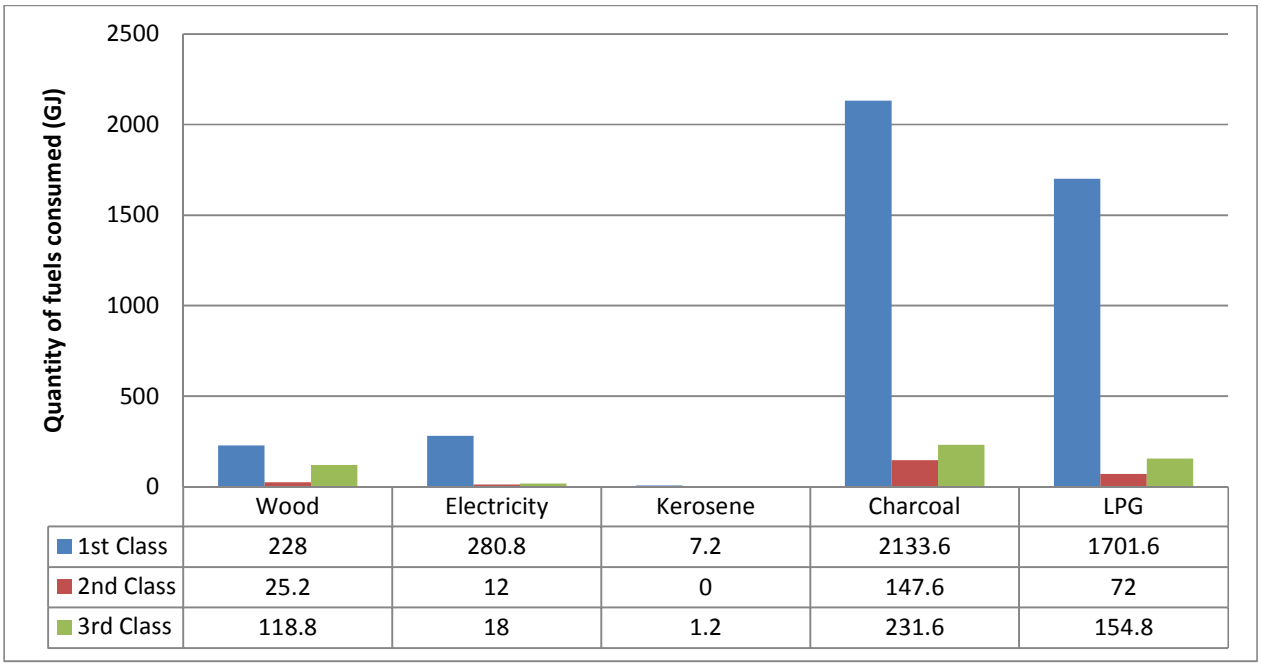


Source: 2014 Energy Survey

4.1.3 Sources of Energy for different End-Uses in the Settlement Classes in GEM

Figures 29 shows the energy sources used for cooking in electrified households across all three settlement classifications in GEM. First class electrified households depend mostly on charcoal and LPG to meet their cooking demands with electricity and wood fuels serving as supplementary energy sources. Second Class electrified households use charcoal the most followed by LPG, wood and electricity for their cooking activities. Third Class electrified households also use more charcoal, followed by LPG, wood, electricity and charcoal.

Figure 29: Sources of energy for cooking among electrified households in GEM

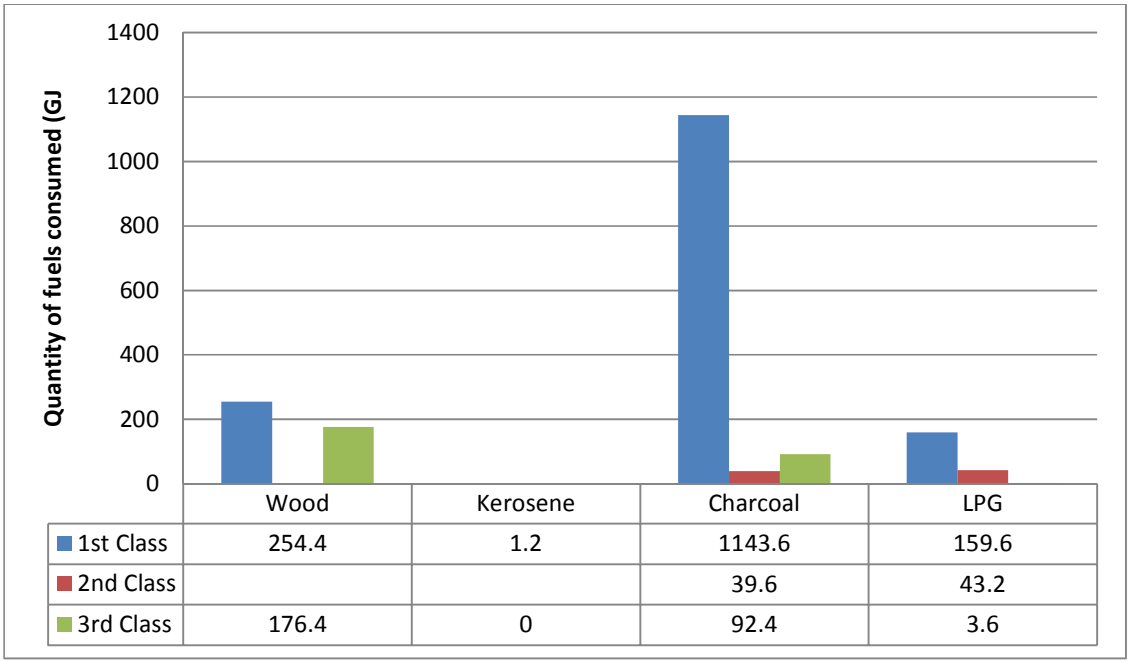


	Wood	Electricity	Kerosene	Charcoal	LPG
1st Class	228	280.8	7.2	2133.6	1701.6
2nd Class	25.2	12	0	147.6	72
3rd Class	118.8	18	1.2	231.6	154.8

Source: 2014 Energy Survey

First Class non-electrified households depend mostly on charcoal, wood and LPG fuels for their cooking demands while second class non-electrified households depend on charcoal and LPG fuels (Figure 30). Third class non-electrified households depend mostly on wood followed by charcoal for their cooking activities in the municipality. Kerosene is used in First Class households to support the use of charcoal. Some households also use kerosene stoves with kerosene as the main cooking fuel.

Figure 30: Sources of energy for cooking among non-electrified households in GEM



	Wood	Kerosene	Charcoal	LPG
1st Class	254.4	1.2	1143.6	159.6
2nd Class			39.6	43.2
3rd Class	176.4	0	92.4	3.6

Source: 2014 Energy Survey

Within electrified households in GEM, electricity is mainly used as a supplementary energy source for cooking in all three settlement classes. Only 0.26 percent of First Class households use electricity as main source for cooking. Meanwhile, about 47%, 40% and 29% of First, Second and Third Class households respectively use electricity as supplementary energy source for cooking (Figure 31). Those who use electricity for cooking are moved by urban influence. Others also regarded it to be accessible and user friendly without much health hazards. Households that do not use electricity for cooking cited the issue of lack of affordability. From the survey results, about 93% of households who use electricity for cooking revealed that they will continue to use electricity for cooking in the future. About 52%, 20% and 50% of First, Second and Third class households respectively, who use electricity for cooking in the municipality regarded electricity supply to be shortfall in the municipality due to urbanization.

Figure 31: Role of electricity in cooking (Percentages of households who use electricity)

	First Class	Second Class	Third Class
Main	0.26	0	0
Supplementary	47.04	40	28.89
Not used at all	52.7	60	71.11

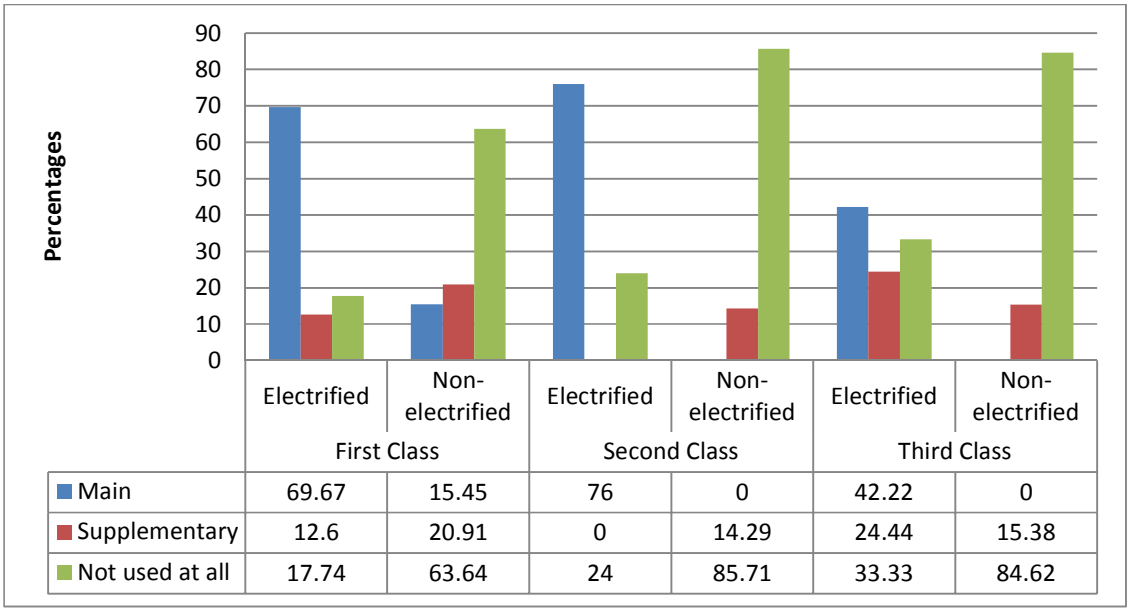
Source: 2014 Energy Survey

In the First Class settlements, about 70% of electrified households use LPG as their main cooking energy source while 13% use it as a supplementary source. Among Second Class electrified households, 76% use LPG as their main cooking fuel while 42% and 24% use LPG as main and supplementary sources among Third Class households (Figure 32). Gas stoves/burners and cylinders that store LPG are the technologies that are used for this fuel type. Households who use LPG, either as a main or supplementary cooking sources argued that LPG is cheap, easy to access, user friendly and has no health hazard. Almost all of LPG users in the electrified households claimed they will continue to use LPG in the future. Households who do not use LPG for cooking in GEM attributed their non-usage to the lack of affordability. About 57%, 42% and 80% of First, Second and Third class households respectively who use LPG for cooking in the municipality believe that, although LPG is more accessible now, there is shortage in the supply of LPG fuel in the municipality in recent times compared to the past, due to urbanization. Conversely, 24%, 53% and 13% of First, second and Third class households who use LPG believe that the supply of LPG to the municipality has increased due to urbanization.

With respect to non-electrified households, only 15% of First Class households use LPG as their main cooking fuel while 21% use it as a supplementary cooking energy source. Among Second and Third class non-electrified households, 14% and 15% respectively use LPG as a supplementary cooking energy source with little or no households using LPG as a main cooking

energy source. LPG users in the non-electrified households cited issues of reliability of LPG, convenience and user friendly as the main reasons they use LPG while non-LPG users cited issues of lack of affordability as the main reason for their non-usage. Nearly all the households who use LPG for cooking reported that they will continue to use it in the future. However, 62% of First Class non-electrified and almost all of Second and Third Class non-electrified households who use LPG for cooking were of the view that, there is a shortfall in LPG supply to the municipality due to urbanization.

Figure 32: Role of LPG in cooking (Percentages of households who use LPG)



	First Class		Second Class		Third Class	
	Electrified	Non-electrified	Electrified	Non-electrified	Electrified	Non-electrified
Main	69.67	15.45	76	0	42.22	0
Supplementary	12.6	20.91	0	14.29	24.44	15.38
Not used at all	17.74	63.64	24	85.71	33.33	84.62

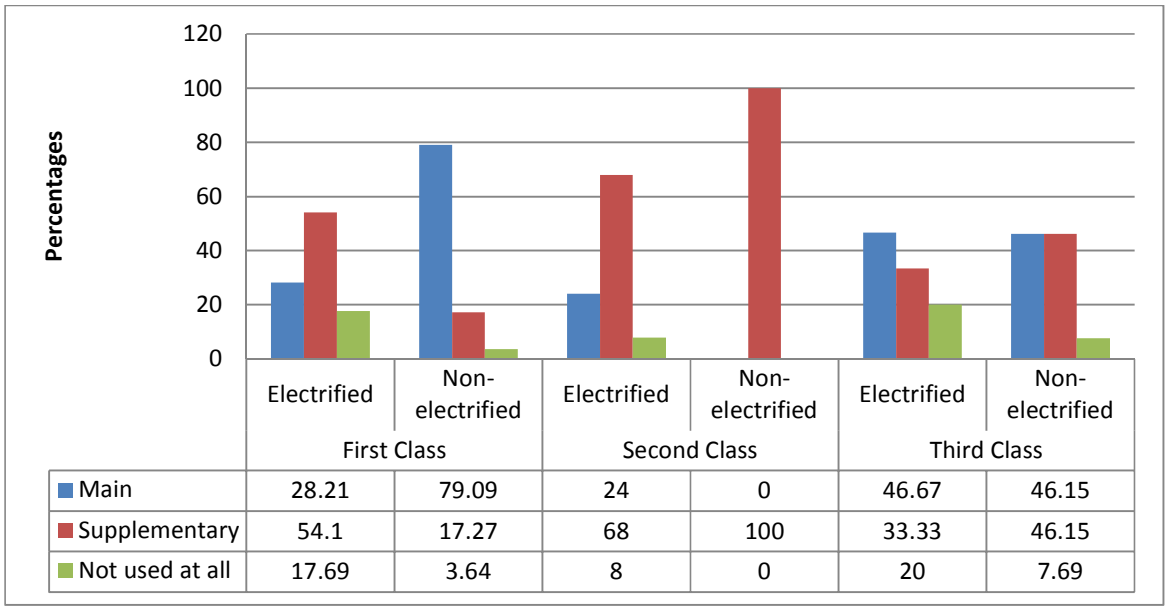
Source: 2014 Energy Survey

About 54% and 68% of First and Second Class electrified households respectively use charcoal as supplementary cooking fuels with only 28% and 24% correspondingly using charcoal as their main cooking fuels. However, 47% of Third Class electrified households use charcoal as a main cooking energy source while only 33% use it as a supplementary source (Figure 33). Coalpot and locally manufactured efficient cook stoves (Gyapa) are the technologies used for cooking with the charcoal fuel. Many households who use charcoal for cooking, either as a main or supplementary source, reported that, they use charcoal because it is cheap and reliable as well. 88%, 100% and 81% of First, Second and third Class electrified households expressed their willingness to continue using charcoal in the future. While 38%, 26% and 50% of First, Second and Third Class electrified households who use charcoal were of the view that there is shortfall in charcoal supply to the municipality due to urbanization, corresponding 21%, 61% and 14%

argued that supply of charcoal to the municipality has increased due to urbanization. Electrified households who do not use charcoal for cooking cited issues of inconveniency and the health hazards charcoal poses as the main reasons for their non-usage.

Charcoal is extensively used in non-electrified households in GEM. About 79% of First Class non-electrified households use charcoal as their main cooking fuels while 17% use it as a supplementary energy source for cooking. In Second Class non-electrified households, nearly all households use charcoal, but mainly as a supplementary cooking fuel. In Third Class non-electrified households, 46% use charcoal as a main cooking energy source while 46% also use it as a supplementary cooking fuel (Figure 33). Non-electrified households who use charcoal argued that it is accessible and cheap. 81%, 100% and 92% of First, Second and Third Class non-electrified households who use charcoal reported that they will continue to use charcoal in the future. Many non-electrified households, who do not use charcoal for cooking cited health issues it poses and the inconveniency in using it. While 51%, 83% and 50% of First, Second and Third Class non-electrified households who use charcoal were of the view that there is shortfall in charcoal supply to the municipality due to urbanization, corresponding 16%, 0% and 42% argued that supply of charcoal to the municipality has increased due to urbanization.

Figure 33: Role of charcoal in cooking (Percentages of households who use charcoal)



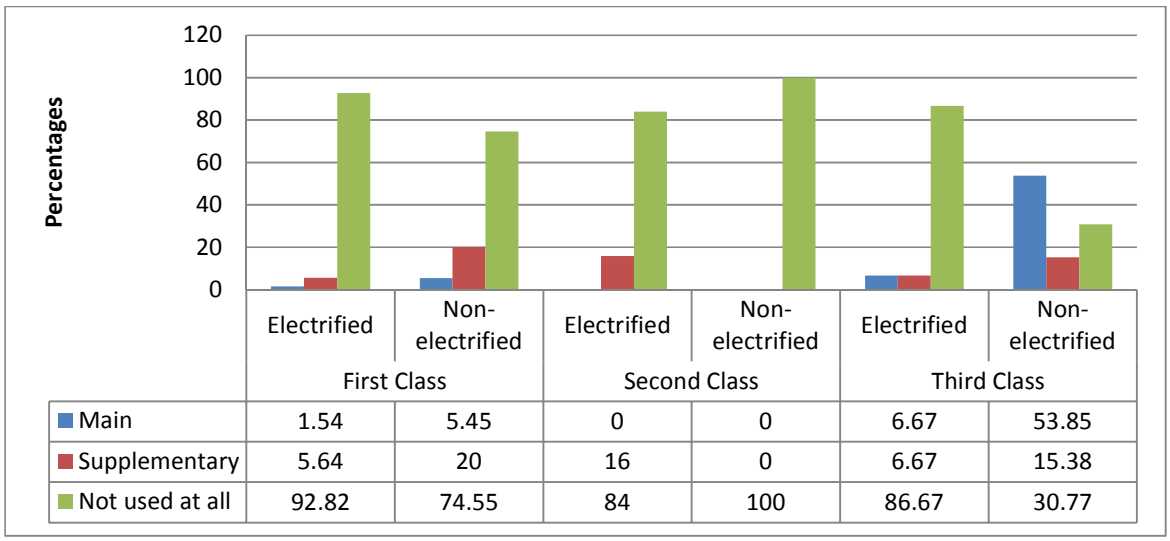
	First Class		Second Class		Third Class	
	Electrified	Non-electrified	Electrified	Non-electrified	Electrified	Non-electrified
Main	28.21	79.09	24	0	46.67	46.15
Supplementary	54.1	17.27	68	100	33.33	46.15
Not used at all	17.69	3.64	8	0	20	7.69

Source: 2014 Energy Survey

In electrified households in the municipality, firewood usage is not very common. About 2% of First Class electrified households use firewood as main cooking fuel while 6% use it as a supplementary cooking energy source. 16% of Second Class electrified households use firewood as a supplementary cooking fuel while 7% of Third Class electrified households use it each as main and supplementary cooking fuels (Figure 34). Heath, metal stand and three cement blocks erected on the ground are the technologies used in cooking with the firewood fuel in GEM. Electrified households who use firewood for cooking argued that it is cheap while those who do not use firewood cited issues related to health hazard of firewood usage and the fact that, it is difficult to get. About 46%, 100% and 83% of First, Second and Third Class electrified households who use firewood for cooking reported that their willingness to continue using firewood in the future. Meanwhile, 43% and 100% of first and Third Class electrified households who use firewood for cooking observed shortage in firewood supply to the municipality due to urbanization.

About 20% of First class non-electrified households use firewood as a supplementary cooking fuel in the municipality while 5% use it as a main cooking fuel. Firewood usage is not very common in Second Class non-electrified households but very common in Third Class non-electrified households in the municipality. About 54% of Third class non-electrified households use firewood as their main cooking fuels while 15% of them use it as a supplementary cooking fuel (Figure 33). For the non-electrified households who use firewood for cooking, they use it because it is affordable and easy to get. About 22% noted that they will continue to use firewood for cooking in the future while 42% and 89% of First and Third class non-electrified households respectively observed the shortage in firewood fuel supply to the municipality due to urbanization.

Figure 34: Role of firewood in cooking (Percentages of households who use firewood)

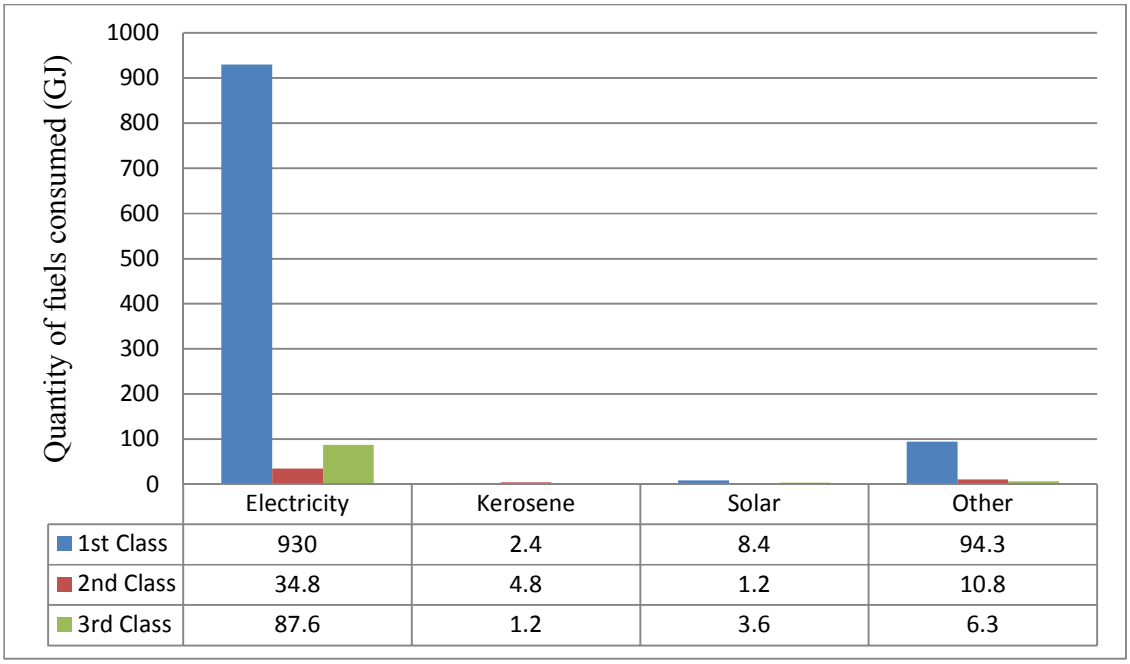


	First Class		Second Class		Third Class	
	Electrified	Non-electrified	Electrified	Non-electrified	Electrified	Non-electrified
Main	1.54	5.45	0	0	6.67	53.85
Supplementary	5.64	20	16	0	6.67	15.38
Not used at all	92.82	74.55	84	100	86.67	30.77

Source: 2014 Energy Survey

Figure 35 summarises the relative sources of energy for lighting in electrified households in GEM. Electrified households in the municipality depend predominantly on electricity from the national grid for lighting purposes. Apart from electricity, First Class electrified households also depend significantly on other fuel types such as dry cell batteries and candles. Second and Third class electrified households also depend a lot on electricity for their lighting needs and other fuel types (dry cell batteries and candles). Solar and kerosene are also used in small quantities.

Figure 35: Sources of energy for lighting in electrified households in GEM

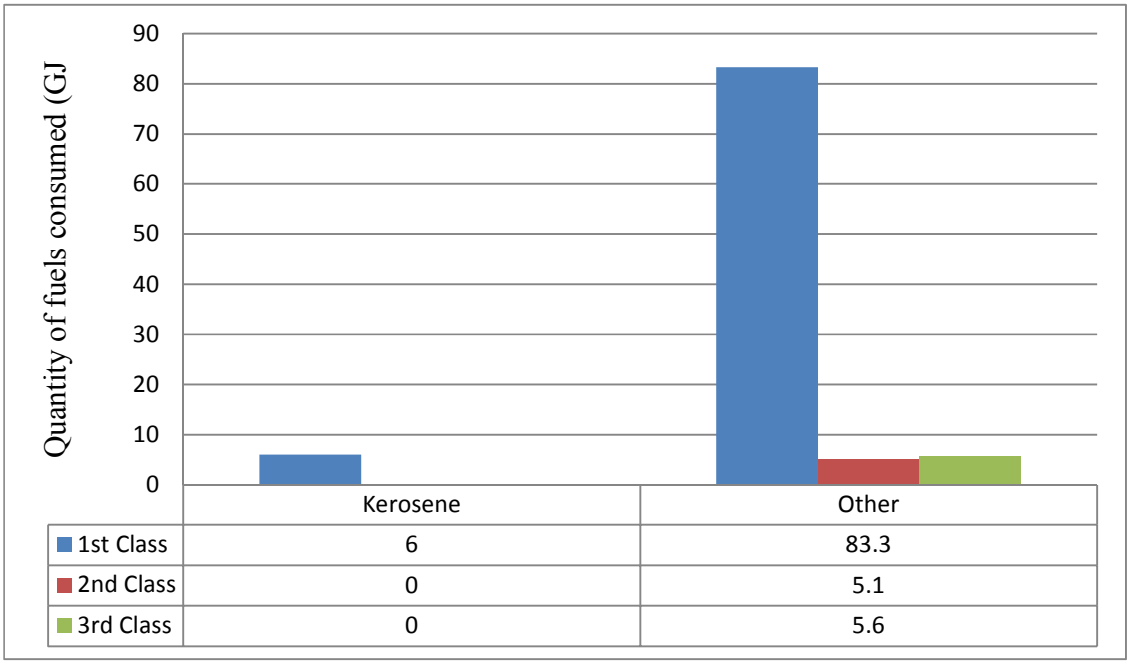


	Electricity	Kerosene	Solar	Other
1st Class	930	2.4	8.4	94.3
2nd Class	34.8	4.8	1.2	10.8
3rd Class	87.6	1.2	3.6	6.3

Source: 2014 Energy Survey

Non-electrified households on the other hand depend on dry cell batteries and candles for lighting purposes in the municipality. First class non-electrified households depend extensively on dry cell batteries and candles and to some extent, kerosene which uses kerosene lamps as the technology (Figure 36). About 6% of First class households have back-up generators. 43% of those who use back-up generators reported that it is very expensive to use while 39% were of the view that it is expensive but not extreme. Only 18% of generator users reported that it is moderate to use in terms of cost. The use of private electricity generators in the municipality has increased due to the current shortfall in electricity supply from the national grid to the municipality.

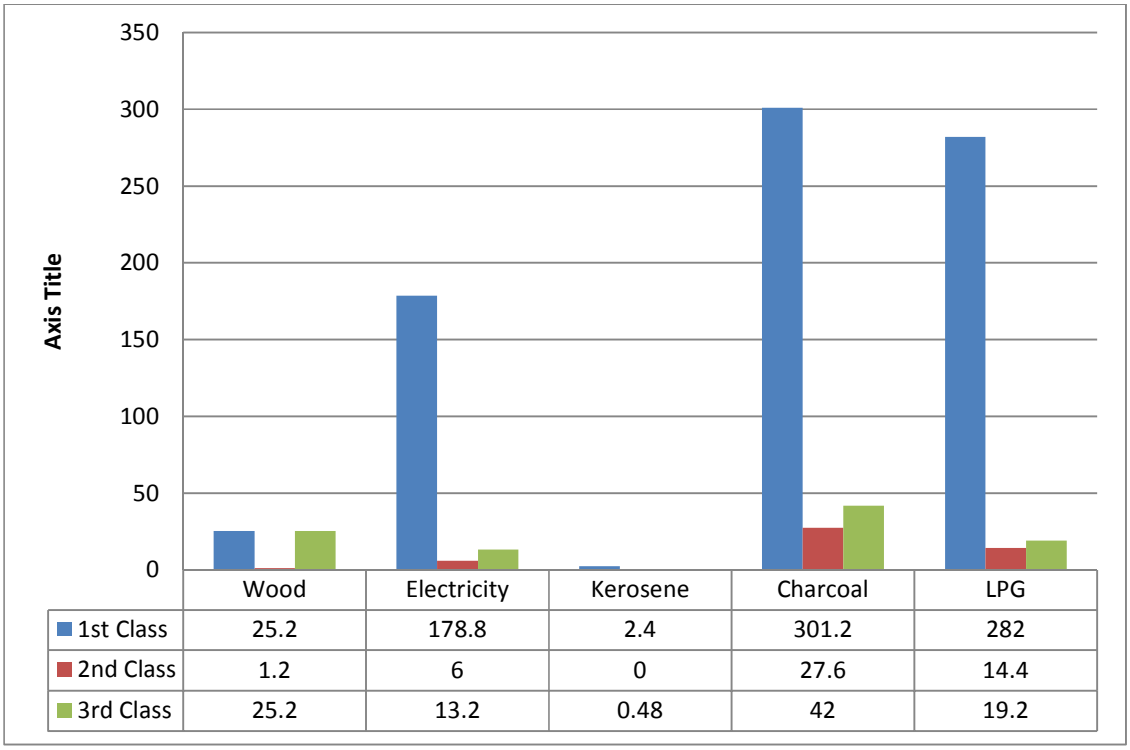
Figure 36: Sources of energy for lighting in non-electrified households in GEM



Source: 2014 Energy survey

Electrified households in the GEM depend on charcoal, LPG, electricity and wood fuels for their water heating needs. First Class electrified households use relatively more of these fuels than Second and Third class electrified households (Figure 37). Electric heaters and kettles are often used for water heating while gas cylinders with burners/stoves are the technologies used for the LPG fuel.

Figure 37: Sources of energy for water heating in electrified households in GEM



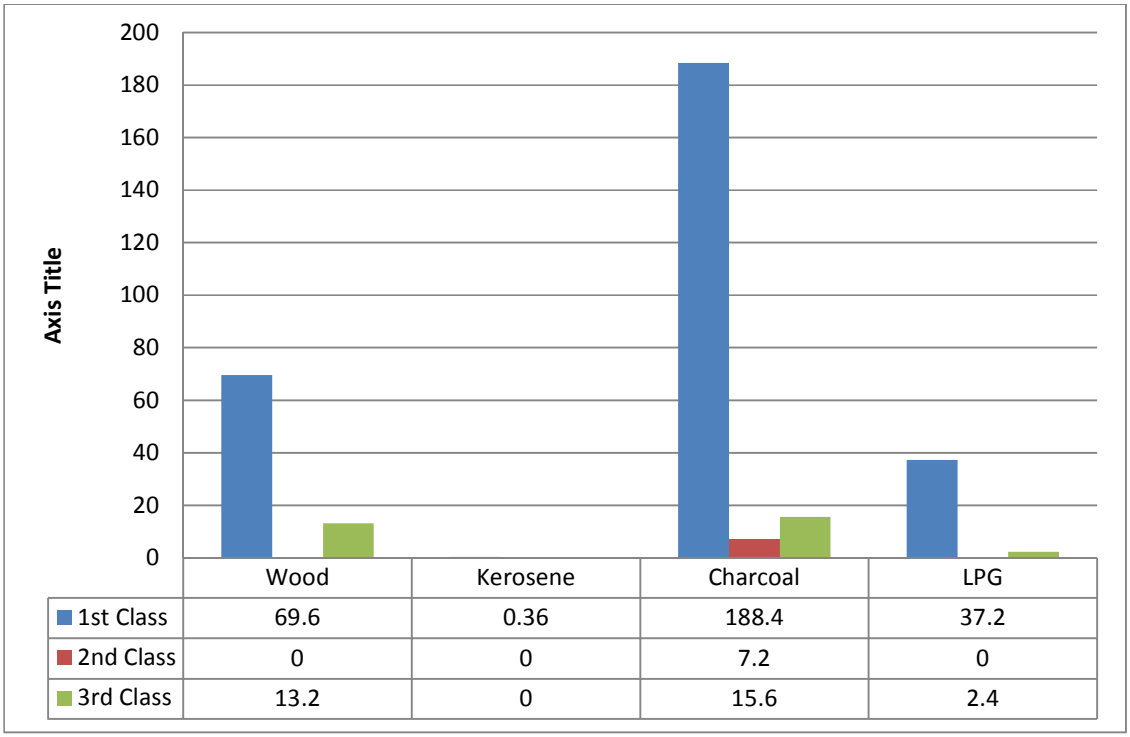
	Wood	Electricity	Kerosene	Charcoal	LPG
1st Class	25.2	178.8	2.4	301.2	282
2nd Class	1.2	6	0	27.6	14.4
3rd Class	25.2	13.2	0.48	42	19.2

Source: 2014 Energy Survey

Non-electrified households in GEM use charcoal, wood and LPG fuels for water heating. Charcoal is used more extensively by First Class non-electrified households, followed by Third and Second Class households. Wood fuels are also used more by First Class non-electrified households followed by Third Class non-electrified households. Similarly, LPG usage in water heating is predominant in First Class non-electrified household than in Second and Third Class households (Figure 38).

Electricity is the main energy source for space cooling supported with diesel and petrol in first class electrified households where they use fan and air conditioners as technologies, but strictly main in second and third class electrified households. For entertainment, electricity is the main energy source in all electrified households but dry cell batteries are used in radio sets for entertainment especially in non-electrified households. For ironing and laundry activities, electricity is the main energy source in all electrified households with electric iron and washing machines as the technologies while charcoal fuel is used in non-electrified households for ironing using the metallic (box) iron.

Figure 38: Sources of energy for water heating in non-electrified households in GEM



	Wood	Kerosene	Charcoal	LPG
1st Class	69.6	0.36	188.4	37.2
2nd Class	0	0	7.2	0
3rd Class	13.2	0	15.6	2.4

Source: 2014 Energy Survey

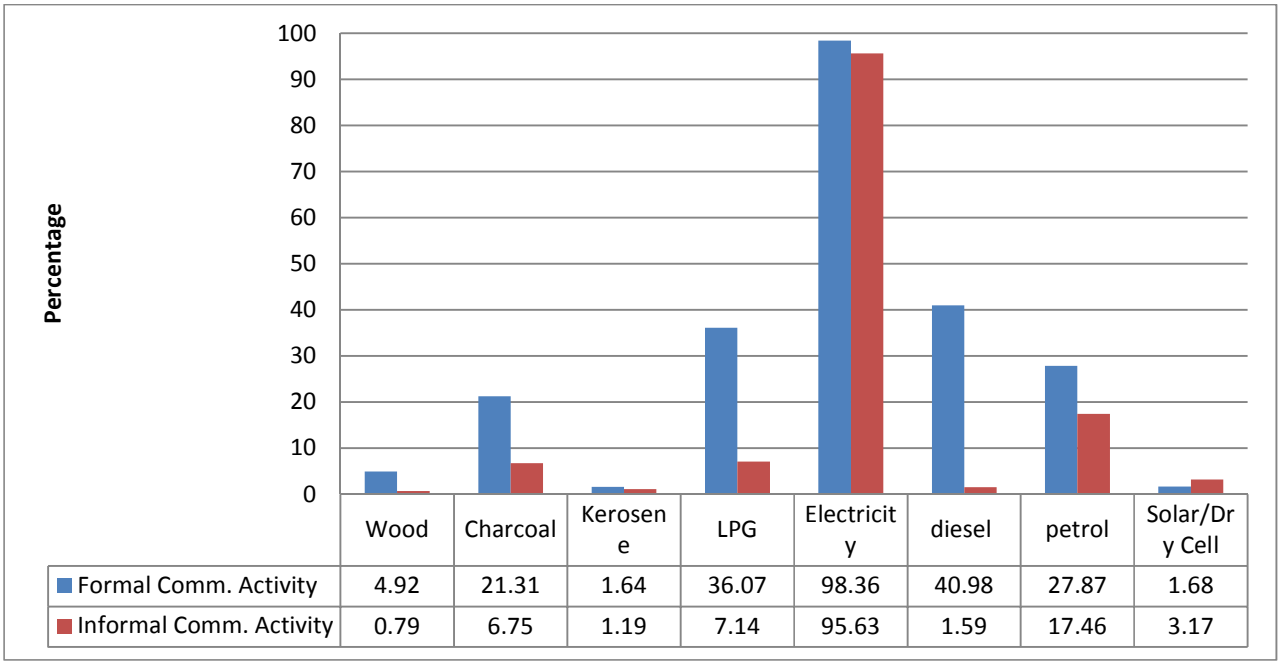
4.2 Commercial Sector

The commercial sector accounts for about 6% of the total energy consumed in GEM and ranks third in the order of the largest energy consuming sectors in the municipality in 2013. The commercial sector consumes almost as much energy as the household sector. This is attributed to the fact that, almost every one in three households in the municipality owns and manages a commercial activity. The energy landscape in the commercial sector is discussed around formal and informal activities as defined in the methodological section above. The ratio of formal to informal commercial activities in the municipality is 2:8 or 20:80 similar to the national image of formal and informal composition of the commercial sector. The formal-informal analysis is to enhance the understanding of the energy consumption patterns among formal and informal commercial activities in the municipality. Formal commercial activities surveyed for the SoE report include schools, hospitals, clinics, banking and non-banking financial services, offices such as Information and Communication Technology (ICT) providers, consultancy firms etc., tourism and hospitality services (hotels, motels and guest houses). Informal commercial activities surveyed also include the operations of saloon and barbering shops, tailoring and

seamstress services, fitting and mechanic works, drinking bars, restaurants and catering services, petty trading, retail shops, carpentry and welding shops, electronic repair shops and others.

About 98% and 96% of formal and informal commercial activities respectively consume electricity. 36% of formal commercial activities consume LPG as against only 7% of informal activities and 40% of formal commercial activities use diesel fuel as against only 2% of informal commercial activities using diesel fuel. Commercial activities also use wood fuel, charcoal, petrol and kerosene in the municipality. Solar and dry cell batteries are used in small quantities in the municipality (Figure 39). The commercial activities in the municipality use energy for ventilation and air conditioning, cooking/water heating, lighting, refrigeration, machine operation, entertainment, transportation and other end-uses including baking, welding, soldering and ironing (Figure 40).

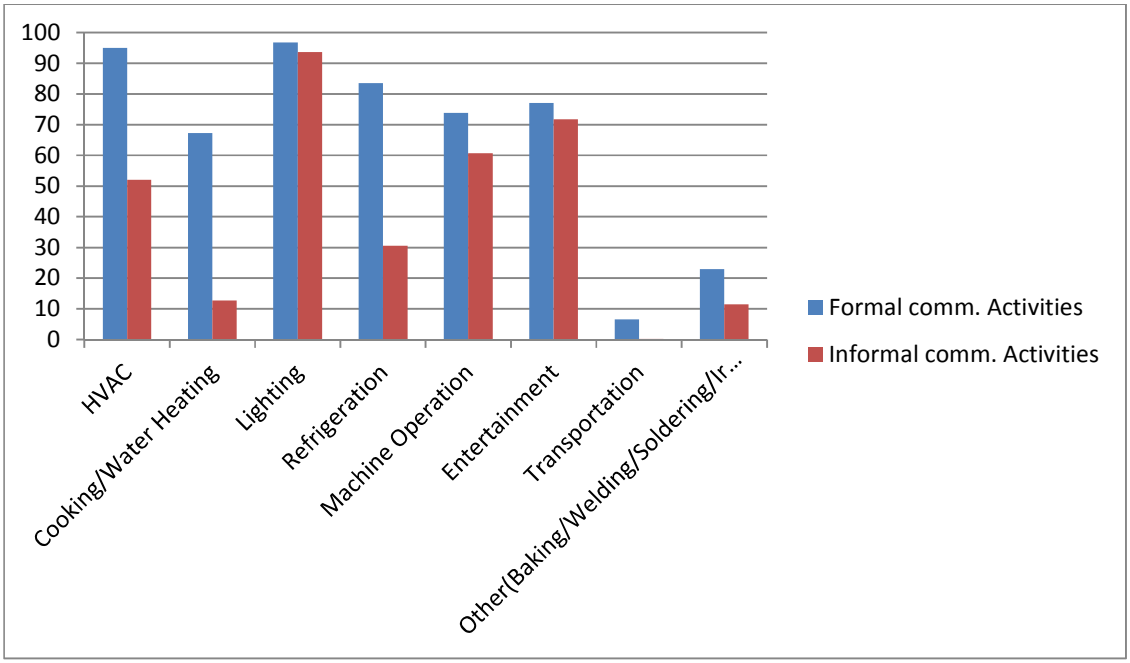
Figure 39: Commercial activities and the percentage share in the use of different fuel types in GEM



	Wood	Charcoal	Kerosene	LPG	Electricity	diesel	petrol	Solar/Dry Cell
Formal Comm. Activity	4.92	21.31	1.64	36.07	98.36	40.98	27.87	1.68
Informal Comm. Activity	0.79	6.75	1.19	7.14	95.63	1.59	17.46	3.17

Source: 2014 Energy Survey

Figure 40: Commercial activities and the percentage share of end-uses in GEM



Source: 2014 Energy survey

Informal commercial activity levels in the municipality have increased tremendously since 2010 (Table 13). The total floor space covered by informal activities in 2010 was about 8573.9 square meter (m^2) (from the sampled commercial activities in the 2013 commercial survey). This increased to 10439 square meter (m^2) in 2011 with a growth rate of 22%. In 2013, the informal activity level covered an area of 14965.68 square meter (m^2) in the municipality. Formal commercial activities in the municipality grew at a decreasing rate. With a floor are of about 83179.42 square meter (m^2) in 2010 based on the sampled formal activities, the floor space of formal activities increased to around 94284.93 square meter (m^2) in 2013 (Table 13).

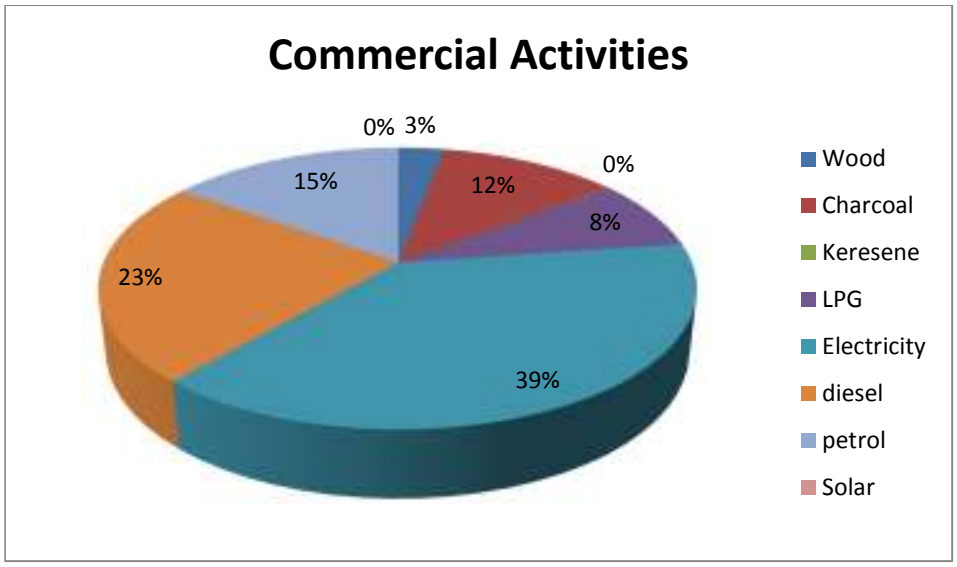
Table 13: Commercial activity levels in GEM

Year	Formal		Informal	
	Floor space (m2)	Growth rate (%)	Floor space (m2)	Growth rate (%)
2010	83179.42	-	8573.9	-
2011	87421.81	5.1	10439.05	21.8
2012	91041.5	4.1	11886.67	13.9
2013	94284.93	3.6	14965.68	25.9

Source: 2014 Energy Survey

Electricity and diesel constitute the largest shares of total energy consumed in the commercial sector in GEM. About 39% of the total energy consumed by the commercial sector is electricity while 23% is diesel fuel (Figure 41). The remaining 38% is shared between charcoal, wood, LPG and petrol. Kerosene and solar energy are consumed in small quantities in the municipality.

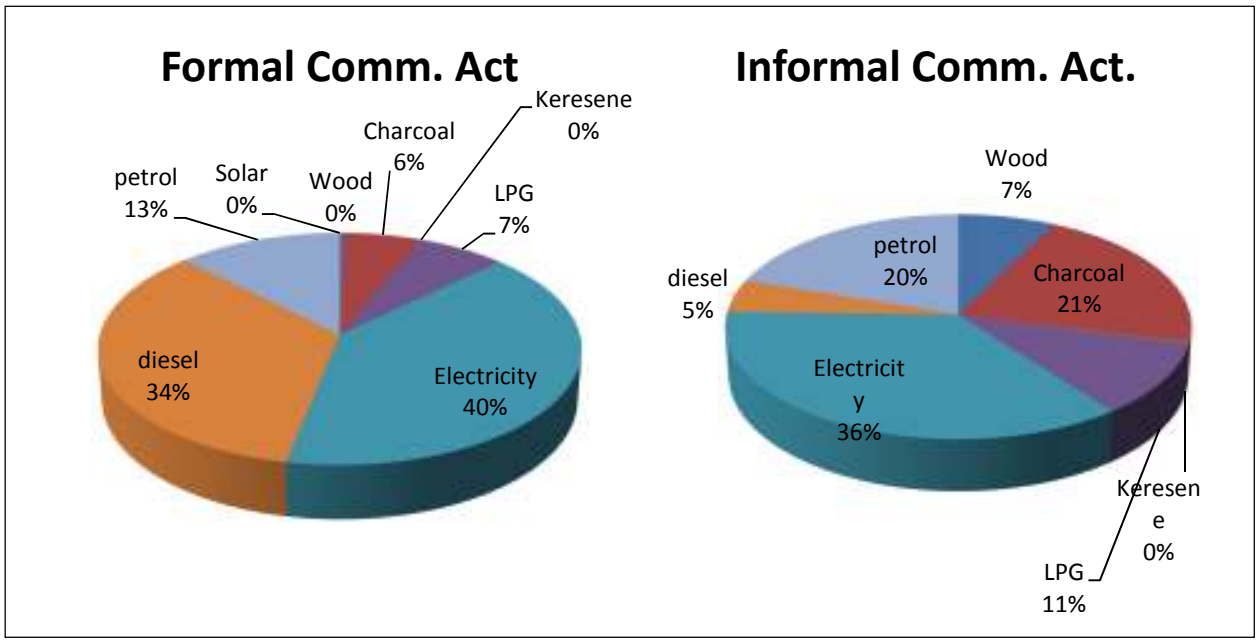
Figure 41: Share of energy consumed by the commercial sector among energy carriers in 2013



Source: 2014 Energy Survey

Figure 42 depicts the shares of energy consumed by the formal and informal commercial activities among the various energy carriers in GEM in 2013. Electricity contributes about 40% while diesel constitutes 34% of the total energy consumed by formal commercial activities in the municipality. Petrol, LPG and charcoal fuels' shares in the total energy consumed by the formal sector are 13%, 7% and 6% respectively while solar energy, wood and kerosene fuels contribute less than 1% of the total energy consumed. In the informal commercial sector, electricity and charcoal are the most consumed fuels. Electricity constitutes 36% of the total energy consumed by the informal commercial sector while charcoal constitutes 21%. Petrol, LPG, wood and diesel constitute 20%, 11%, 7% and 5% of the total energy consumed by the informal commercial sector respectively.

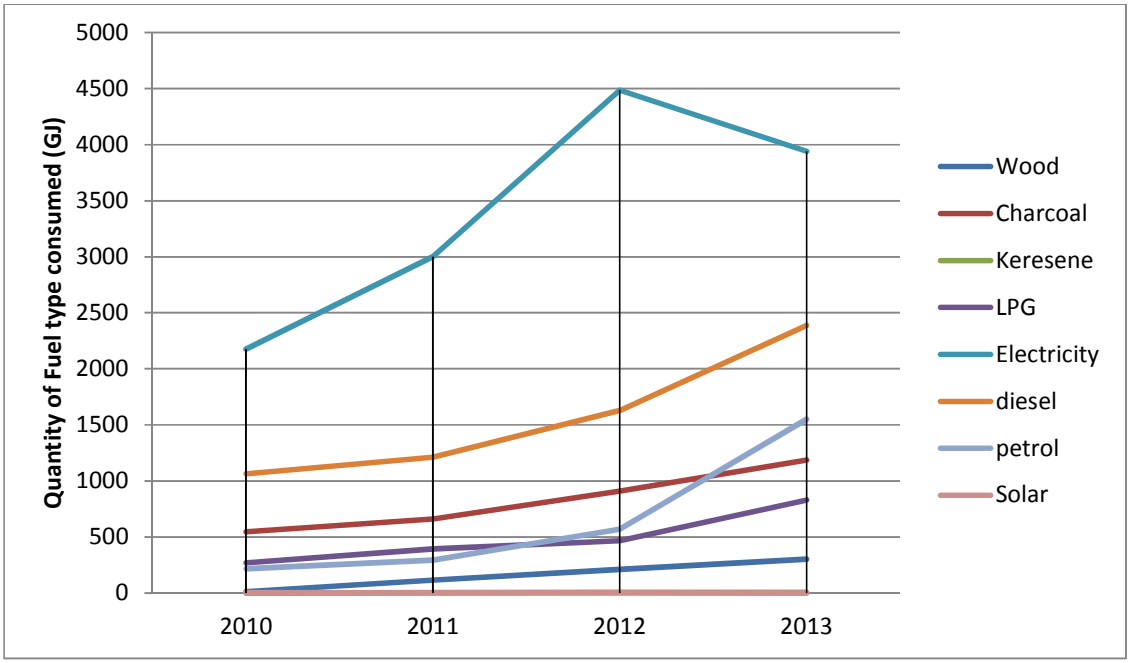
Figure 42: Shares of energy consumption among energy carriers in formal and informal commercial activities (2013)



Source: 2014 Energy Survey

Figure 43 shows the trend in fuel usage in the commercial sector from 2010 to 2013 in GEM. The quantities of all the fuel types consumed by the commercial sector have increased steadily since 2010, except for electricity which dipped in 2012. The fall in electricity consumption is attributed to the acute electricity shortage the country has been experiencing since 2012. As a result, most commercial activities have procured generators which are fueled by petrol and diesel fuels, hence the increase in their consumption.

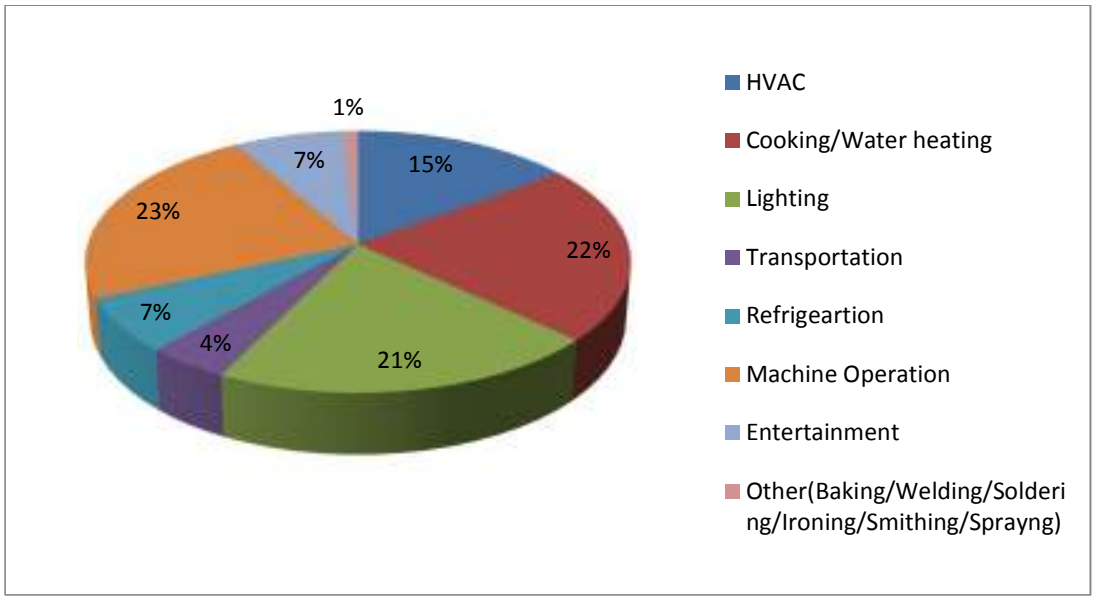
Figure 43: Trend in Energy usage in the commercial sector in GEM



Source: 2014 Energy Survey

Machine operation, cooking/water heating and lighting are the most energy intensive end-uses in the commercial sector. Machine operation consumes about 23% of the total energy, while cooking/water heating and lighting consume about 22% and 21% respectively of the total energy by the sector (Figure 44). Ventilation and air conditioning (HVAC) consumes about 15% while 7% each is consumed by refrigeration and entertainment of the total energy used by the commercial sector. Transportation consumes 4% and other uses such as welding, baking, smith activities, soldering and spraying consume only 1% of the total energy consumed by the commercial sector (Figure 44).

Figure 44: Share of energy consumed among the end-uses in the Commercial sector in 2013

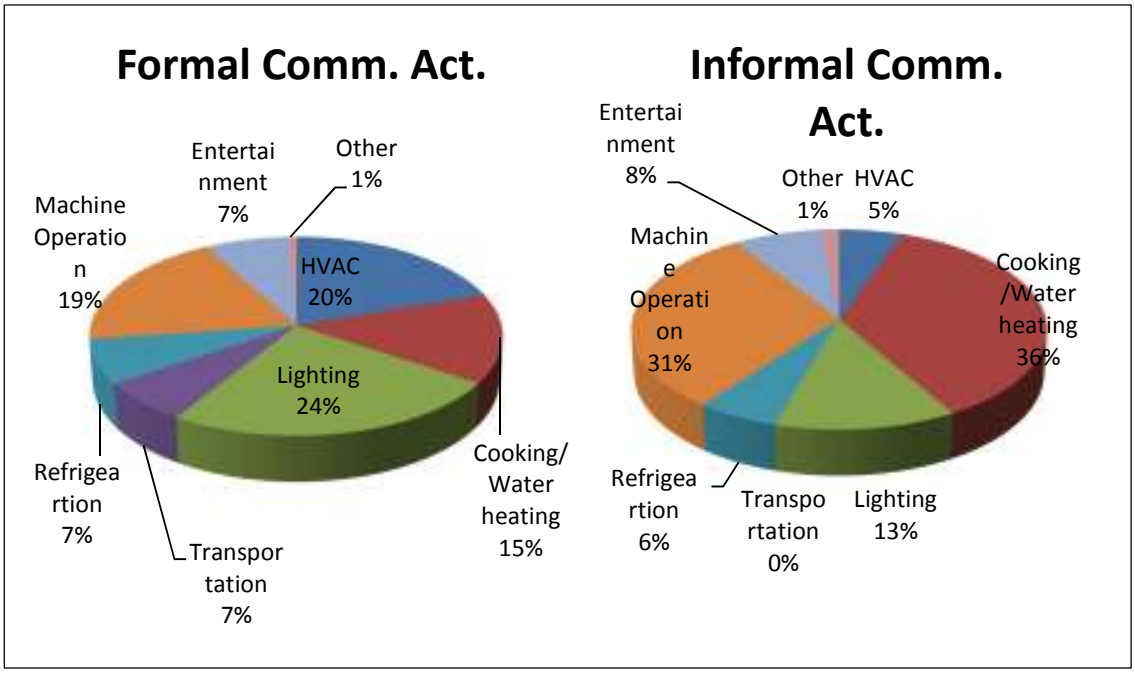


Source: 2014 Energy Survey

Figure 45 encapsulates the energy consumption by formal and informal commercial activities among various end-uses. Within the formal commercial activities in GEM, lighting consumes the most energy, accounting for 24% of the total energy consumed by the formal commercial sector. HVAC consumes about 20% while machine operation such as the use of computers, printers, photocopy machines and others consume about 19% of the total energy consumption in the formal commercial sector. Cooking/water heating activities, which often take place in schools (school feeding programme), hospitals and hotels/guest houses, consume about 15% of the total energy consumption in the formal commercial sector. Entertainment, refrigeration and transportation consume 7% each of the total energy of the formal commercial sector.

Cooking/water heating is the most energy intensive activity in the informal commercial sector. This activity consumes about 36% of the total energy of the informal commercial sector (Figure 45). Cooking and water heating are undertaken by the teeming restaurants, bars and food joints in the municipality. Machine operation is the second most energy intensive activity in the informal commercial sector. These machine operations include machines used in mechanic shops, sewing machines in tailoring shops and other machines used in other informal commercial activities. Additionally, lighting consumes about 13% of the total energy of the informal commercial sector, followed by entertainment (8%), refrigeration (6%) and ventilation (5%).

Figure 45: Percentage share of total energy consumed among various end-uses in the commercial sector in 2013 in GEM



Source: 2014 Energy survey

4.3 Industrial Sector

The industrial sector accounts for less than one percent of the total energy consumed in GEM in 2013. It is the fourth largest energy consuming sector in the municipality after transport, residential and commercial sectors. The energy picture in the industrial sector is discussed around its sub-sectors manufacturing; water & sewerage; and construction to enhance the understanding of the pattern of energy consumption among these sub-sectors.

Table 14 shows the total level of industrial activity in GEM with the production outputs converted into tonnes. In 2010, the total production of the industrial sector was around 691378.1 tonnes mainly from the water and sewerage sub-sector. This production level increased to 830146.9 tonnes, 1505918 tonnes and 3279305 tonnes in 2011, 2012 and 2013 respectively with the highest contributor being the water and sewerage sub-sector. The manufacturing sector had being the least contributor to the industrial sector's production until 2013 when construction least contributed to the industry's production.

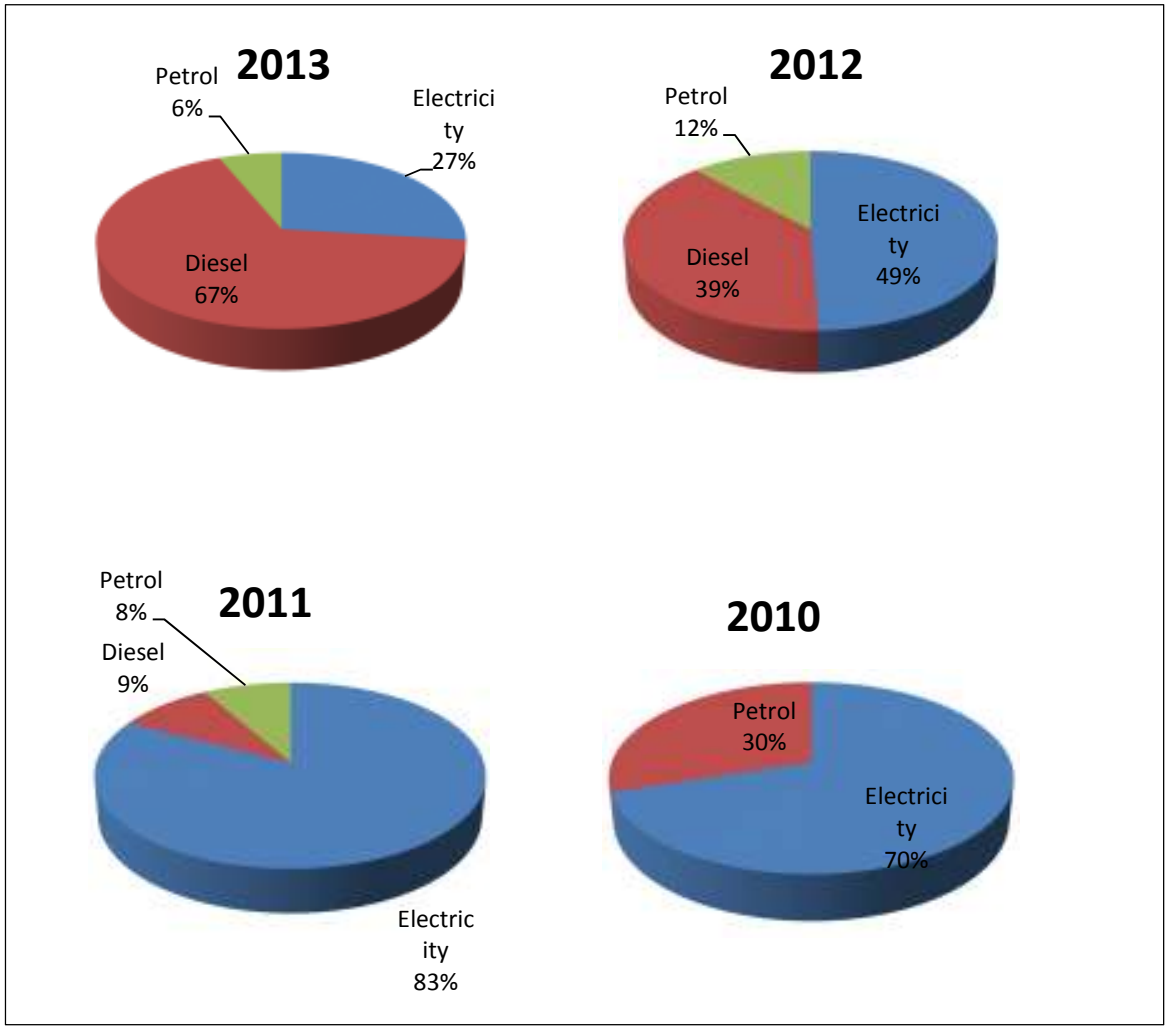
Table 14: Total level of industrial activity in GEM

Sub-sector	Activity level in tonnes per production			
	2010	**2011**	**2012**	**2013**
Manufacturing	8679.39	16462.29	19853.89	816089.4
Water & Sewerage	668400	792400	1234400	1938855
Construction	14298.73	21284.6	251664.4	524360.4
Total	**691378.1**	**830146.9**	**1505918**	**3279305**

Source: 2014 Energy Survey

The industrial sector consumes three main kinds of fuel; electricity, diesel and petrol as depicted in Figure 46. The trend in energy consumption in the industrial sector of GEM over the years reveals the current electricity supply shortfall the country is experiencing. In 2010, about 70% of the total energy consumed in the industry sector came from electricity while 30% was from petrol. In 2011, more energy consumed in the sector was sourced from electricity (about 83%) while the remaining 17% came from diesel and petrol. From 2012, the consumption of petrol and diesel increased at the expense of electricity consumption when the power shortage became acute in the municipality. Electricity constitutes only 49% of the total energy consumed by the industrial sector in 2012. Petrol constitutes 39% while diesel makes up the remaining 12% of the total energy consumed by the industrial sector in 2012. In 2013, petrol constitutes about 67% of the total energy consumed by the industrial sector while electricity and diesel constitute 27% and 6% respectively.

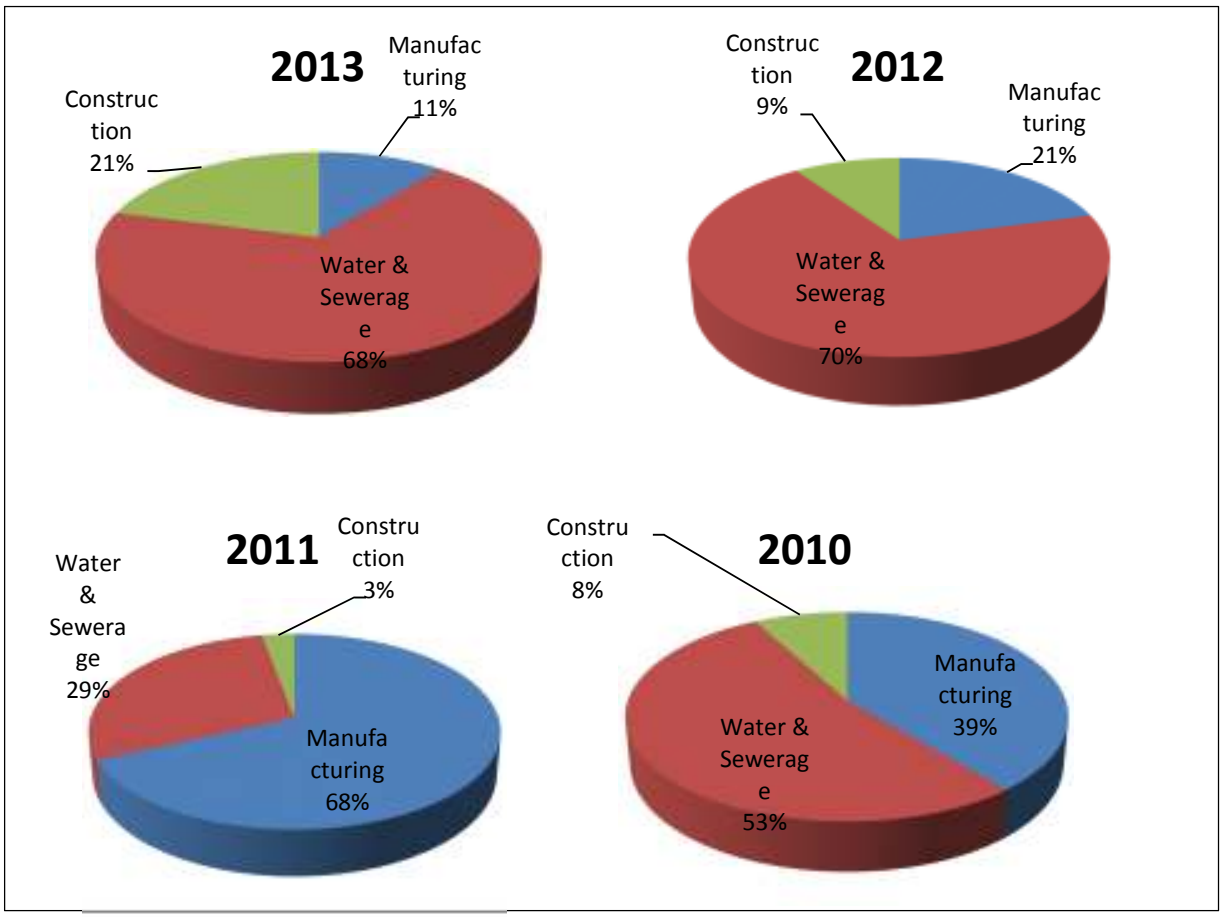
Figure 46: Percentage share of energy sources consumed by the industrial sector in GEM from 2010 to 2013



Source: 2014 Energy Survey

By virtue of its contribution to the industrial sector's production, water and sewerage sub-sector also remains the most energy intensive sub-sector in the municipality. In 2010, water and sewerage sub-sector consumes about 53% of the total energy consumption of the industrial sector while the construction sub-sector consumes the least, about 8% (Figure 47). In 2011 the manufacturing sub-sector consumed about 68% of the industrial sector's energy, followed by water and sewerage sub-sector (29%). In 2012 and 2013 however, the water and sewerage sub-sector consumed more energy. The share of construction sub-sector's energy consumption increased from 8% in 2010 to 21% in 2013. This increasing share is attributed to the real estate activities ongoing in the municipality.

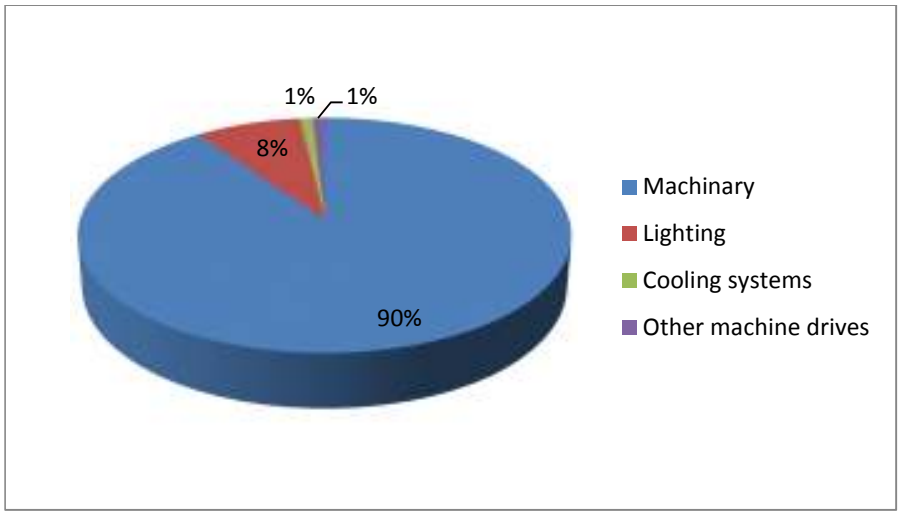
Figure 47: Share of total energy consumption among various industrial sub-sectors in GEM from 2010 to 2013



Source: 2014 Energy Survey

About 90% of the energy consumed in the industrial sector is used on machinery (Figure 48). Industrial activities often involve heavy machines that depend solely on energy to power them. These include vehicular machines, sachet water manufacturing machines and cement blocks cutting machines in the construction sub-sector. Lighting accounts for about 8% of the total energy consumption in the industrial sector while the remaining 2% is consumed by cooling systems and other machine drives.

Figure 48: Share of energy consumption among industrial demands in 2013 at GEM



Source: 2014 Energy Survey

4.4 Transport Sector

The transport sector is the most energy intensive sector in the municipality consuming about 8782423.8 GJ of energy. Vehicle population in the municipality as at 2013 was about 23315 (Table 15). The total number of vehicles in the municipality consisted of 3 public vehicles, 18804 private vehicles and 4508 commercial vehicles (Tables 16). Most of the heavy passenger, light passenger, mini buses, taxis and motorbikes are efficient vehicles although few old light, medium and heavy trucks still operate in the municipality. Almost all the light passenger vehicles with a capacity of less than 12 passengers are private vehicles while most of the mini buses, taxis motorbikes and the trucks are used for commercial purposes. There are three Metro Mass Transit (MMT) buses operating in the municipality that are publicly owned. The number of these buses reduced to three after the La Nkwantanang-Madina Municipality was carved out from the Ga East Municipality hence some of the buses stationed at the newly created municipality.

Table 15: Population of vehicles in GEM as at 2013

Type	Number of vehicles	Growth rate (%/yr)	No. and (%) of Efficient vehicles
Heavy passenger vehicle >12	3	-80%	3 (100%)
Light passenger vehicle <12	18672	20%	14938 (80%)
Mini buses (trotro)	2879	30%	2015 (70%)
Taxi	1491	20%	1267 (85%)
Motorbikes	120	60%	100 (83%)
Light trucks	60	-48%	20 (33%)
Medium and heavy trucks joint	90	-50%	30 (33%)
TOTAL	**23315**		

Source: 2014 Energy Survey

Table 16: Distribution of vehicle population by sector/ownership in GEM as at 2013

Type	Public	Private	Commercial Passenger
Heavy passenger vehicle >12	3		
Light passenger vehicle <12		18672	
Mini buses		120	2759
Taxi			1491
Motorbikes		12	108
Light trucks			60
Medium and Heavy trucks			90
TOTAL	**3**	**18804**	**4508**

Source: 2014 Energy Survey

The average usage of vehicles is shown in Table 17. The MMT buses transport about 8640 people per week from various locations to and fro the municipality. Mini buses (trotro) transport about 3454800 people per week in the municipality while taxis transport about 322056 people per week. The use of mini buses has grown over the years (about 11%) while the use of taxis decreased (about -10%). This is attributed to high fuel prices resulting in high fees charged especially by taxis. Economically, the mini buses were considered more affordable than taxis in the municipality.

Table 17: Average usage of vehicles per week in 2013 at GEM

Type	Units	Average Use
Heavy passenger vehicle >12	people/week	8640
Light passenger vehicle <12	people/week	224064
Mini buses	people/week	3454800
Taxi	people/week	322056
Motorbikes	people/week	3600
Light trucks	tonnes/week	1800
Medium /Heavy trucks	tonnes/week	4050

Source: 2014 Energy Survey

The average cost per litre of petrol increased from GHC1.44 in 2010 to GHC2.56 in 2013. Diesel on the other hand was about GHC1.33 per litre in 2010 and increased to an average of GHC2.44 per litre in 2013. The cost per 1 kilogram of LPG was about GHC 2.12 in 2010, GHC 2.57 in 2012 and GHC 2.72 in 2013 (Table 18). A total of about 2200000 litres of petrol was sold in GEM in 2010, increasing to about 2400000 litres being sold in 2013 (Table 19). About 2700000 litres of diesel was sold in 2010 and 2011 in the municipality. The quantity sold increased to about 2750000 litres and 2800000 litres in 2012 and 2013 respectively. About 83330133.33 kg of LPG were sold in 2010, increasing to about 97970960 kg being sold in 2013.

Table 18: Trends in average cost (GHC) of fuel in GEM from 2010 to 2013

Fuel type	per unit	Year			
		2010	**2011**	**2012**	**2013**
Petrol	litre	1.44	1.78	2	2.56
Diesel	litre	1.33	1.67	2	2.44
LPG	kg	2.12	2.37	2.57	2.72

Source: 2014 Energy Survey

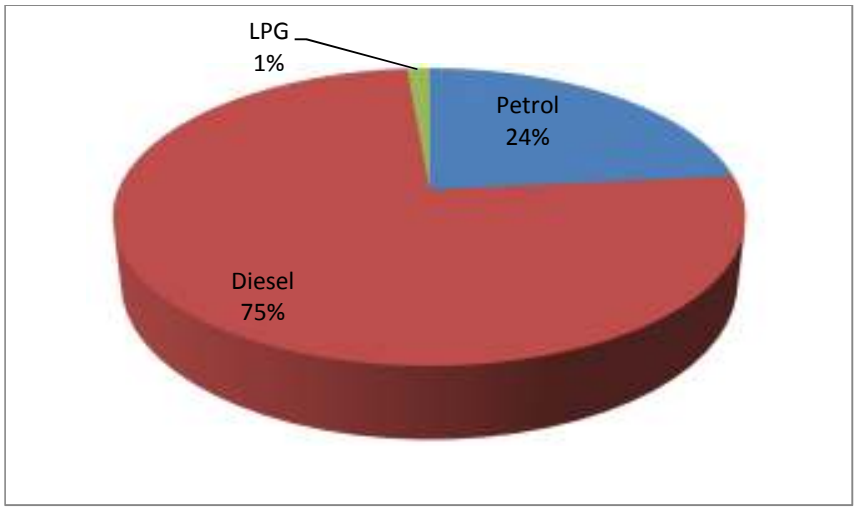
Table 19: Trends in total quantity of fuel sold in GEM from 2010 to 2013

Fuel type	year	Unit	Quantity	growth (%/yr)
Petrol	2010	Litre	2200000	
	2011	Litre	2200000	0
	2012	Litre	2400000	0. 1
	2013	Litre	2400000	0
Diesel	2010	Litre	2700000	
	2011	Litre	2700000	0
	2012	Litre	2750000	0.02
	2013	Litre	2800000	0.02
LPG	2010	Kg	83330133.33	
	2011	Kg	111363640	33.6
	2012	Kg	110931120	-0.4
	2013	Kg	97970960	-11.7

Source: 2014 Energy Survey

About 75% of the total energy consumed by the transport sector in the GEM is from diesel fuel (Figure 49). Petrol fuel constitutes about 24% of the total energy used by the transport sector while 1% of LPG is consumes in the municipality. LPG is consumed mainly by taxis, which have converted onto the LPG fuel from either petrol or diesel fuels because it is considered to be more economical than petrol and diesel. While the use of LPG by taxis has environmental benefits, it inadvertently created shortage of LPG for domestic users in the past. Mini buses (trotro) and the trucks are very dependent on diesel fuels for commercial purposes.

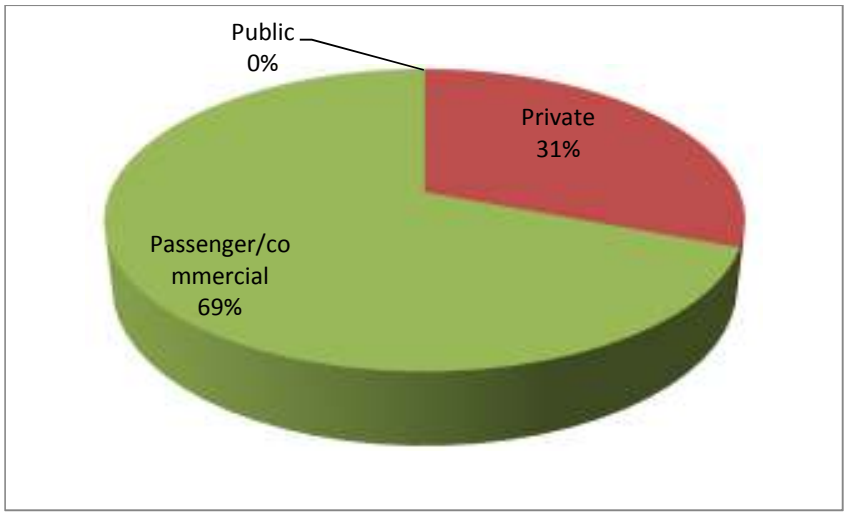
Figure 49: Percentage share of fuel type consumed by the transport sector in GEM



Source: 2014 Energy Survey

Commercial vehicles consume about 69% of the total energy in the municipality. This is followed by private vehicles which consume about 31% of the total energy used in the transport sector. The public vehicles (MMT buses) consume less than 1% of the total energy used in the transport sector (Figure 50).

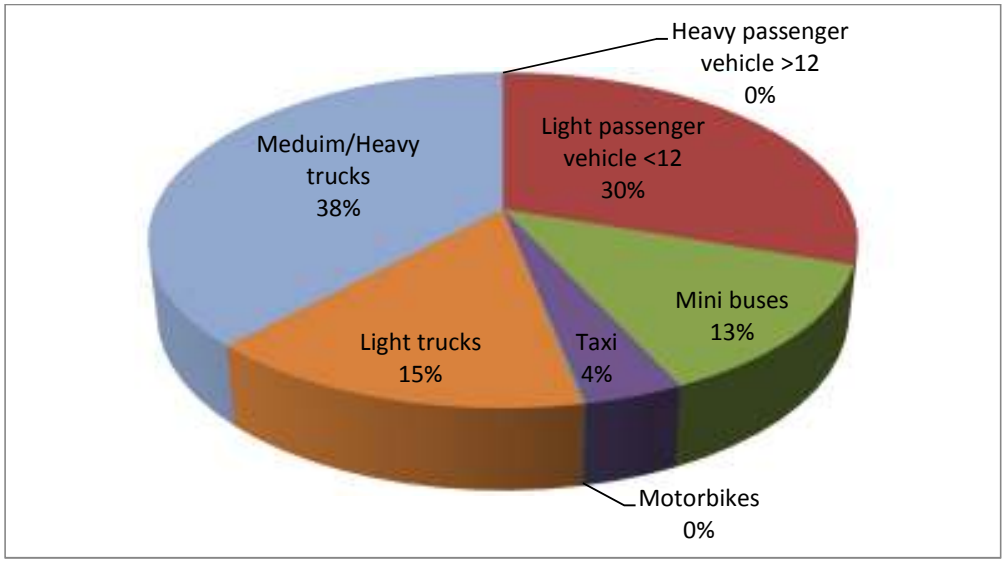
Figure 50: Percentage share of energy consumed by different vehicular operations in GEM



Source: 2014 Energy Survey

Figure 51 shows the share of energy consumption among the different types of vehicles in GEM. Medium and heavy trucks energy consumption constitutes the highest (38%) in the transport sector, followed by light passenger vehicles (30%). Light trucks consume about 15% while trotros (mini buses) consume about 13% of energy in the transport sector. Taxis' energy consumption constitute only 4% of the total fuel consumption in the transport sector while motorbikes and heavy passenger vehicles consume less than 1% of the total energy consumed in the transport sector in GEM.

Figure 51: Percentage share of energy consumed by vehicle types in GEM



Source: 2014 Energy Survey

4.5 Local Government Sector

GEMA is the least energy consuming sector in the municipality. The Assembly consumed about 11909.3 GJ of energy in 2013 from two main energy carriers; electricity and diesel fuels. The energy is primarily consumed through lighting, ventilation and air conditioning, refrigeration, transportation, office machines and water treatment. GEMA currently operates from 15 office buildings with a total floor space of about 8860.6 square meter (m^2) in 2013 (Table 20). The Assembly has 8 diesel-engine vehicles currently which together, cover a distance of about 520 km per day (Figure 21). The Assembly previously owned 17 vehicles in 2010 and 2011 with an average usage of about 1120 km per day. Nine of the vehicles were given to the newly created La Nkwantanang-Madina Municipality in 2012.

Table 20: Office buildings occupied by GEMA and the total floor space of the buildings

Year	No. of building	Floor space (m2)
2010	19	9779
2011	19	9779
2012	19	8712.6
2013	15	8860.6

Source: 2014 Energy Survey

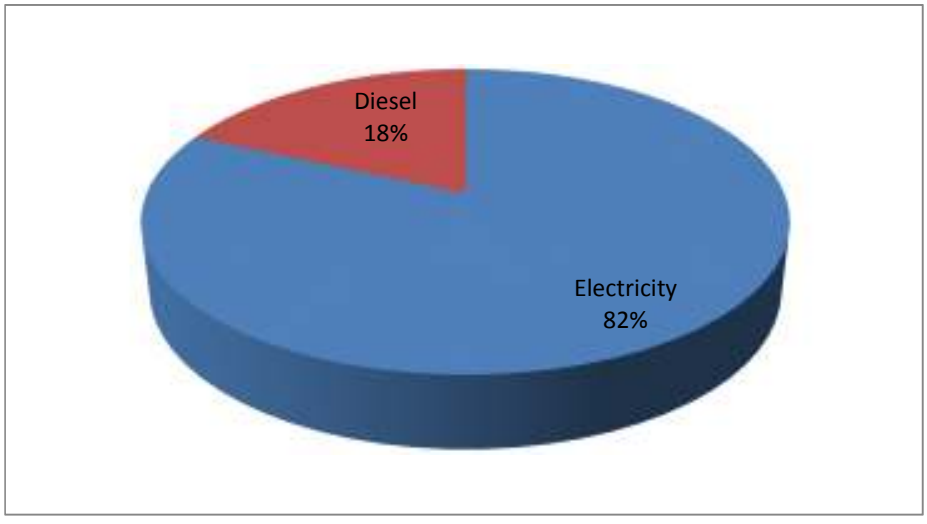
Table 21: Total number of vehicles used by GEMA and vehicle mileage

	2010	2011	2012	2013
No. of vehicles	17	17	8	8
Average use (km/day)	1120	1120	520	520
km/year	13440	13440	6240	6240

Source: 2014 Energy Survey

The predominant energy source consumed by GEMA is electricity from the national grid. Electricity constitutes about 82% of the total energy consumed by GEMA in 2013 (Figure 52). The remaining 18% of the energy consumed came from diesel fuel which is used in the vehicles and also for powering the back-up generator.

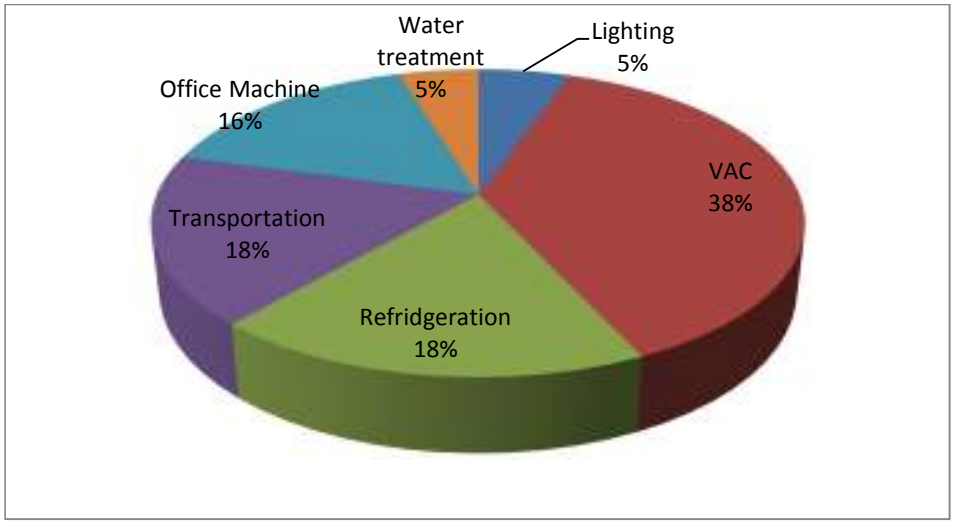
Figure 52: Share of total energy consumed by carriers in GEMA



Source: 2014 Energy Survey

Ventilation and air conditioning (VAC) is the largest energy end-user, accounting for about 38% of the total energy consumed by the GEMA in 2013 (Figure 53). 18% each is consumed through refrigeration and transportation while office machines accounts for about 16% of the total energy consumed by the Assembly. 5% each is consumed through lighting and water treatment. Electricity is the main source of energy for lighting but GEMA also depends on a 60kv capacity diesel-powered generator which uses about 125.22 litres of diesel per month during periods of black-outs.

Figure 53: Percentage share of energy consumption in GEMA by various end-uses in 2013



Source: 2014 Energy Survey

SECTION FIVE

ENERGY EFFICIENCY PROGRAMMES: KNOWLEDGE-BASED EVIDENCE AT THE MUNICIPAL LEVEL

5.0 Introduction

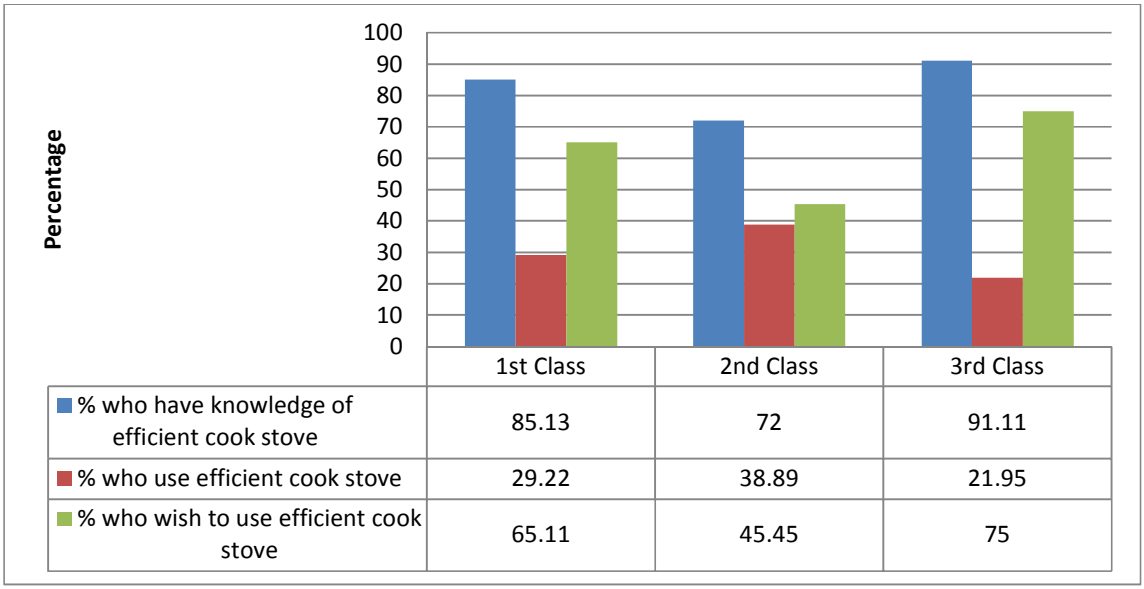
This section assesses the depth of knowledge and awareness of inhabitants of GEM in adopting ongoing energy efficient programmes being ran by the national energy institutions such as the Energy Commission of Ghana. The assessment is to help gauge the penetration rate of these national programmes at the municipality level and the level of willingness on the part of the municipal residents in taking advantage of such initiatives.

5.1 Energy Efficient Cook stoves and light bulbs

The energy efficient cook stoves, also known as *Gyapa*, is designed and produced to perform at optimal level in heating and cooking and at the same time minimize the waste of charcoal fuel in the process. It is a locally manufactured, low cost cookstove that reduces the amount of charcoal needed for cooking by up to 50%, resulting in significant savings for low-income households and also results in a reduction of harmful Greenhouse Gas (GHG) emissions (MESTI, (2012). The campaign for the use of *Gyapa* is championed by the Energy Commission (EC) of Ghana and other Non-Governmental Organisations and International-based programmes such as the United Nation's initiative "Sustainable Energy for All", ClimateCare and Relief International programmes. These cook stoves are disseminated to different parts of the country, regions and districts including GEM. Figure 54 shows the percentage of people who have knowledge on the efficient cook stoves, those who currently use it and those who wish to use it in the future.

Knowledge on the existence of *Gyapa* cookstoves in GEM is very high as more than 70% of electrified households across all three classes of settlements indicated their awareness of the cook stoves. Conversely, a very low percentage of these households currently use the efficient cook stoves despite the high level of awareness (Figure 54). Meanwhile, the percentage of electrified households who wish to use efficient cook stoves is also high, especially in First and Third Class electrified households, implying the possibility of increase in use of the technology in the municipality in future. Among non-electrified households, more than 75% of households noted their awareness of energy efficient cook stoves. However, less than 50% of such households with highly perceived awareness rate have used these efficient cook stoves. Over 75% expressed willingness to use these energy efficient cook stoves (Figure 55).

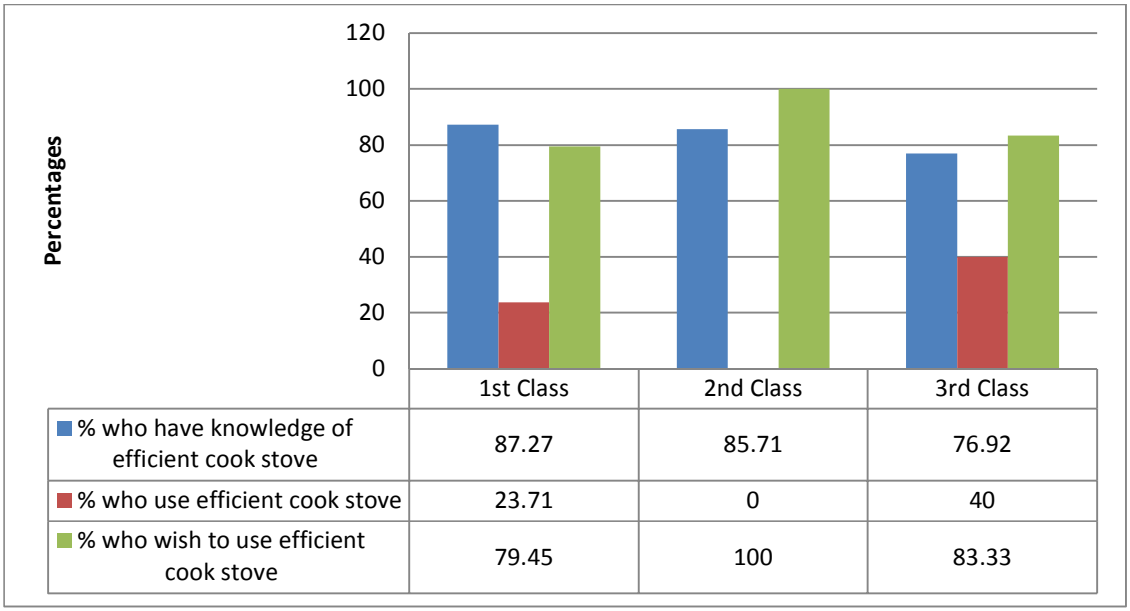
Figure 54: Percentage of electrified households who have knowledge, are using or wish to use efficient cook stoves in GEM



	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	85.13	72	91.11
% who use efficient cook stove	29.22	38.89	21.95
% who wish to use efficient cook stove	65.11	45.45	75

Source: 2014 Energy Survey

Figure 55: Percentage of non-electrified households who have knowledge, are using or wish to use efficient cook stoves in GEM



	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	87.27	85.71	76.92
% who use efficient cook stove	23.71	0	40
% who wish to use efficient cook stove	79.45	100	83.33

Source: 2014 Energy Survey

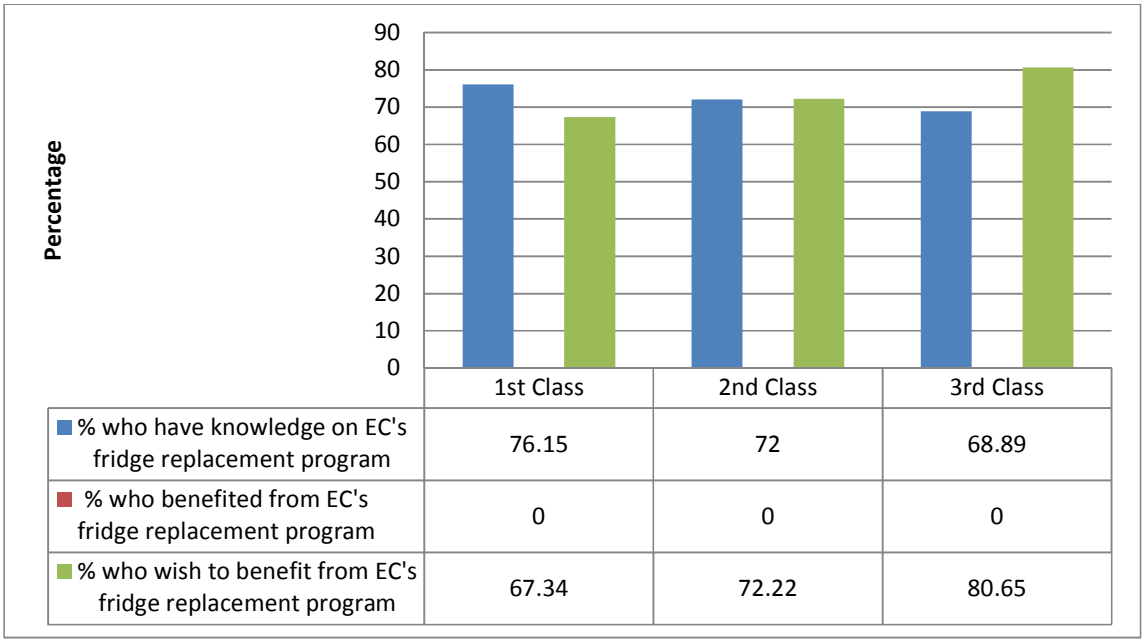
The Ghana Appliance and Energy Efficiency Standards and Labeling programme spearheaded by the EC of Ghana in 2007 saw the distribution of six million incandescent lamps in the country which helped reduce peak load of electricity by 124 MW (Energy Commission, 2010). This programme was described by the EC of Ghana as successful and the extent of penetration and coverage of the programme in GEM confirms this success story. From the survey, about 99% of First Class households strictly use energy efficient bulbs for lighting while 96% and, nearly all of Second and Third Class households respectively use efficient lighting bulbs. Those who still depend on the old florescent and incandescent bulbs noted that, the old florescent and incandescent bulbs are brighter than the efficient ones, and that, the bulb holders have never been replaced as they are only made to suit incandescent or florescent bulbs.

5.2 Penetration level of Energy Commission's fridge replacement programmes in GEM

In the last quarter of 2011, the EC of Ghana commenced the Refrigerator Energy Efficiency project which was expected to run up to 2014. The project intended to introduce very efficient refrigerators into the economy with the potential of reducing electricity consumption in refrigerators by 50% in the medium term. The project targeted the replacement of about 15,000 old inefficient refrigerators in the country which consume on average, 1200kwh per year with efficient ones which consume about 250kwh per year by mid-2014. Accordingly, importers and retailers of refrigerators (and other appliances such as room Air Conditioners (AC) and Compact Fluorescent Lamps (CFL)) are required to import and sell only products that meet minimum efficiency and performance standards approved by the Ghana Standards Board. However, the importation of second-hand inefficient refrigerators is still a common practice in Ghana and people still demand them because they are considered cheaper than the new ones. In GEM, about 50% of those who use fridges and freezers in first class households acquired them new while some 48% acquired second-hand brands. In second class households, some 52% acquired their fridges and freezers at their new states while some 48% of them rather went in for second-hand brands. About 68% of those who use fridges and freezers in third class households acquired them at their second-hand state. Only 29% bought and use new fridges and freezers in third class households in the GEM.

With respect to the EC's fridge replacement programme, the survey results show that it is well known in the GEM. Over 60% of households across all three settlement classes have knowledge on the programme (Figure 56). Regardless of the high awareness, patronage of the programme is rather abysmal. None of the households in all three settlement classes participated in the programme. Meanwhile, a significant percentage (over 65%) of households that indicated their awareness of the programme wish they could benefit from it in the future. This implies that there is a disconnection between awareness about the programme in the municipality and accessibility.

Figure 56: EC's fridge replacement programme: knowledge and accessibility



	1st Class	2nd Class	3rd Class
% who have knowledge on EC's fridge replacement program	76.15	72	68.89
% who benefited from EC's fridge replacement program	0	0	0
% who wish to benefit from EC's fridge replacement program	67.34	72.22	80.65

Source: 2014 Energy Survey

5.3 Energy Commission (EC) Appliance Efficiency Labels

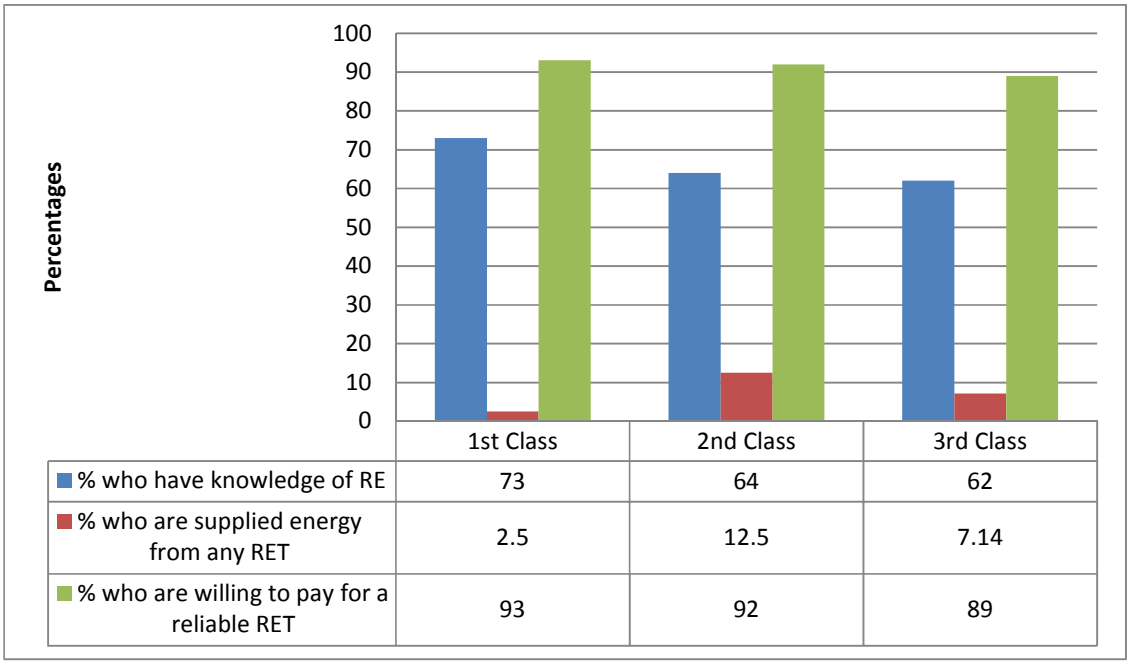
The Energy Efficiency Standards and Labels programme was designed to ensure that only appliances that meet minimum energy efficiency standards enter the Ghanaian market. In accordance with the provisions of the Energy Efficiency Standards and Labelling (Non ducted Air Conditioners and Self Ballasted Fluorescent Lamps) Regulations, 2005 (LI1815) appliance manufacturers who export to Ghana and retailers who sell in Ghana are obliged to display a label which indicates the energy efficiency rating of the product before the first retail sale. It is an offence under LI1815 to import, display for sale or sell air conditioners and compact fluorescent lamps in Ghana unless they meet the minimum performance standards and are properly labeled.

In the survey, households in the GEM were asked whether the new appliances they bought had the energy efficiency labels on them. For those who use air conditioners, -- in First Class households—about 88% of them bought the ACs with the EC's efficiency labels on them while 12% of them bought new ACs without the efficiency labels. For refrigerators users, about 59% of First Class households bought new refrigerators with the EC's efficiency labels displayed on them. Only 10% and 40% of Second and Third class refrigerators users bought new refrigerators with the efficiency labels displayed on them. In other words, more second and third class households demand second-hand brand fridges and freezers. The few who buy new brands likely end up with inefficient cheap ones which may not have the EC's efficiency labels on them.

5.4 Knowledge and use of Renewable Energy Technologies (RETs) in GEM

Public knowledge on RETs is quite encouraging in the municipality. About 73% and 42% of first class electrified and non-electrified households respectively have knowledge on renewable energy. About 64% and 57% of second class electrified and non-electrified households have knowledge on renewable energy while 62% and 54% of third class electrified and non-electrified households respectively, are also aware of renewable energy (Figures 57 and 58). The most common RETs known to these household members are solar photovoltaic PVs and wind.

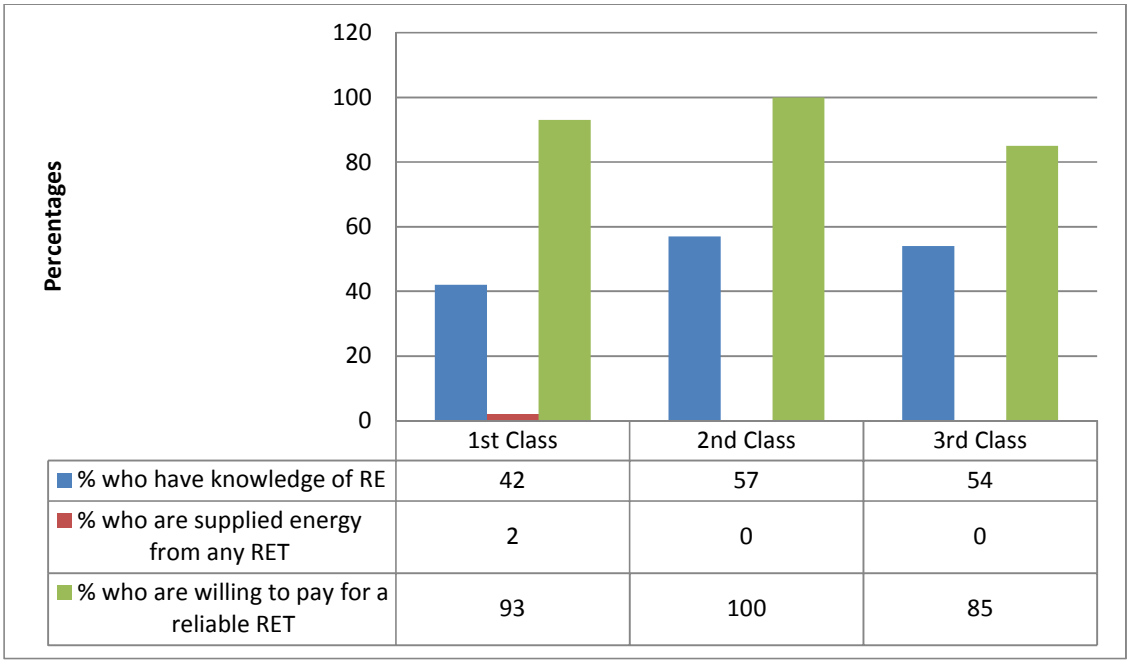
Figure 57: Percentage of electrified households who have knowledge of RE, supplied energy from RETs and are willing to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	73	64	62
% who are supplied energy from any RET	2.5	12.5	7.14
% who are willing to pay for a reliable RET	93	92	89

Source: 2014 Energy Survey

Figure 58: Percentage of non-electrified households who have knowledge of RE, supplied energy from RETs and are willing to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	42	57	54
% who are supplied energy from any RET	2	0	0
% who are willing to pay for a reliable RET	93	100	85

Source: 2014 Energy Survey

Despite the awareness level, more than 80% of these households across all three settlements are not supplied energy from these RETs. Meanwhile, there is high willingness to pay for these RETs so far as they are reliable. According to the survey, over 85% of households across all three classes of settlements have expressed willingness to pay for renewable energy at a reasonable cost so long as it is readily available and reliable.

SECTION SIX

MUNICIPAL STRATEGIC ENERGY ISSUES

6.0 Introduction

This section looks at some of the strategic mandates and controls of the GEMA with respect to sustainable energy issues in the municipality. The views expressed in this section of the SoE report are those gathered from the Focus Group Discussion held with GEMA personnels.

6.1 Mandates of GEMA in influencing energy supply, demand and efficiency

GEMA does not produce nor distribute any form of energy to demand sectors of the municipality. All of the conventional energy carriers demanded by the various demand sectors in the municipality including the Assembly itself are supplied by national institutions. Nevertheless, the Assembly furnishes Electricity Company of Ghana (ECG) with information regarding communities that are not electrified, illegal connection activities and congestions on transformers due to population increase. The Assembly also sometimes procures and installs electricity poles in non-electrified communities in order to speed up ECG's work on extending electricity to those communities. In the area of Renewable Energy Technologies (RETs), the Assembly has made little stride in terms of energy production. GEMA is partnering with La Nkwantanang-Madina municipality and a private investor to produce energy out of the waste that is deposited at the Abokobi landfill site. There are also some street lights in the municipality that are powered through the solar PV systems.

GEM oversees the general planning of the municipality before power is extended to the various dwelling units (houses and structures). In terms of residential buildings and other structures that are put up in the municipality, the Assembly has no mandate to impose building plans on individual property owners. However, all building plans go through vetting procedures at the Assembly to ensure the plans entail proper ventilation systems and minimal use of lights. Regarding spatial planning, the Assembly has prepared town layouts (schemes) for specific areas in the municipality. Based on these town schemes, permits are issued to individual land developers who which to put up residential buildings, office structures, warehouses or other

structures. Permits are denied if building plans at particular areas do not match the plans for those areas in the Assembly's layouts. Rezoning of the area becomes necessary when structures do not tally with what is proposed in the schemes for the area.

GEMA often gives permits of six months for the erection of temporal structures in the municipality. The issuance of such permits coupled with the erection of structures at unauthorised areas by residents without permit has resulted in the growth of informal settlements in certain areas of the municipality. Occasionally, GEMA embarks on slum management programmes in order to limit inconveniencies in such areas. In terms of transport management, there are 45 urban passenger transport operator unions in the municipality that are regulated by the Assembly. The Assembly, however, does not determine which vehicles are road-worthy or not to operate in the municipality. This falls within the remit of the Driver and Vehicle Licensing Authority (DVLA). The Assembly only levies passenger vehicle operators in the municipality for their operations.

6.2 The control of GEMA over new developments in GEM

Electricity extension to new communities and also to new residential buildings and other structures in already connected communities is an ongoing activity in the municipality. The Assembly has no direct control over such connections, but indirectly provides information regarding such communities. GEMA has full control over spatial layouts of the municipality and building structures. In 2013, 168 development permit applications were received at GEMA. A total of 224 development applications were approved in that same year which included the outstanding applications of the previous years. It is, however, not uncommon to see people putting up permanent and temporal structures at unauthorized locations without permits from the Assembly. This often attracts fines and demolition of the structures once the Assembly finds out about such activities.

With respect to the transport sector, the GEMA has no control over construction and maintenance of roads in the municipality (which are mandates of the Urban Roads Department). The Assembly, however, supervised the setting up of some new bus terminals in the municipality and also upgrade of some existing ones in the past year. New passenger/commercial transport

unions were registered under the Assembly including the registration of new commercial vehicles as well. About five (5) liquid fuel service stations were granted permits to site and operate in the municipality in 2013. The Assembly ensured that the locations of these fuel service stations conformed to the general layouts of the area.

SECTION SEVEN

SUMMARY AND IMPLICATIONS FOR SUSTAINABLE ENERGY TRANSITIONS

7.0 Introduction

The activities leading to the preparation of the state of energy report were carried out in two phases. First phase activities, which basically involved scoping and review of relevant existing secondary data, helped in unraveling the huge paucity in the energy data for the municipality. This forms the basis for carrying out phase two activities which involved primary data collection. Analysis of the data from the 2014 Energy Survey helped in preparing the State of Energy report for GEM. The report provides comprehensive states of energy in the household, commercial, industrial, transport and local government sectors of the municipality. Discussed below are the summary of the major findings and the implications they hold for sustainable energy transition in GEM.

Major findings: Most electrified households in GEM live in compound and separate houses and they predominantly use louvre blade window types while non-electrified households, who dwell mostly in kiosks/containers, have wooden windows as the predominant window type. For louver blade window s users in electrified households, 46%, 21% and 86% of First, Second and Third Class households respectively depend on the natural ventilation system while corresponding 53%, 79% and 14% use fans. Meanwhile, sliding glaze windows users in GEM mostly depend on fans and air conditioners. About 52% of First Class households who use sliding glaze windows depend on fans while 23% depend on air conditioners as their main ventilation systems.

Implications: Households who use predominantly, sliding glass windows have higher tendencies of consuming more energy than households who use louvre blade and wooden window types. The architectural designs of buildings and specifically, window designs therefore have implications on energy consumption in the municipality.

Major findings: A significant proportion of households in all three settlement classes use modern forms of energy in GEM. Electricity and LPG together constitute about 49% of the total energy consumption of the residential sector. However, the residential sector of GEM still depends heavily on biomass energy specifically, for cooking activities. Charcoal and firewood constitute about 45% of the total energy consumed by the residential sector in GEM. The main cooking and water heating energy source for First and Second Class electrified households is LPG with electricity used as supplementary energy source in the municipality. Third Class households and most non-electrified households depend heavily on charcoal as their main cooking and water heating energy source with some also depending on firewood as supplementary source. Fewer percentages of biomass users for cooking wish to discontinue using biomass in the future while majority cited the issue of lack of affordability of modern forms of

energy (electricity and LPG) as the major reason they will continue to use charcoal and firewood in the future.

Implications: Biomass will remain a major cooking and water heating energy source to most third class and non-electrified households in the municipality in the near future. While little can be done about electricity charges and LPG prices in the municipality since they are outside the control of the GEMA, a lot can be done in terms of sustainable use of biomass energy such as promoting the use of energy efficient cookstoves.

Major findings: Knowledge on the on-going national energy efficient programmes in GEMA is very high. More than 70% and 75% respectively of electrified and non-electrified households are aware of the existence of energy efficient cook stoves. However, just about 30% each of electrified and non-electrified households across all three classes have used efficient cook stoves in the municipality. Meanwhile, over 65% of electrified and 70% of non-electrified households reported their willingness to use efficient cook stoves. Similarly, more than 70% of households within First, Second and Third Class electrified settlements have knowledge on the Energy Commission's fridge replacement programme. Regardless of the high awareness level, the proportion of households in the municipality that have taken advantage of such programmes is rather abysmal (less than 1% across all settlement classes). Meanwhile, the willingness to ever take advantage of such programmes is high among all three settlement classes (over 65%).

Implications: From the survey results, there is high awareness level of energy efficiency programmes in the municipality and also high willingness on the parts of households to take advantage of the energy efficient programs. Clearly, there is a disconnection between awareness about the energy efficiency programmes in the municipality and accessibility. Insufficient distribution points of the energy efficient cook stoves and the fridge replacement programmes in the municipality may seriously undermine awareness creation and patronage of the programmes.

Major findings: The commercial and industrial sectors in GEM depend largely on petroleum fuels (diesel, petrol and LPG) and electricity for their commercial, industrial and agricultural activities such as transportation, lighting, machine operations, ventilation, and refrigeration. The current shortfall in the supply of electricity to the municipality has attributed to increasing consumption of petroleum fuels. Diesel constitutes about 39% of the total energy consumed by the commercial sector and 67% of the total energy consumed by the industrial sector in 2013. Although transport activities in these sectors consume some amount of the petroleum fuel, a significant proportion is consumed by petrol and diesel powered generators to supplement the national electricity supply.

Implications: The production of clean energy using RETs by commercial and industrial activities in the municipality is non-existence since there are no binding regulations to that effect. Dependence on electricity from the national grid has implications on the power available to these sectors. More so, supplementing the national electricity supply with diesel and petrol powered

electricity generators has implications on the carbon emission level of Ghana as a whole. Other retrofitting technologies such as the installation of human sensors in offices are limited in many of the commercial and industrial activities while energy inefficient air conditioners and refrigerators are still in use in some offices.

Major findings: Though the use of private cars in the municipality is growing rapidly, at 20% on average annually, lots of people also depend on the commercial mini-buses passenger vehicles (*trotros*), taxis and the public transport system in the municipality. The mini-buses (*trotros*) transport about 3454800 people per week in the municipality while taxis and the public transport (MMT buses) transport about 322056 and 8640 people per week respectively, in the municipality.

Implications: Effective regulation of the transport systems in the municipality including provision of sufficient bus terminals, ensuring regular maintenance of public vehicles, regulating taxis and *trotro* unions will discourage private ownership of cars. Promoting heavy passenger carrier vehicles at the expense of light passenger vehicles will have implication on total petroleum fuel consumption and carbon emission level in the municipality and Ghana at large.

Major findings: GEMA depends largely on electricity supply from the national grid. Ventilation and air conditioning systems consume about 38% of the total energy consumption of GEMA, followed by refrigeration and transportation (18% each), office machines (16%) and then lighting and water treatment (5% each).

Implications: Energy efficient electrical gadgets consume about 79% less energy than inefficient gadgets hence, the use of energy efficient electrical gadgets will have implications on the total energy consumption of the GEMA. Individual behavioral actions also have consequences on the total energy consumed by GEMA. When office occupants forget to put off electrical gadgets and office lights when they are out of the offices, energy consumption increases. Moreover, there are no installed retrofitting technologies such as human sensors which can automatically turn of office lights when occupants are out of the office.

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APPENDIX 1

COMMUNITY CLASSIFICATION

GA EAST MUNICIPALITY

CLASS	COMMUNITIES			
FIRST CLASS	1	North Legon	7	Kwabenya
	2	Haatso	8	Dome
	3	Akatsi-Abor	9	Taifa
	4	Atomic Area	10	Agbogba
	5	Ashongman	11	Hills Estate
	6	Atomic	12	Part of Adenta
SECOND CLASS	1	Abokobi	3	Taifa North
	2	West Abladjei		
THIRD CLASS	1	Agbogba Village	6	Boi
	2	Old Ashongman	7	Akporman
	3	Dravaga	8	Adenkrebi
	4	Sesemi	9	Agyankote
	5	Adoteiman	10	Krorabiwoho